STORAGE TANK FIREFIGHTING

EARLY WARNING LINEAR HEAT DETECTION SYSTEMS

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Today's social and economic market make it more important than ever for petrochemical and refinery operations to be prepared to effectively cope with a large-area hydrocarbon fire. Such events, while costly in financial terms, also extract a very heavy burden in terms of public image. Following each of these disasters is generally a barrage of media coverage and public pressure to increase regulatory pressure on the petrochemical industry. No longer can we rely on the fire protection methodologies that have guided the industry in the past. Obviously, they have served the industry well during times of industry prosperity and low public awareness, but they no longer provide the margin of safety required today.

In view of the relatively low frequency of large-area tank fires, the industry still has not been able to maintain the momentum needed to accept existing technology or develop and refine new techniques and methods for rapid detection and suppression of fires in storage tank facilities. Recent surveys conducted by the American Petroleum Institute, Committee on Safety and Fire Protection, indicate the success rate for extinguishing rim-seal fires is relatively good, however, the success rate for handling fully involved tanks is not nearly so positive. It is understandable that a growing number of fire safety professionals within the fire protection community have concerns about the ability to successfully extinguish a fully involved 350 foot or larger tank.

While a number of scenarios are used to claim a successful extinguishment, the measure of success follows that the fire must be extinguished with significant quantity of product remaining in the tank, not bottom solids or wastes, that the fire should be extinguished within one hour of beginning a foam attack, and that the value of the product saved must be greater than the cost of the agent used for extinguishment plus the cost of the tank. Emerging early warning detection technologies will require the true measure of success as the ability to prevent the large tank fire from occurring.

In an uncertain future of a changing industry, refiners will be faced with the challenge of producing new generations of gasolines. In addition to normal refinery inventories, the Oxygenated Fuels Program will require refiners to blend over 300,000 barrels per day of oxygenate into gasoline, a level far exceeding current U.S. production capability. As a result, substantial volumes of gasoline blending components, primarily MTBE, will be drawn during a period when gasoline inventories have traditionally increased. Coincident with new productions, larger storage areas will be required that can no longer be effectively protected by conventional techniques. With crude oil storage tanks being built larger every day, the need to prepare to handle fires is more crucial than ever. It's no wonder that a recent survey of petroleum industry executives showed that they have major problems
revolving around environmental issues, negative publicity, pollution control, and severe financial loss resulting from the incidents of tank fires.

Fires in Floating Roof Tanks

The foremost cause of floating roof rim fires is lightning. However, few, if any floating roof rim fires are the result of direct lightning strikes. Most, if not all lightning ignited rim fires result from induced charges on the roof, which in the immediate vicinity of the thunderstorm, may reach a potential gradient immediately after a flash comparable to the appearance of a direct hit. Recent surveys have indicated that lightning ignited rim fires have increased with changes in design. Design changes required as tank capacity grows larger have reduced the number and capacity of direct contacts between the roof and shell of the tank above the roofs or contained seal and projections and cross wires above the roof connecting the roof contacting the shell of the tank. However, the most feasible method of preventing ignitions appears to be the establishment of contacts between the roof and shell above the gas tight seal. The ease with which rim seal fires can be effectively extinguished is dependent upon the attack of the fire before large sections, or all of the seal has burned out. Installation of an early warning heat detection system in the seal area has proven advantageous in preventing seal fires from spreading.

For years after the advent of the floating roof, few fires were reported in tanks from lightning ignition. In recent years quite a few floating roof rim fires have been caused by lightning. It might be assumed that the reason for this is the increased number of floating roofs. However, the proportionate number of lightning ignited fires is several times greater in recent years than formerly. To arrive at the real reason, the phenomena of lightning must be applied to the design and construction of early floating roofs and those of recent years.

A study of earlier constructed floating roofs reveal that there were more hangers, and these hangers were above the seal. Most of the roofs had a network of pipes and projections from the roof, and many had wire connections extending from these pipes to hangers. Experience indicates that even where roof hangers are above the seal, they--together with the ladder--are not enough to provide a sufficient area of connection at the right places to prevent all fires. Also, grounding of the tank itself will not greatly influence the number of lightning ignitions of these tanks. Lightning ignited rim fires in floating roofs have increased with larger diameter tanks being built and with the reduction in the number and capacity of direct contact between roof and shell.

