# Wrestling with Fire Safety

By Khusro Khan

The 375-degree deep-fat fryer seemed to explode into a blazing ball of fire, engulfing the poultry processing plant in flames. Employees inside the windowless, one-story brick building tried desperately to pry open the locked doors or find shelter in the ice freezers as the blaze raged on. Witnesses outside that day would later recall hearing the horrific screams of those trapped inside.

When the last embers were extinguished and the black smoke cleared, 25 people had died and almost 60 were injured in one of the worst industrial accidents in United States history. The building's owner, Imperial Food Products Inc., went out of business and the charred, abandoned building was eventually demolished. Today on that site in Hamlet, N.C., sits a memorial park and twin monuments that detail the tragedy that unfolded on the morning of Sept. 3, 1991.

An investigation later determined that hydraulic fluid — expelled under pressure from a burst hydraulic line connector — had spattered into the open burners of the 26-foot-long fryer. The heated fluid vaporized, flashed and triggered the conflagration. An estimated 50 to 55 gallons of hydraulic fluid sprayed from the ruptured hose, fueling the spread of the fire.

Sixteen years later, the Hamlet fire still serves as a cautionary tale of the inherent dangers in some industrial work environments — and the measures that should be taken to ensure fire safety. Among those measures, say advocates, are tough standards for fire-safe hydraulic fluids.

## Setting the Standard

"If a fluid fails, we want it to fail in the lab, not with the end user," asserts Rich Ferron, group manager at FM Approvals, a Norwood, Mass.-based third-party certification program that sets the test protocols for industrial and commercial loss-prevention products. FM Approvals

*Ruins of a factory fire*

is part of FM Global (formerly Factory Mutual), the world's largest commercial and industrial property insurance organization, according to Ferron.

"FM Approvals tests industrial fluids for flammability properties to assure end users that during a spray-fire incident, the fluids will have a minimal contribution to the fire, thus reducing the potential size of a loss," says Ferron. Its certification program tests and approves a variety of fire-protection products, building materials and electrical equipment and services that best prevent property loss. It assures that all products or services have been objectively tested and conform to strict national and international standards.

FM Approvals says it periodically reviews the standard to determine if the latest science and methods are being used, so that property loss-prevention products are held to the highest standards.

The latest edition, issued February 2002, of FM Approvals Standard 6930, "Flammability Classification of Industrial Fluids," incorporates newer technology that produces more accurate and repeatable results, Ferron says. This revision addressed fluids that do not exhibit fire points, and the calculation method also was modified, he said.

Collectively, the standard mandates nine tests for fire-safe hydraulic fluids, beginning with flash and fire point tests to determine at what temperature those points exist. Spray fire tests determine the chemical heat release of an industrial fluid — how hot and long it burns. The heat of combustion, determination of water content, fluid density and elemental analysis — used to determine the flame temperature of the industrial fluid concentrate — are also determined and used in calculations.

Research chemist Eric Burkhardt at Supresta, a maker of phosphate ester hydraulic fluids in Ardsley, N.Y., describes how the spray flammability test used

 

to be performed: In the old test, a container of fluid was warmed up to a specific temperature and pressurized. The container would be opened up to release an aerosol of the lubricant — mimicking a line rupture in a hydraulic line — through which the flame from a torch would be allowed to pass. The test would evaluate whether or not the lubricant aerosol would ignite, and if so, whether the material would continue to burn after the torch flame was removed. "Essentially, you would have a pass/fail result," Burkhardt says.

By contrast, the current method rates the fluid using calorimetric measurements. "FM's current test procedure determines the 'Chemical Heat Release' of a fluid," points out Peter Skoog, technical manager of fluid power products at Quaker Chemical Corp. in Conshohocken, Pa. "Fluids are sprayed vertically through a high-kilowatt, gas-fired ring burner and the fire products are collected. Using this data, as well as the weight of the fluid burned along with a couple of constants, a mathematical formula is used to arrive at a Spray Flammability Parameter, or SFP." The lower the SFP value, the better.

"In short," he adds, "FM has created a test that will make all fluids burn. The lower the heat release, the safer the fluid in their eyes."

Candidate fluids now are classed by their SFP in one of three groups:

- The top tier, Group 0 products, are considered non-flammable.
- Group 1 products are generally unable to stabilize a spray flame, and may call themselves "less flammable" than mineral oil fluids.
- Group 2 products also earn the rating "less flammable" than mineral oil fluids, but may stabilize a spray flame under certain conditions.

After a product has been certified with the FM Approval stamp, it is audited annually to ensure that the product still retains its integrity when it was originally evaluated. It also can be labeled with FM's logo, signaling to customers that it earned the thumbs-up.

## Sacrificing for Safety?

Hydraulics are at the heart of most industrial machinery, transferring energy through the flow of fluid and signaling parts to move. Over 200 million gallons of industrial hydraulic fluid are sold annually in the United States, according to the National Petrochemical & Refiners Association.

When the focus turns to fire safety, manufacturers primarily use synthetic fluids — polyalkylene glycols, phosphate esters, polyol esters and water glycols — as opposed to easy-to-burn mineral oils. Some synthetics are mixed with high volumes of water to impart their flame resistance.

