FIRE SUPPRESSION DESIGN

FOR FLOATING ROOK TANK APPLICATIONS

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The primary protection issue is the fire protection of Class-B external floating roof liquid storage tanks, specifically the adequate protection against potential fire hazards encountered in the rim seal area, and the equipment used to suppress potential fires caused in conjunction with this hazard area that meet the intent of fire safety requirements as prescribed by the Oil Industry Safety Directorate (OISD) and National Fire Protection Association Standards NFPA 30 and NFPA 11. ACAF Systems, Primary Flow Signal - Fire Suppression Group, LLC (ACAF Systems) provides a unique and effective combination of delivery equipment and fire suppression agent in one proven package. Due to the nature of the enhanced system design and the compressed air foam (CAF) agent formulation, the fire suppression equipment and design proposed do not directly comply with the prescriptive requirements of NFPA 30, NFPA 11 Standards for the floating roof tank rim seal.

Alternatively, NFPA does not restrict designs to purely singular or a set of prescribed systems of fire suppression. NFPA documents allow for the latitude in design and do recognize that there are always new technologies and arrangements to be considered that may potentially meet fire safety and protection requirements outside the direct scope as prescribed in the standards. To this end, NFPA 11, para 1.2.2 states "Nothing in this standard is intended to restrict new technologies or alternative arrangements, provided the level of safety prescribed by the standard is not lowered." Thus, allowing for the introduction of new technologies such as that developed by ACAF Systems.

NFPA DESIGN REQUIREMENTS

As specified in NFPA 30, Section 21.6.4, "Fire Control. Tank storage facilities for flammable and combustible liquids shall be reviewed to ensure that fire and explosion hazards resulting from lost containment of liquids are provided with corresponding fire prevention and emergency action plans. (See Section 6.3)" Section 6.3 states the following "Management of Fire and Explosion Hazards. This chapter shall apply to the management methodology used to identify, evaluate, and control the hazards involved in the processing and handling of flammable and combustible liquids. These hazards include, but are not limited to, preparation, separation, purification and change of state, energy content or composition."

On an international level, in compliance with Sections 6.3 and 6.4 (Hazard Analysis) and through the work of OISD, the hazards have been identified with regard to floating roof liquid storage tanks, specifically, the potential fire hazards within the rim seal area. In order to protect the rim seal area, in conjunction with NFPA 30, Section 6.7 (Fire Protection and Fire Suppression Systems) states "Where the need is indicated by the hazards of liquid processing, storage, or exposure as determined by Section 6.4, fixed fire protection shall be provided." Subsequently, Section 6.7.6 states "Where provided, fire control systems shall be designed and maintained in accordance with the following NFPA standards, as applicable: NFPA 11, NFPA 12, NFPA 12A, NFPA 13, NFPA 15, NFPA 16, NFPA 17, and NFPA 2001. In conjunction with the NFPA 30 reference prescribed above, NFPA 11 is the jurisdictional standard for design of foam systems for floating roof tank applications, specifically the rim seal applications, which are the concern being addressed. The current design requirements for this application are covered under NFPA 11. Section 5.3 (Outdoor Open-Top Floating Roof Tanks), specifically Section 5.3.4 (Methods of Seal Fire Protection). As specified in NFPA 11, Table 5.3.5.3.6.1, Below-the-Seal Fixed Foam Discharge Protection for Open-Top Floating Roof Tanks, specified that the minimum application rate shall be 0.50 gpm/ft^2 (20.4 L/min-m^2) with a minimum discharge time of 10 minutes. The application rate is based on based on low expansion foams combined with delivery equipment that has been utilized in the market for many years without significant technology upgrades.

PROPOSED ACAF SYSTEMS ALTERNATIVE DESIGN TO NFPA 11 REQUIREMENTS

ACAF Systems utilizes Solberg RF foam concentrate as the basis for the compressed air foam fire suppressant in conjunction with its new uniquely engineered delivery equipment. CAF is an homogenous foam produced by the combination of water, foam concentrate, and air or nitrogen under pressure. A unique fire fighting foam agent, CAF, extinguishes the fire by establishing a blanket of foam on the flammable liquid surface. The blanket creates separation of oxygen and heat from the burning fuel, extinguishing the fire and preventing re-flash. CAF's ability to reduce heat contributes to the effectiveness of this agent. CAF created with nitrogen provides an even more effective blanket for superior re-flash protection as the incorporation of nitrogen into the CAF mixture enhances the fire suppression capabilities due to its inherent nature as an inert gas. This combined with the unique, FM approved ACAF Systems delivery systems provide for a total package for effective fire suppression of Class B hydrocarbon and polar solvent liquid fires similar to those encountered in floating roof tank rim seal applications.

ACAF Systems' CAF fire suppression systems are pre-engineered, special hazard, fire suppression systems that deliver compressed air foam through a variety of delivery systems. The delivery system that pertains specifically to the rim seal applications is an automatic fixed pipe system of specially-designed nozzles. CAF is created by expanding a foam concentrate RF-3 (for hydrocarbon fuels) or alcohol-resistant AR-AFFF (for polar solvents) foam-water solutions. The expanded material is applied to the hazard area much the same as foam water systems are. CAF, however, has many distinct properties that need to be considered in the design and installation of a system. How the CAF is created and discharged is an important aspect of the design; as such, special nozzles are used to distribute the CAF over a hazard area. It extinguishes the fire threat through the following combination of processes:

1. Excludes air from the flammable vapors.
2. Eliminates vapor release from fuel surface.
3. Separates the flames from the fuel surface.
4. Cools the fuel surface and surrounding structural surfaces.

