Safety Aspects of the Receiving and Bulk Storage of Extraction Solvents

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IN THIS PAPER we shall attempt to outline what we believe should constitute reasonable, safe facilities and procedures for receiving and storing extraction solvents, based on sound petroleum industry experience and practice. In our marketing territory we receive, store, and distribute some nine billion gallons of petroleum products of all types each year. This volume of product is handled in more than 500 bulk plants and terminals, which range in size from those with a storage capacity of less than 50,000 gal. to large plants with tankage for almost 100,000,000 gal. Essentially, all the tankage at these plants is aboveground. Some 25,000 service stations receive, store, and dispense our motor fuel products, but their storage is essentially underground.

Regardless of the size or complexity of these plants and service stations, their basic function is to receive petroleum liquids, store them in tanks, and finally discharge them from the tanks. In its fundamentals the process of receiving and storing petroleum solvents, such as hexane and heptane, very closely parallels the operation of a petroleum bulk storage plant.

The incidence of fire in the petroleum industry (1) has been quite low for this particular phase of the operation, and, so far as we can determine, in the extraction industry (2) also. Such fires, spills, and mixtures as have occurred have resulted primarily from failure to follow established procedures.

It has always seemed to us that a procedure which has provided adequate safety in the petroleum industry should suffice also in an industry performing the same functions with the same materials on a smaller scale. As compared with safeguarding the extraction process itself or the process by which solvents are manufactured, the safeguarding of the receiving and storage of solvents by the supplier or at the extraction plant is relatively simple.

Freedom from fire will be provided if the solvent-receiving-and-storage facilities are designed, installed, and maintained so that all the equipment is liquid and vapor-tight (except for vents), tankage is vented to a safe location and through vent lines with sufficient capacity, and sources of ignition are not present at the same time and place that solvent vapor/air mixtures within the flammable range are also present; and procedures are formulated and adhered to so as to insure that the proper solvent is received and the amount delivered does not exceed the storage space available.

The American Association of Railroads pamphlet No. 34 (3) contains what appears to us to be an adequate procedure for unloading tank cars.

We have seen proposed or required by municipal ordinance, by rating groups, and even by persons within our industries many requirements made in the name of safety which do not contribute to safety but rather increase the cost of doing business and provide a false sense of security.

In the petroleum industry there have been errors on the side of providing facilities and following procedures far beyond what was really required for safe operation. In the past we attempted to combat some hazards that did not in fact exist. Some familiar examples which come to mind are the use of drag chains on tank trucks, the use of flame arrestors and mushroom vent-caps on service-station tank-vents, and the requirement for wires imbedded in rubber hose to connect electrically the two metal ends. Most people now recognize that these and many other former requirements not only did not contribute to safety but in some cases provided a hazard. Such things become rooted in the mores of the industry and tend to be accepted as fact without question. Worse still, they may become imbedded in law or regulation where they are difficult or impossible to uproot.

IT is our understanding that the National Fire Protection Association is in the process of preparing a tentative standard for solvent extraction plants to be designated as N.F.P.A. No. 36-T (4). When this standard is distributed, it should be studied thoroughly and critically in the light of experience, and comments should be made known. In its present form it contains several provisions which cannot be justified by theory or experience. This standard, along with Factory Insurance Association publications (2), will certainly be consulted by those who may wish to regulate the oil and fat industry. If these publications call for facilities and procedures beyond what is necessary for safety, sooner or later they will be written into law, regulations, or rating schedules. Furthermore such standards are always "minimums," upon which even more restrictive provisions are frequently pyramided.

The requirement that nonferrous or "spark-proof" hand tools be used in plants to prevent ignition of solvent-vapor/air mixtures is to be found in every publication we have seen relating to solvent-extraction plant safety. This requirement has also long been in effect in the petroleum industry even though it is not possible to cite an instance where steel hand-tools have provided an ignition which nonferrous tools would have prevented. Whether or not the so-called "spark-proof" tool is necessary to prevent ignition of dust or other materials in other parts of extraction plants, it is most certainly not necessary to prevent ignition of petroleum solvents (5). The petroleum industry has long followed the practice of using steel tools, wetting them with a stream of water where vapors may be present. Here is a case where a "safety" requirement in addition to increased cost and decreased efficiency may add a hazard by providing a false sense of security.

