compared to no deaths in the case of pressure-extraction plant fires.

Attention is invited especially to the fact that, of the 47 accidents listed in Tables I and II, only 14 of these plant fires involved solvent whereas 33 did not involve the use of solvent in any way. Thus the handwriting on the wall is sufficiently plain that the management of the plants in the oil and fat industry should bestir themselves to greater awareness of and effort in combatting the fire hazard that permeates the entire industry, including pressure-extraction plants and storage and handling plants for both raw and finished products as well as solvent-extraction plants.

By way of criticizing the foregoing, one could point out that the solvent-extraction plants are newer, better designed, and more carefully protected from a fire-hazard standpoint than the older pressure-extraction plants and the storage and handling plants, thereby enabling them to show a comparatively better safety record even though the fire and explosion hazards are greater. It could be mentioned that there are more fires in these latter plants than in the solvent extraction plants because there are more of them. Likewise it might be explained that the accidents listed in Tables I and II do not cover all of the accidents, especially the numerous small fires, and if they did, solvent-extraction plants might not compare so favorably with the nonsolvent plants. But regardless of what explanations may be made or how detailed the analysis, the fact still remains that the data in Tables I and II are sufficient to show that solvent extraction is not the only culprit from a fire hazard standpoint. Dust has been a contributing if not the causative factor in several extraction-plant fires or explosions that have been attributed to solvent. Insurance firms and fire officials should not exuberantly apply rules and regulations for the construction and operation of solvent-extraction plants which increase costs unless the rules and regulations definitely make a tangible contribution from a safety standpoint.

For example, a number of insurance firms and fire officials make a fetish of requiring underground installation of solvent tanks and piping—a procedure that is more expensive from a first-cost standpoint and decidedly more treacherous and expensive from a trouble-shooting standpoint. It is debatable whether underground installations are safer than those above ground. Many chemical engineers and other technicians skilled in general plant-operations and related safety matters prefer the above-ground type of installation of tanks and piping from a fire-hazard standpoint (Figure 1). But regardless of what theoretical or other arguments might be advanced for requiring underground installation of tanks and piping, one certainly is entitled to question their scientific accuracy or justification when the newspaper (1) reports:

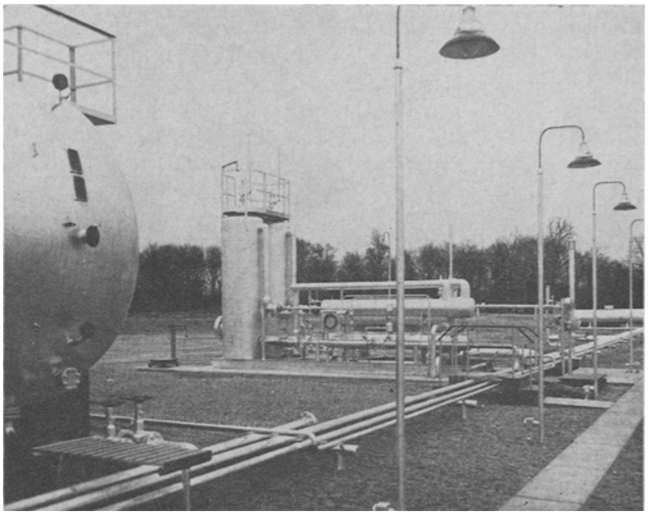

FIG. 1. Typical above-ground installation of tanks and piping.

> after weeks of living with a dangerously combustible situation, employees in a large office building are beginning to breathe normally since the baffling gasoline mystery has been solved after the building owners' expenditure of about $14,000 to eliminate extensive gasoline seepage into the basement. Apparently there is a submerged creek system in parts of downtown Kansas City, and this permitted movement of thousands of gallons of gasoline from defective underground storage tanks several blocks from the office building into which it was seeping.

Numerous other cases could be cited of fires, threats of fires, and other troubles that were traceable to underground storage and piping and largely would have been eliminated if the above-ground type of installation had been made.

In conclusion, everyone should be aware of the fact that safety permeates all manufacturing operations and that management, technical personnel, and operating engineers should recognize that other phases of their operations, as well as the solvent extraction process, deserve more careful consideration from a fire-hazard standpoint.

REFERENCE

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Foam Protection for Solvent-Extraction Plants

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ANY EXTRACTION PLANT using hexane or some solvent similar in nature lives with the always-present possibility of fire which, in some cases, may be accompanied by more or less severe pressure waves. That the industry has experienced no greater number of fires than it has is a tribute to the care and watchfulness of all who are concerned with the operation of the plants. The lives and well-being of the men employed in the plants depend upon the continued efforts of all. Property can be insured and the plant that has been destroyed can be rebuilt, but there is no way to call back to life the man who has died in the fire that destroyed the plant. We can only bend every effort to keep him alive. The men who work in solvent plants have reason to be grateful to top management for willingness to make substantial investments to contribute to safety in the plants and for willingness to close down plants when conditions call for shutdowns to insure safe operating conditions even at sometimes heavy costs.