Hazards that CAF systems are permitted to protect include the following:

1. Flammable liquids (flash points below 38°C (100°F) having a vapor pressure not exceeding 276 KPa (40 psi).
2. Combustible liquids (flash point of 38°C (100°F) and above).

ACAF Systems are suitable for Class B hydrocarbon and polar solvents flammable liquids, storage and handling locations where the risk of spill and pool fires exist. Note, polar solvents are liquids that have high dielectric constants, are chemically active, and form coordinate covalent bonds; examples are alcohols and ketones - methanol, ethanol, propanol, formic acid, ethyl acetate, acetonitrile, etc.

The ACAF Systems rim seal systems components that have been proposed for protection are fully tested and evaluated and have received FM Approvals for the meeting and/or exceeding the requirements of extinguishing and suppressing hydrocarbon and polar solvent fires as prescribed. The system utilizes Solberg RE-HEALING Foam Concentrate in 6% concentration. When utilized with the unique CAF delivery equipment, the CAF is delivered to the fire at a 13 to 1 expansion ratio. With the receipt of FM Approvals, the equipment meets the requirement set forth in NFPA 11, under the

general requirements for System Components and System Types, Chapter 4, NFPA 11, para 4.1.1 "All components shall be listed for their intended use." As a note, NFPA defines listed as follows "Equipment, materials, or services in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products and services, that maintains periodic inspection of production of listed equipment, materials or periodic evaluation of services, and whose listing states that either the equipment material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose." FM is a recognized authority and leader in testing, evaluation, and approval of such products, materials, and services. It shall be noted that FM has no approval standard for rim seal protection systems.

Through the testing, evaluation, and approval process specified above, the systems have received approvals for use to extinguish Class B hydrocarbon and polar solvent fuel fires. Specific to the rim seal application, the systems are designed as a total flood foam extinguishing system with the ability to extinguish Class B hydrocarbon and polar solvent fuel fires with an application rate of 12.4 L/min-m^2 (0.3 gpm/ft^2), a rate of application that is seven times greater than the FM approved ROA for hydrocarbons. The variation from the NFPA 11 requirements is that the discharge will not continue for 10 minutes as required, it will completely discharge and entirely fill the rim seal void space in approximately 1.5 minutes, therefore not requiring the extended discharge. The design is intended to provide a total flood of the rim seal space this is due to the characteristics of the CAF specifically its 13 to 1 expansion ratio combined with its ability to hold 25% draintime for greater than 1.5 hours. The CAF will remain place in a stable state that will not break down significantly enough to allow reflash of the fire. The agent is of high integrity and will not break down. This has been proven through testing. These characteristics support the use of the compressed air foam as a total flooding extinguishing agent for this application and should support it approval for use above prescriptive requirements.

ACAF Systems has developed a design for installation of the CAF fire protection system that meets the parameters of NFPA 11 with a rate of application of 20.4 L/min-m^2 (0.50 gpm/ft^2). This, according to NFPA 11, is the recommended level of protection that will protect against the incident of the potential hydrocarbon and polar solvent fuel fires that may occur within the rim seal application on the floating roof liquid storage tanks. The delivery system combined with the CAF formulation has significantly increased the fire suppression capability of the foam system over the long used equipment of the past decades. The detection and alarm system will be cross-zoned and consist of approved, listed components per requirements of NFPA standards. Also of note, that with the achievement of gaining FM Approvals, the systems have also met or exceeded the requirements of UL 162, UL Standard for Safety of Foam Equipment and Liquid Concentrates.

OISD REVIEW AND APPROVAL

As previously stated, under the parameters of NFPA 11, para 1.2.2, an authority having jurisdiction, in this case OISD, has the option after review and evaluation, to provide approval based on the facts presented, to approve the use of ACAF Systems CAF systems to protect the rim seal area of floating roof liquid storage tanks against Class B hydrocarbon fuel and polar solvent based fires. ACAF Systems submitted schematic design and performance data to OISD for review and approval use in rim seal fire suppression applications. OISD performed a comprehensive review of the submission, and upon completion of final qualification testing may grant final approvals for ACAF Systems' design with regard to floating tank rim seal applications.

PERFORMANCE SUMMARY

In conclusion, ACAF Systems rim seal fire suppression provides the following advantages over older more dated technologies:

- Utilizes an environmentally-safe foam that is fluorine free
- Significantly increased expansion ratio than currently used foams, on the order of 13 to 1
- Due to the internal structure of the CAF, there is greater reflash protection
- The CAF provides total flooding characteristics to fill the rim seal space completely
- Greater drain time, which equates to slower breakdown and longer lasting foam
- Reduced hardware requirements
- Centralized control equipment translating into greater reliability and reduced life cycle costs
- All control valves, solution levels, and nitrogen pressure are monitored to minimize failure modes and maintain optimal performance condition
- Electric / pneumatic release systems
- Manufactured and installed with stainless steel piping systems for longer service life