When rim fires began to increase as sizes became larger, it was felt that extensive grounding of the tank and providing bond wires from the roof to shell would solve the problem. Neither of these had any noticeable effect on the number of ignitions. No doubt, if the seal itself was of effective conductive material, the lightning ignitions would be reduced if the seal was kept in good repair. No material has been found to build seals that have as small a resistance as metals, therefore there exists sufficient resistance in the seal to cause it to be ripped open.
Linear Heat Detection Technology

The challenge of any fire detection system is to catch overheat before it leads to a fire, or at the very least, to pinpoint small, localized fires before they have a chance to spread. To meet this challenge requires more complete protection than is available with conventional detection methods. Heat detection remains the most pervasive detection technology in use due to the rapid thermal response times, superior reliability, low cost, and simplicity of its operation.

The means of thermal detection is typically inherent in the materials of which the detector is constructed. There is relatively little that can go wrong with melting a piece of alloy metal or heat sensitive material. The simplicity of thermal detectors also translates to a lower cost, which becomes an important factor in the overall design of a system. Since fire produces heat, thermal detection is a consistently valid method of detecting the fire in its early stages.

The distinct advantage of linear heat detection technology is the ability to place the detector in direct contact with or in close proximity to the area or equipment being protected. It is this application flexibility that makes linear heat detection so desirable. To maximize the speed of the heat sensing detection, one must maximize the transfer of heat from the source to the sensor. Many classes of eventual fires may be detected long before the incipient stages of the fire takes place.

Linear heat detection systems have been in use throughout industry over 50 years as a primary means of early detection in high risk industrial areas such as cable trays, coal conveyors, cooling towers, and many other associated properties. Only recently has this technology seen a growing interest for applications in large floating roof storage tanks for the detection of rim seal fires. Ideally suited for applications in environments requiring a high aromatic hydrocarbon resistance, linear heat detection enables the detection loop to be placed within the seal area for optimum response to the early stages of overheat and fire caused by lightning ignition.

Intrinsically Safe Circuit Design

Coping with electrical hazards in a hydrocarbon processing facility is largely a matter of compliance with codes and standards. Safe electrical equipment, practices, and installations are governed by complex sets of recommended procedures and principles. Unfortunately, these are not consistent among countries, and are not even uniform within the U.S. because of different philosophies of the various certifying and approval agencies. The result has been a certain reluctance at the processing plant to become involved in a morass of regulation. However, from the system design point of view, the generally accepted approach to electrical safety in hazardous areas is that prescribed by the internationally recognized
official governing body, the International Electrotechnical Commission (IEC), and the European Committee for Electrotechnical Standardization (CENELEC).

The need for intrinsic safety is born of the fact that electronic analog and digital transmission instrumentation is becoming increasingly popular in the hydrocarbon processing facility due to advanced signal transmission and processing capability relative to earlier types of pneumatic equipment.

Many processing applications involve flammable or explosive atmospheres. If electronic monitoring devices are to be used in these areas, precautions are necessary to prevent ignition due to associated electrical or thermal energy. Intrinsic safety is a technique for preventing explosions in hazardous areas by limiting the electrical energy available in circuits and equipment to levels that are too low to ignite the most easily ignitable mixtures of gas and air that is ever likely to be present.

Two ignition mechanisms are taken into account, namely, electrical sparks and electrically heated surfaces. The "gas" can include other flammable materials such as dust, fibers, and flyings. The circuits and equipment are designed so the safety is maintained both in normal use and under all probable fault conditions. Intrinsic safety is essentially a low power technique, restricted in practice to about 1 watt in hydrogen atmospheres, and therefore well suited to industrial instrumentation. Of major concern for typical hydrocarbon facilities, particularly in oil or fuel storage areas is that equipment must operate safely in a hazard classification of Class 1, Division 2, Group D which covers the majority of flammables that the instrument engineer is concerned with.

Besides the ignitability of the gas and the probability of its being present, it is necessary to consider the question of energy storage in hazardous-area cables and associated equipment. Clearly there is no point in limiting the transmitted voltages and currents of instrumentation if they can be stored up in capacitors and inductors over a period of time and then released in a burst of greater magnitude. This probability must either be eliminated by design or quantified and allowed for.

The capacitance and inductance of long interface cables from the control system to the monitoring devices will store a certain amount of electrical energy in normal operation and even more under fault conditions. There is no simple way in which this can be suppressed, so the specifications for the interface always stipulates the maximum values of capacitance and inductance that are permitted for the associated cables. These "cable parameters" depend on the ignitability of the gas but, in practice, they seldom constitute a limitation, even when the gas is hydrogen.