The requirement for distances of 50 ft. or 100 ft. between solvent-storage tanks and solvent-unloading locations and extraction and preparation facilities is not consistent either with petroleum industry practice or with nationally recognized standards, such as N.F.P.A. Flammable Liquids Code (6). Storage tanks constructed and vented and diked as outlined in N.F.P.A. have proven not to be a source of hazard in thousands of bulk storage plants, even when located within a few feet of public thoroughfares.

There is no valid safety reason for providing large distance separation between the tank car or tank-truck-unloading location and the storage tank itself. If the tank is underground, the unloading location might well be within a few feet of the tank with the fill piping rising vertically from the tank to the ground level. This is the normal preferred practice in gasoline service stations and eliminates the need for offset fillpiping. In the case of aboveground storage tanks 25 ft. would seem to be a satisfactory distance between tanks and unloading locations. It is also necessary that the unloading location be outside the dike wall surrounding the tankage. This is the normal preferred arrangement at gasoline bulk plants and certainly minimizes the amount of piping necessary. Certainly good pratice dictates that the unloading area should be graded to direct possible spills away from building, public property, or possible sources of ignition.

The practice of providing flame arrestors on solvent-tank vents not only does not provide any significant contribution to safety but may create a hazard by blocking or partially blocking the vent line. Here again the petroleum industry is sometimes forced through outmoded regulations to provide equipment less safe than it would like. On aboveground tankage we believe that pressure-vacuum vents of appropriate size are all that is necessary or desirable. Experience of many thousands of tank years bears this out. On underground storage the preference is for a vent pipe 2 in. in diameter with the discharge end unencumbered with any device and pointing directly upwards.

What is necessary for protection against static electricity? There are three areas where this should be considered. The first is during bottom or top unloading from tank trucks or tank cars through tight connections. Here no static protection is required. It is not necessary to ground the vehicle nor is it necessary to bond between the vehicle and the piping into which the product is discharged. The entire transfer takes place in a closed system, and there is no gap across which a spark could jump even if a flammable mixture were present.

The second area is during unloading from tank trucks through open domes by means of a suction pipe. Here the truck and the suction piping should be electrically connected by a bonding cable. This connection should be made before opening the dome cover and removed after the dome has been closed. The reason for this connection is to insure that the suction pipe and the truck dome remain at the same electrical potential even though static charges may be generated by the flow of solvent through the piping.

And third is the unloading of tank cars by means of suction piping through open domes. Here the same possibility of static generation exists as in the case of the tank truck, but the car is already sufficiently well electrically connected to the piping to prevent differences of potential. The stray current grounding of the railroad rails and the piping, plus the ordinary contact between the tank car wheels and rails, are enough. No additional bonding is necessary (7).

Since the advent of jet fuels there has been increasing concern over the possibility of internal tank-ignitions because of the static charges placed on the fuel by its flow through piping and the turbulence as it enters the tank. This concern, of course, applies only to tanks containing products with a vapor pressure such as to provide a vapor/air mixture within the flammable range at the storage temperature.

In the case of hexane under equilibrium conditions, tank vapor-spaces would be within the flammable range at temperatures from —20°F. to +35°F. Heptane storage would provide flammable mixtures between about +20°F. and +75°F. (8). The build-up and accumulation of static charges by a petroleum product depends on the rate at which the charge is generated, the resistance of available paths for the dissipation of the charge, and the amount of charge the product can accumulate. The charge can be minimized by slow pumping-rates. In the petroleum industry initial pumping rates are generally held to a velocity of 3 ft. per second through the piping into tankage, except where floating-roof or inert-gas blanketed tanks are used. This is not a magic number, and its origin is not known. It is known that the slower the rate, the less static.

It is also known that products such as kerosene and jet fuel are particularly active in generating static whereas hexane and heptane apparently are not as active. Moderate pumping rates on the order of 3 ft. per second until the inlet piping is well covered by solvent are advisable to reduce the possibility of static discharge within the vapor space.

The unloading of tank cars through the bottom outlet connection is the method most widely used in the petroleum industry. With the exception of tank cars containing liquefied petroleum gas, which can only be unloaded from top connections, tetraethyl lead which is vacuum-unloaded, and very corrosive chemicals which pose a special hazard, we unload all tank cars from the bottom. Indeed our instruction manual (9) states:

> Tank cars shall be unloaded through the bottom connections except where local regulations prohibit it. If it becomes necessary to unload through the dome, contact your District Office for instructions.

There are certain advantages to bottom unloading. Certainly it is faster, requires a smaller pump and less piping, and eliminates the need for a rack structure. There is less chance for injury from falling off the car.