Because of their expense, the fluids are used mainly where fire safety is top priority, for example, in electrical power plants, offshore drilling platforms, underground mining equipment, refining operations. However, the emphasis on fire prevention also brings into question whether other important elements are sacrificed, such as oxidative stability, lubricity, rust control, and ability to withstand high pressures.

At Houghton International, fluid power research and development manager Rich Adams says, "Water glycols provide the best fire-resistant protection, and in most cases compare to an anhydrous FR fluid. Water does not burn or initiate an explosion in most situations."

But water is not the greatest lubricant, he notes, so the hydraulic pump's bearing life consequently can be shortened. Recent improvements in pump designs and in metallurgy by some OEMs have provided pumps that can operate at higher pressures with a premium water glycol fluid.

Valley Forge, Pa.-based Houghton also offers phosphate ester chemistries. While these provide adequate lubrication, the hydrolytic and oxidation stability of many ester products including fatty acid esters are going to be inferior to most mineral oil hydraulic fluids, Adams observes.

Skoog at Quaker Chemical, which makes fluids based on polyol esters, says that "depending on the technology used to obtain fire resistance, there might be some compromises in performance. Because water is not a strong film-forming component in a lubricant formulation, water glycol fluids tend to have their operating pressure maximums reduced. Phosphate esters are excellent lubricants but their high specific gravity can cause problems at the pump inlet and in waste treatment. PAGs have shown themselves to be good lubricants, but are not cost effective. Polyol esters are excellent lubricants and, when formulated properly, will perform as well as mineral oil in lubrication and pump testing."

However, Supresta's Burkhardt insists that — when it comes to fire safety — the chemistry of the fluid must match its end use. "The choice of what type of hydraulic fluid to use is determined by the particular application for the fluid and also whether fire resistance is required due to exposure, or potential exposure, to high temperatures or ignition sources where a lubricant fire could lead to catastrophic loss of life or equipment. Water glycols and phosphate esters are not typically used in the same types of applications. Phosphate esters exhibit superior fire properties over all non-aqueous fluids because they are self-extinguishing."

D.A. Stuart Co. market manager David Lindsay's experience has taught him that "fire-resistant hydraulic fluids require the same dedicated service that all hydraulic fluid systems should receive. Some systems, however, may expose the hydraulic fluid to localized high temperatures, conditions that will stress the fluid. Hydraulic fluids that rely on water content to impart fire resistance have the added test requirements for water content, and are typically used in systems with de-rated pumps."

Based in Warrenville, Ill., his company produces and markets water glycol fluids. "Formulating any product requires balance that is often difficult to achieve," says Lindsay. "There are minimum performance requirements for hydraulic fluids that cannot be compromised however. A simple example would be maintaining viscosity grade while incorporating additives to ensure oxidative stability."

In Midland, Mich., Dow Chemical pro-

 

duces PAG based fluid concentrates, that are then sold to formulators for dilution with water. According to Dow, both water glycols and phosphate esters offer excellent fire-resistant properties, but each has its limitations. Water glycols should not be used in high-pressure hydraulic equipment operating at temperatures above 150 F, the company advises. Phosphate esters can have seal compatibility challenges and have only moderate thermo-oxidative stability and viscosity indices. And in industrial equipment, extreme care needs to be taken in monitoring acidic degradation by-products of phosphate esters, which can lead to corrosion challenges.

### Not on the Same Page

Regardless of their chemical composition or end-use, all fire-safe fluid manufacturers — like it or not — must be certified through FM Approvals before their product can gain acceptance in the market.

"I think the work of Factory Mutual over the last several years has created a level playing field for formulating chemists, resulting in positive improvements in products and their safety rating," Lindsay comments. "[They] have also created new testing and approval regimes for water-based fire-resistant fluids that overcame the serious flaws that existed in previous tests."

Dow's marketing manager Peter Pendergast agrees. "While it has required us to conduct additional testing which increases the cost to manufacture our products, we have had no issues with compliance to the new testing or standards. It hasn't had any significant impact on our business. In fact," he adds, "it actually helps us in preventing others from 'piggy backing' on our approvals."

"Products that meet FM Approvals' standards prove that they have outlasted the most rigorous testing and worst-case scenarios, and in the end, maintain their integrity," says FM's Approvals' Ferron. "The FM Approvals mark is the product differentiator." But not all in the fluid power industry are in agreement.

"We are concerned that recent changes in the FM tests may not provide the user with an indication of the relative fire-protection properties of the different fluids," says Supresta's Burkhardt. "FM changed their criteria to grant approval to any fluid which exhibits more fire-resistance than mineral oil. As a result, fluids that continue to burn — once ignited — are included in the FM Approvals list along with superior fire-resistant water-containing or self-extinguishing fluids."

Quaker Chemical's Skoog concurs: "I am not a fan of the current FM [spray] test procedure. Because the fire point of the fluid figures so prominently in the approval, as opposed to the old spray flammability tests which modeled real workplace occurrences, it is possible to have a product that is less safe in the workplace under the current guidelines. I've always had an issue with the current test protocol, as have many in the fluid power industry.

"The test is the test, however, and we must meet the current FM specification to have an approved fluid." ▮

 