The fire may originate in either of two general areas. It may start in some piece of processing equipment, or it may begin in some part of the surrounding area. The history of our industry is that most of the fires and by far most of the property losses and injuries to personnel have been the result of fires that that took place outside the processing vessels. This discussion will therefore be concerned only with fire in the extraction plant, outside of the processing equipment.

We all know that in order to start a solvent fire we must have two conditions present at one and the same time. We must have a space that contains solvent vapor in concentration that falls within the limits of flammability, and we must have concurrently within the same space a spot at elevated temperature. This spot can be the result of a very large number of things. To name but a few, electrical sparks or arcs caused by static potentials, voltages induced by lightning, arcs caused by the careless or uninformed fellow who grounded his electric welding machine to a pipe perhaps half a mile away, mechanical sparks, smoldering oil-soaked insulation, and so on. It follows that if we can keep the solvent confined to its designed containers, we can have no fire in the space which we mention. Likewise, if we can keep every ignition source out of the space, we can have no fire. Note that this space of which we speak can, under certain conditions, extend for a surprisingly long distance, possibly for as far as half a mile. Our first line of defence is set up by the two required conditions for fire. Keep the solvent where it belongs and keep ignition sources away.

Ideally no more than the above is required for complete safety. Practically the solvent does sometimes get out of bounds, and mishaps do occur that could ignite the solvent vapor if present in the right concentration. Probably some persons have waded in liquid solvent or in visible layers of solvent waste-high. They may have been wet to the skin with liquid solvent, and certainly many have breathed in enough solvent vapor to be thoroughly intoxicated. Probably the same ones have been present when something happened that would certainly have ignited vapor had there been any there to ignite. Most of us who have seen the two requisites for fire are most happy to be alive to say that we did not see both of the fire requirements at the same time.

These two essential elements for fire have one thing in common with a plain old crap game. Roll the dice a sufficient number of times, and snake eyes will jump up. You lose. Spill solvent enough times and have ignition spots enough times, and it becomes a mathematical certainty that the two will get together, and again you lose. The results will make newspaper headlines.

Accepting the fact that solvent will get loose now and then, it would be desirable to have as little in the extraction area as possible and to get the spilled solvent out of the extraction area to some safe place as speedily as possible. Some plants drain any spilled solvent to a holding pit located out of the extraction area where the chance that it will become ignited is as remote as possible. The quantity of fuel within the extraction area might be minimized by locating certain containers in or above this holding pit. For example, the water-separator tank might be located above the holding pit, and the amount of solvent in it would not provide fuel for a fire in the extraction area.

In most of the fires which the industry has experienced, the fire was extinguished only when there was no available fuel remaining to be burned. Obviously, if it is not possible to extinguish the fire, then the smaller the volume of fuel, the shorter the duration of the fire.

Once solvent has been spilled into the extraction area, it is desirable to keep it in liquid phase insofar as possible and to remove and dissipate any vapor as speedily as possible. In some plants natural means have been relied upon for the dissipation and removal of solvent vapors. It is interesting to note that most of the fires in such plants have taken place at times when there was no perceptible wind.

The Minneapolis Fire Prevention Bureau desires to have the extraction building purged continuously at the rate of 20 changes of atmosphere per hour. Our first reaction to this idea was that it represented an unreasonably high rate. The longer we thought about it, the more logical the idea seemed to be. Twenty changes per hour may amount to 50,000 CFM or more, and a huge solvent spill would be required to maintain a vapor concentration equal to the lower limit of flammability for a very long period of time. Depending upon the efficiency of design, the solvent vapor would be very rapidly diluted and the space occupied by vapor of flammable concentration would be very limited. Limited hazardous space and shortened hazardous time both tend to reduce the chance of fire.

The vaporizing of spilled liquid solvent can be reduced or terminated by either of two methods. Previously mentioned has been the idea of draining it out of the extraction area, and the drainage might be hastened by flushing with water. A second method utilizes foam. Foam can be released to cover the solvent that has been spilled and will effectively terminate the vaporizing of any solvent that can be covered. While foam cannot deal with every condition that can arise, it can substantially reduce the quantity of fuel available to support fire; it can effectively reduce the space occupied by vapor, and it can effectively reduce the time interval during which vapor is present. Each of these reductions lessens the chance for fire to break out, and will tend to decrease both the intensity and duration of the fire if it does take place.

To prevent the fire is much to be preferred over extinguishing or, as with most solvent-plant fires, allowing the fire to consume all of the available fuel. While we try in every way we can to prevent the outbreak of fire, we do have to consider that sometime we may actually have an extraction-plant fire. If we have a fire, we would certainly want to extinguish it just as quickly as possible. To put out the fire something more than plain water will be needed.