It has been our experience in unloading countless numbers of tank cars through the bottom that this is a safe procedure from a fire-risk standpoint. We are sure that cars with leaking foot valves are not loaded at our refineries. They are repaired before filling. These cars are filled with the bottom cap removed, and any leakage is readily detected.

During the war when water transportation of crude to our refineries was seriously curtailed, we set up temporary tank-car unloading locations where we received and unloaded hundreds of tank cars every day. During this emergency period almost every tank car with wheels was pressed into service. Many of these cars were in very poor condition, and maintenance was considerably less than good. All of these cars were unloaded through the bottom. Even under these conditions we had no fires and very few spills of any consequence.

Two widely used sources of reference for tank-car unloading procedures are the Association of American Railroads (3) and the Manufacturing Chemists'

Association (10). The wording of the A.A.R. rules and the M.C.A. recommended practice is almost identical except that M.C.A. has added a recommendation against bottom unloading, some warnings against the use of ferrous tools, and some rather elaborate static-grounding procedures. None of these additional precautions is followed in our bulk plants because we are convinced they do not provide additional safety. Many years of experience have borne out this contention.

WE do not plan to discuss in detail the requirements of the National Electric Code and definitions of the various classes, groups and divisions which provide the basis for determination of the types of electrical equipment suitable for various parts of petroleum handling facilities. Certainly in refineries any over-all requirement for Class I, Group D equipment throughout cannot be justified. However it is desirable to provide only explosion-proof, electrical pumping-equipment throughout our own bulk storage plants. (This is not necessarily a general practice in the petroleum industry but one where the additional cost can be justified.) With fixed equipment for normal operation this is a simple matter to control. Where repair work is being performed or temporary equipment is being used, we have occasionally found a gasoline-engine-driven pump being used. These have caused fires and should not be used in solvent storage and unloading operations except possibly in extreme emergency.

An extension of the reasoning and experience which justifies the exclusive use of explosion-proof motors and switches cannot include a requirement for "permissible" flashlights (11).

It is our policy to provide fixed fire-protection at bulk storage plants only where this is required by local ordinance or regulation. This policy is based on experience of low fire-loss in this type of operation. In 1955 the petroleum industry reported to the American Petroleum Institute (1) on 14,289 bulk plants with an investment of more than $685,000,000. In that year there was a total of 48 fires with an average loss per fire of less than $3,000. The total loss ratio was 2¢ per $100 of investment. Incidentally none of these fires spread to other property. In our own experience over the past 10 years we have had just one bulk-plant fire while unloading petroleum liquid. This occurred in 1950 when a storage tank was overfilled because our plant man failed to gauge the tank prior to emptying a tank-truck load into it. Fixed fire-protection would not have extinguished this fire. We have had three tank-fires during the past 10 years. All of these occurred while the tanks were being prepared for cleaning, and all three occurred as a result of failure to follow simple procedures. Two were extinguished by portable extinguishers, and the third was extinguished by the municipal fire department.

We provide no extinguishing equipment specifically for tank fires in bulk-storage plants. Pumps and unloading racks are protected with hand-portable, dry-chemical extinguishers except at very large installations where larger, wheeled, dry-chemical units are provided.

We have attempted to point out in this paper some conclusions reached as a result of many years of experience in handling petroleum products in the petroleum industry. Many of these conclusions have resulted in the adoption of procedures which are notably less restrictive than procedures governing similar operations in the solvent-extraction industry. Certainly the fact that the handling of petroleum products is incidental in your industry and primary in ours may give rise to justification of differing procedures.

Our purpose has been to point out some of these differences, to provide some justification for the procedures we endorse, and to stimulate some discussion concerning them.

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Safety in the Solvent Pilot Plant

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BY DEFINITION a pilot plant is a guiding or steering plant. Webster would call it a plant "to guide one through difficulties." A pilot plant therefore is employed to find possible fallacies in equipment design and operation on a small scale and to correct those fallacies at a relatively low cost.

The purpose of a commercial-scale, solvent plant is to provide an uninterrupted extraction of one material from another. This purpose implies continuous, or at least uninterrupted, batch operation. On the other hand, the purpose of a solvent pilot plant is to provide for the study of the extraction of one material from another. This purpose implies interrupted operations.

The operations in a pilot plant are interrupted because alterations in equipment or flow of materials may be required as the study progresses. The plant must therefore be shut down to make these necessary alterations. Furthermore certain changes may be required because of the nature of the raw material be-