The rules of thumb then for the determination of acceptable limits for intrinsically safe wiring is that all instrument cables, including feed cables, long lengths of interface cables, and cables in the area of detection, have values less than capacitance of 200 picofarads/meter; inductances of 1 microhenry/meter; and L/R ratios of less than 25 microhenries/meter. The most important of these parameters, capacitance, must not exceed a total value of 1.2 microfarads for the total length of the monitoring loop. These
maximum cable parameters simplify the problem considerably and provide an adequate solution to all but the most complex problems, particularly when designing floating roof storage tank fire detection systems that may be considerable distances from the control facility.

The ideal application of linear heat detection cable is within the rim-seal area of the entire circumference. Placed in the vapor space, the detector remains in the optimum location for detecting overheat and fire caused by lightning ignition. The type of seal used determines the location of the detector, be it tube seal, foam log, or mechanical shoe seals. In earlier floating roof tanks, mechanical shoes or pantograph hangers were incorporated under a flexible weather seal between the roof and shell area. It is virtually impossible to remove the seal to place the detector in the vapor space, so it is mounted on the top surface of the seal externally.

Newer types of seals generally have a secondary weather seal, or double flex-a-seal combined primary and secondary seal systems, which may be pulled back to allow the detector placement on the tube seal or foam log directly. While numerous mounting clips and attaching hardware is available, in all cases, stainless steel must be used to deter the adverse effects of corrosion. Linear heat detection cable is installed around the entire circumference of the tank, with beginning and end of loop terminations being made in heavy duty NEMA-4X fiberglass junction boxes.

Careful regard should be given to the method of connecting the roof mounted junction box to a similar box in vertical alignment above on the tank shell. Preferably, junction box mounting should be at the gaugers platform to facilitate installation or service.

A number of methods have been incorporated to allow the interconnecting cable from the stationary shell top box to the movable roof box. Generally, a 24" diameter soil pipe, 36" high is cemented on the roof area to allow the suspended cable from the box above to collect the wire as the roof moves upward to a full tank. The same function may be accomplished by installing a flexible, heavy duty cord between the top box and roof box to maintain to taut connection.

**Control Systems**

The monitoring control system for linear heat detection systems is configured to accept the maximum number of tanks required for detection of overheat as well as solenoid releasing circuits for directional valves, water inlet valves, foam concentrate valves, tamper supervisory switches, and remote annunciation.

When configuring control panels, careful attention must be considered to the maximum allowable loop resistance factor that the input zone of the panel will accept. Calculations must be made of the entire monitoring loop with detail given to the resistance of the line detector, interface cables, and long interface cables. Since conventional fire alarm control panels are not manufactured with extended loop resistance availability, the criteria for configuring control panels must be those which are listed and approved by known agencies.
for the intended use as a complete system, preferable from a single manufacture. Individual internal components of the control panel such as diode barriers, releasing circuits, control logic must be listed and approved as an entity so as not to compromise the integrity of the complete working system. Larger systems in use with multiple tanks to control could be located at distances that may require multiplexing remote information to the control room. In such installations, local control panels are installed in valve pit areas controlling specific sections of the system and information transmitted over data loops from local transponders to master controls and annunciators.

In view of varying demands for monitoring tanks for overheat, there has evolved three stages of systems that are currently in use. A Stage One type system allows for detection of overheat and general annunciation to control facilities only. This type of system requires personnel to manually activate yard valves for agent flow. While critical time may elapse to release agent, the system as a minimum at least provides the capability of early warning heat detection. Stage Two systems are configured for both detection and release of agent to the respective alarming tank. Upon initial alarm the system simultaneously activates the tank directional valve, water inlet valve, and foam concentrate valve for immediate delivery. Subsequent alarms from other tanks will require manual release from the control panel since the automatic function has already been activated. Stage Two systems offer the advantage of selectively releasing agent to any tank that may be in danger of igniting from adjacent conflagrations. Stage Three systems combine the functions of automatic and manual operation for any combination of tanks such that a more precise control is provided over the entire system.

In summary, over the last few years, many hydrocarbon processing facilities have undergone major changes in how they operate their plants and equipment. Market changes and demands, and environmental and safety concerns have materially influenced how these facilities will operate in the future. Additional constraints on resources and manpower have shifted the emphasis towards new demands and standards for products and services. Reliable and safe operations are high on the list of objectives. The impact of environmental issues surrounding burning, uncontrolled tank fires alone has created deep public apprehension. The overall financial loss with regard to a lost tank is obviously immense in comparison to the cost of an early warning detection system for rim seal fire detection. The return investment will be surprisingly high.