We have been privileged to see the results of several extraction-plant fires. Some of the completely destroyed plants were supposedly protected by automatic sprinkler systems, fog systems, or deluge systems. One thing has stood out like a sore thumb. The plants were completely destroyed, and in some cases lives were lost. The water systems by whatever name were distinguished by their failures and not by their successes. When anything has failed as conspicuously as sprinkler systems in extraction plants, it is high time to look for something better. That something better may be automatic foam protection. There is at least the promise that foam can put out the fire, and the same thing cannot be accurately said about untreated water in connection with a solvent fire.

In the event that we have not been able to extinguish the fire by whatever means might be available, then we would certainly want to try to control it and to limit the intensity. We would like to have as little solvent in the extraction area as possible. While water is completely ineffective in the primary purpose of extinguishing the fire, it can be used to limit the intensity, to keep things cool, and possibly to avoid the dumping of additional quantities of fuel through failure of structural supports, rupturing vessels, and so on.

Some thought must be given to the disposition of the water used in deluge systems. The water is likely to carry considerable quantities of solvent along with it, and this water needs to be held in some spot where burning solvent will do no damage.

Usually automatic foam extinguishing is combined with water deluge. One practical reason is that insurance companies tend to give no credit on premium for foam which will extinguish a solvent fire but will give credit on premium for water deluge which will not extinguish a solvent fire. Foam can be used to put out the fire while water deluge can be used to get the reduction on the premium.

THE NORMAL combined system applies foam while the supply lasts. The supply may continue for 10 to 20 minutes, at the conclusion of which time a foam blanket, possibly some two feet thick, will have been built up on all horizontal surfaces where it is not free to flow away. Depending upon the nature of the foam, some blanket may be present on vertical or inclined surfaces. When the foam supply has been exhausted, the same nozzles which have applied the foam will provide water. Naturally, if the fire has been smothered out before the foam supply is exhausted, there will be no need to throw on the tons of water by the deluge system.

The automatic application of foam can be actuated either by automatic vapor detectors or by rate of temperature-rise elements. Ideally both would be provided, and the provision of both means is not expensive. If the vapor detectors are well located, a solvent spill of any kind will be detected within seconds and the foam immediately applied. With an adequate purging system the interval of time during which the hazardous conditions exist will be very short. The space occupied by vapor in flammable concentration will be severely limited, and the chance of fire greatly reduced. The well-designed system can entirely prevent the fire which would have been, without such a system, but we shall not hear about that. We shall learn only of the ones that do start.

The economical installation of automatic foam protection puts some requirements on the extraction-plant design. Application to some existing plants might prove to be somewhat expensive. If the extraction plant design can be coordinated with the automatic foam system, the installation of automatic foam system can be for a relatively low cost in view of the protection that can be afforded.

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Application of Mechanically Produced Airfoams to Fire-Protection Problems

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Part I. Development and Characteristics of Fire-fighting Airfoams

J. M. PERRI (1), in his chapter on "Fire-Fighting Foams, Foam Theory, and Industrial Application" by J. J. Bikeman, recalls the earliest practical experiment with fire-fighting foams. Chemical foam made by the reaction of solutions of aluminum sulfate and sodium bicarbonate obtained its buoyant property from the carbon dioxide thus formed and well dispersed in the solution. Stability of dispersion was accomplished through the use of saponin. Development of the chemical foam fire-protection field was rapid in the early 1900's and, with early application to the hand fire-extinguisher, quickly was adapted to the protection of large storage tanks containing flammable liquids. Principal modifications of chemical foam were in the selection of stabilizer materials, the method of producing solutions from easily stored chemical powders, and conduction and application of foam to the flammable surface.

The so-called mechanical or airfoam had its beginning in the mid-twenties. The principal differences between airfoam and chemical foam are found in the use of air in place of carbon dioxide as the buoyant constituent. Contrary to first observation, the air-solution suspension does not contribute to the burning mechanism nor does it have any lesser effect than carbon dioxide on the extinguishing mechanism.

One's earliest recollections of the production of mechanical foams undoubtedly date back to the egg beater, whipped cream, chiffon pie, and strawberry mousse. The domestic ability of any housewife is ultimately measured by the permanence of the "mechanical foam" which she can produce by inducting air through agitation and then holding it in fine suspension in the face of searing oven-heat and bated breath.

Economics takes its toll, and stabilized airfoam suspensions had to be produced from less expensive solutions. There seemed to be no synthetic stabilizers which would meet all of the tests of fire. Materials which shared the classification of protein were found to be most suitable. Standardized water solutions made from products like stockyard scraps, fish scales,