# Design of a Fuel Oil Storage Facility

**Background**

The goal of this project is to design a new, state-of-the-art fuel oil storage facility for the Kanawha Valley Facility, such as the one illustrated in Figure 1. The types of fuels to be stored at the Kanawha Valley Facility are 200,000 gallons of No. 2 Diesel Fuel Oil, 2 million gallons of No. 2 Fuel Oil, 400,000 gallons of No. 6 Fuel Oil, and LPG's (Propane – 20,000 gallons and Butane – 25,000 gallons). The storage practices to be implemented must follow the highest standards currently demanded by industry and the law. There are many environmental concerns to the public that must be investigated. To this end, a full environmental impact statement (EIS) must be prepared. In general, industry must find a balance between the advantages of technological improvements for the good of society and the risk involved in implementing them.

One of the major concerns is the environmental impact of an oil spill. Several factors need to be investigated: type of oil spill, causes of an oil spill, costs for cleanup and litigation, and ecological damage. One prevalent trend in the causes of oil spills is human error and equipment failure. Another trend is that ecological damage is lessened when the spill is small and cleanup is quick and efficient. The design should address these factors.

The type of oil is also very important when considering the effects of an oil spill. Lighter fuel oils can be cleaned up more easily than heavier oils. The cost for cleanup depends on the amount spilled and the time delay before cleanup. The most important of all efforts for an oil spill is the preplanning cleanup activity.

The Kanawha Valley was chosen due to its close proximity to West Virginia University and the local chemical industry. The EIS addresses the impact on the surrounding environment. Therefore, information, concerning local wildlife and the environment, must be obtained. This design is meant to be a guide, and should be modified for the location chosen for the storage facility.

**Process Description**

The plot plan minimizes the space required for construction, while still following all applicable laws and codes. Two tanks for each fuel oil are used with a common dump tank that is large enough to hold the contents of the largest tank (No. 6 fuel oil). One pressurized containment vessel is used for each LPG product. Because of its high vapor pressure, propane is stored in a sphere, while butane can be stored in a bullet. The Dow Fire and Explosion Index (1) blast radius for propane and butane were a major factor in the placement of all tanks and vessels. No major equipment is placed within these radii to minimize damage in case of an accident. Diking walls are placed around each set of tanks and the dump tank for secondary containment purposes.

The LPG vessels use a vapor recompression system, which helps eliminate vapor loss during loading and unloading. Also, to ensure safety of the facility, its workers, and the surrounding community, a fire prevention system has been designed for the facility. Making use of Aqueous Film-Forming Foam Concentrate (AFFF, 2), the system protects each tank and diked area with a separate foam tank system. AFFF is an aggregate of air filled bubbles formed from aqueous solutions and is lower in density than flammable liquids. It is used principally to form a cohesive floating blanket and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents reignition by suppressing the formation of flammable vapors. The LPG storage tanks will be protected by water deluge systems to keep the vessels cool in case of a fire or explosion.

**Necessary Information**

In 1984, Congress responded to the problem of leaking tanks by adding Subtitle I to the Resource Conservation and Recovery Act (RCRA). This Subtitle requires the EPA to provide regulations, which will protect the environment and the public health from the leakage of underground storage tanks. Subtitle I states certain requirements for correct installation, spill and overfill protection, corrosion protection, and leak detection (3) for aboveground and underground storage tanks (AST/UST). A UST is defined as "any tank, including underground piping connected to the tank, that has at least 10% of its volume underground." (4) Furthermore, the owner/operator is responsible for the cost of cleaning up a leak and compensating other people for bodily injury and property damage caused by the leakage of the UST's.

AST's fall under the legislation of 40 CFR Part 112, the *Oil Pollution Prevention Regulation* (3). This is also known as the *Spill Prevention, Control and Countermeasure Regulation* (SPCC). The SPCC was revised in 1993 in two phases. The first phase made modifications mandatory, not discretionary. The second phase regards the revision of the Oil Pollution Act of 1990 (OPA), which places liability for the removal costs and damages for spills on the on-shore facility tank owner/operator (3).

LPG's are stored under pressure in vessels designed to withstand their vapor pressure at the maximum expected liquid temperature. The ASME code states that any vessel containing propane shall have a design pressure of 250 psi, for reference propane has a vapor pressure of 205 psi at 100°F. Also, butane must be stored in a vessel with a design pressure of 100 psi, for reference it has a vapor pressure of 37 psi at 100°F. Pressure release devices on these types of vessels must begin to operate at the design pressure, so as not to exceed 120 percent of design pressure under fire exposure conditions (5).

LPG storage has escaped some of the major attention in newer legislation. For example, NFPA 59 states that older tanks are permitted as long as they comply with the appropriate standards at the time of construction (6). To aid in the detection of atmospheric leaks, all LPG's are required to be odorized. The additive used must enable detection of the LPG down to one-fifth the lower limit flammability (LFL). The lower limits in volume percent are 2% for propane and 1.5% for butane (7,8).

Dikes are a form of "secondary" containment in the event of a spill. The diking arrangement used in the plot plan is a combination of a concrete wall reinforced with earth on the outside. The dike volume is calculated to hold the contents of the largest tank within the diked area.

Heat exchangers are required in some portions of the facility. The fuel oils, particularly No. 6, will require heating during the winter when the temperature falls to a point approaching the solidification condition. Additionally, the LPGs will require heating for vaporization since they are delivered as gases. The heat transfer coefficient for the heating coils was obtained from Perry's Chemical Engineers' Handbook (9). The heating coil used a standard inward spiral design, with an outer ring within 6 inches of the tank wall (10).

**Reference:**


1. Crowl, D. A., and Louvar, J. F., *Chemical Process Safety*, Prentice Hall PTR, p. 317, Englewood Cliffs, NJ, 1990.

2. NFPA 11, Standard for Low Expansion Foam, 1994, p.11-14.

3. 40 CFR Ch. I, Part 60 (7-1-93 Edition), *Environmental Protection Agency*.

4. United States Environmental Protection Agency, Office of Underground Storage Tanks, Musts for USTs, September 1988.

5. ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, "Rules for the Construction of Unfired Pressure Vessels," 1986, and all addenda and errata thru 1988.

6. NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1991 Edition, NFPA Standards Council, Quincy, MA.

7. NFPA 45, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1989 Edition, NFPA Standards Council, Quincy, MA.

8. NFPA 45, *Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants*, 1989 Edition, NFPA Standards Council, Quincy, MA.

9. Perry's Chemical Engineer's Handbook6$^{th}$ ed., McGraw-Hill Book Company, NY, 1984.

10. Petroleum Refiner, "*How to Design Tank Heating Coils*", April 1959.

**Equipment Descriptions**

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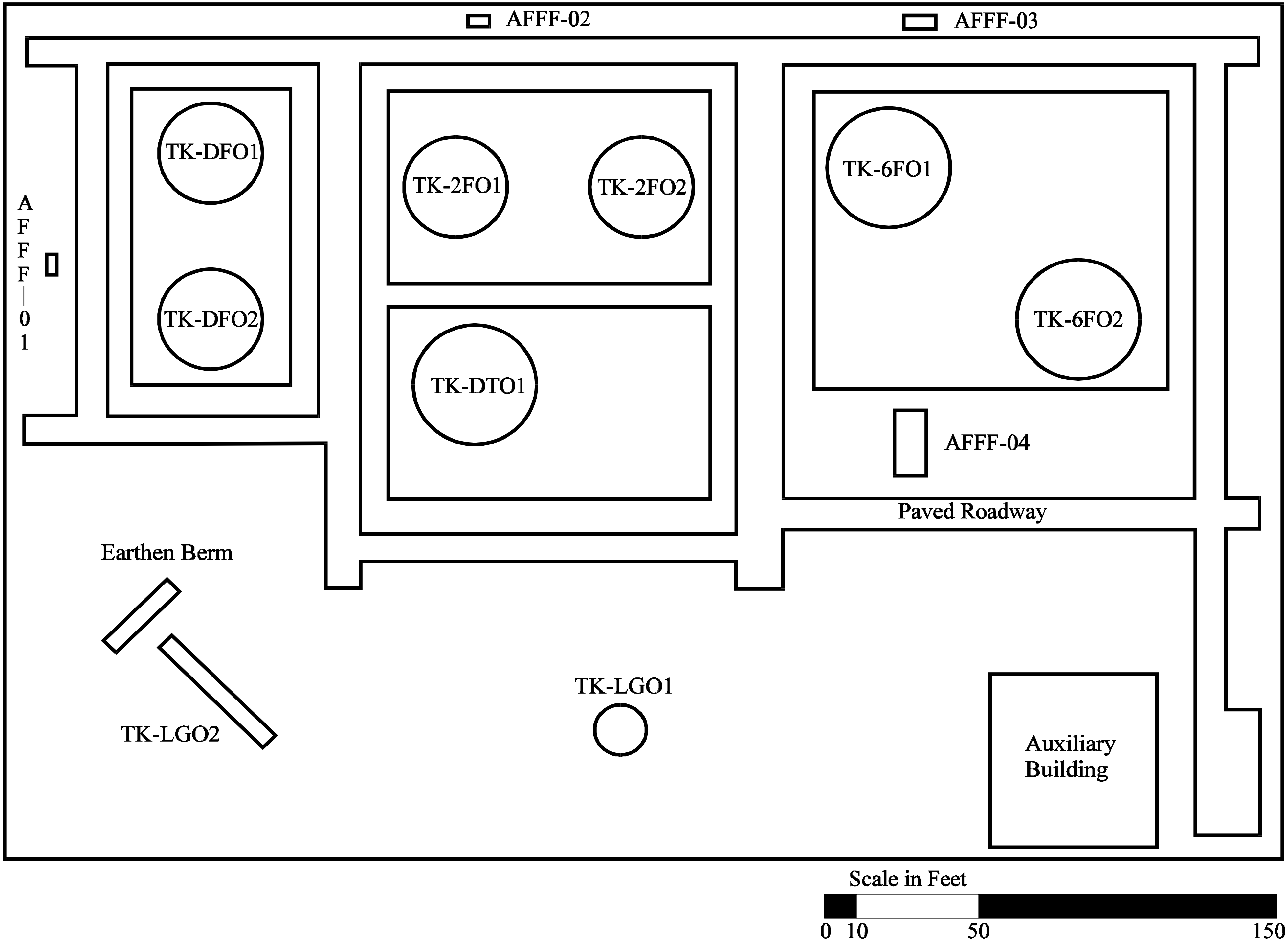
| AFFF-01 | Aqueous Film-Forming Foam Storage/Dispenser |
| AFFF-02 | Aqueous Film-Forming Foam Storage/Dispenser |
| AFFF-03 | Aqueous Film-Forming Foam Storage/Dispenser |
| AFFF-04 | Aqueous Film-Forming Foam Storage/Dispenser |
| TK-DFO1 | Diesel Fuel Oil Tank |
| TK-DFO2 | Diesel Fuel Oil Tank |
| TK-2FO1 | No. 2 Fuel Oil Tank |
| TK-2FO2 | No. 2 Fuel Oil Tank |
| TK-DTO1 | Common Dump Tank |
| TK-6FO1 | No. 6 Fuel Oil Tank |
| TK-6FO2 | No. 6 Fuel Oil Tank |
| TK-LGO1 | Propane Hortonsphere Tank |
| TK-LGO2 | Butane Bullet Tank |




# Figure 1 : Kanawha Valley Plot Plan