An Approach to Safety in Solvent-Extraction Operation

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SAFETY IN THE SOLVENT-EXTRACTION INDUSTRY is a complex problem, and the degree of complexity depends upon the extent and kind of protection provided. Safety generally is first, a matter of seeking out the hazards and, second, the eliminating or minimizing of these hazards.

Before entering the field of solvent extraction our company appointed a solvent committee to study the various processes available at the time and to formulate safety procedures which would safeguard employees from injury and protect the company's investment in buildings and equipment. The committee functioned in an advisory capacity only; however its recommendations were usually followed.

The safety aspects of solvent operations were considered on a fundamental basis. Hexane is a volatile hydrocarbon, having a flash point of —7°F., an explosive range of 1.2 to 6.9% in air; a vapor density of about 3 times that of air, and a vapor pressure of about 5 p.s.i. at 100°F. In recognition of the hazards a system of safeguards was set up, which was designed to give a maximum of protection. This system is now being used at 5 continuous and 1 batch solvent-extraction units. The oldest has been in operation about 15 years. To date we have had no serious mishaps because of the solvent, and we feel that this results, in a large measure, from the safeguards provided and from the safety consciousness trained into our employees.

The basic hazards are: fire caused by ignition of escaped solvent and explosion caused by ignition of explosive mixtures of solvent vapor and air within or outside of equipment.

To counteract these hazards it is obvious that we must prevent the formation of combustible mixtures and prevent ignition. To accomplish this and to set up the necessary safeguards the committee proposed the following program: prevent solvent accumulation outside of solvent-containing equipment; prevent ignition; set up standards for extraction area; set up fire prevention standards; set up purging procedures; and set up inspection schedules.

Taking each item separately, we shall list the more important precautions recommended:

Prevention of Solvent Accumulation Outside of Solvent-Containing Equipment

1. Use only solvent equipment which can be maintained tight and reasonably free of leaks.
2. All solvent or miscella drain lines or sampling lines to be double-valved and plugged.
3. Provide down-draft ventilation in the building so that a reasonable amount of solvent leakage may be safely dispersed.
4. Provide continuous solvent-detection equipment so that concentrations of solvent vapor are detected before they become dangerous.
5. Provide a spill basin large enough to contain all solvent, miscella, and oil in the building. Connect all floor drains in building to the spill basin. Connect spill basin to a catch basin through a manually-operated valve. Level in spill basin is to be kept low and is to be lowered only at times when basin contains no solvent.
6. Conveyors connecting solvent building with preparation building are to be ventilated at the extraction building end, and a continuous detector is to be installed in each to give warning before any appreciable solvent can reach the preparation building. A continuous detector is also to be installed in the finished-oil surge-tank so that no oil containing appreciable amounts of solvent is pumped to oil storage.
7. All process water leaving the extraction building is to be stripped of solvent before leaving building. This water is to flow directly to the catch basin, and a continuous solvent detector is to be installed to give warning if any solvent is lost by this route.
8. An emergency 30-minute supply of condenser water is to be available, which will automatically flow through the solvent condensers in the event of power failure. This will give an opportunity to shut down plant without risking the escape of solvent vapor.

Prevention of Ignition

1. All electrical equipment in extraction buliding is to be explosion-proof, Class I, Group D, and, with the exception of the extraction building control room, all equipment within 100 ft. of the extraction building is to be explosion-proof.
2. All tools used during regular operation to be spark-proof.
3. All equipment to be well grounded to the building frame. The building to be grounded at each corner and inter-connected without splice by No. 2/0 stranded cable inside the building. All equipment must test less than 0.1 ohm resistance to ground.
4. In new installations no power-transmission belts to be used. In old installations requiring belts, only static conducting belts to be used.
5. All access or inspection doors on equipment in extraction building to be made of spark-proof material.
6. Spark-proof trash cans in restricted area to be emptied daily to prevent accumulation of combustible materials.
7. Safety rules effective within the restricted area: no smoking; no carrying of matches, lighters, cigars, cigarettes, or other smoking equipment; no welding, cutting, or open flames; only people wearing conductive shoes allowed; shoes with exposed iron or steel nails or plates prohibited.

Standards for Extraction Area

1. *Building.* Extraction building to consist of structural steel frame with light incombustible material, such as asbestos cement board, covering wall and roof areas. Glass area to be at least 1 sq. ft. per 50 cu. ft. of building volume.

   Access platforms and upper floors to be steel grating, except under solvent-containing equipment. These areas are to be solid concrete with concrete curbs and with a drain piped to the spill basin.
2. *Restricted Area.* Extraction building to be fenced at 50 ft. from building. This is the restricted area and is to be covered with crushed stone to prevent growth of vegetation.

   Solvent storage and spill basin are to be located in the restricted area.
3. *Separation.* Electrical control room for extraction building to be fire-proof and detached 15 ft. from extraction building and elevated eight or more feet above ground and on side of building with least solvent exposure. All other buildings are to be at least 100 ft. from extraction building. Solvent-unloading station is to be at least 100 ft. from other buildings.
4. *Vapor Dikes.* If the terrain is such that solvent vapor could flow toward other buildings, earthen dikes are to be constructed around the restricted area and the area graded so as to cause the flow of vapor to be away from other buildings.

Standards for Fire Protection

Extraction biulding is to be protected by an automatic water fog deluge system tripped by rate-of-rise, heat-actuated devices and by manual pulls on outside and inside of building. Operation of fog system is automatically to cut off all power and steam to extraction building.

Water supply may be a reservoir containing at least a one-hour supply of water or may be a gravity tank or a reliable city water-supply connected through a fire pump.

Automatic electrically-operated fire pumps are to be used which are actuated by pressure drop in the fire lines. Pres-

sure in the fire lines to be maintained by means of a jockey pump, or by city water pressure, or by gravity tank riding on the line. If power source is not reliable, a stand-by gasoline engine should be provided for operation of the fire pump in the event of a power outage.

Stand-pipes to be located in the extraction building, to which fire hoses, equipped with combination straight stream and fog nozzles, are attached.

Portable fire extinguishers of the dry powder type are to be located strategically throughout extraction building.

Hose houses are to be located around the extraction area which are equipped with connected fire hose and combination straight stream and fog nozzles. Spanners and hydrant wrenches to be available in each house.

Employees are to be trained in use of fire-fighting equipment.

Purging for Repair or Inspection

All solvent equipment is to be purged and tested safe before opening for inspection or repair.

Equipment containing solvent or miscella is to be emptied and then purged with steam. Purging is to be continued until no solvent can be detected, using a portable, combustible gas indicator.

The extractor cannot be purged with steam because of the presence of flakes. An extractor which has been emptied of flakes and miscella may be safely purged, as follows.

A purge blower with a capacity of one extractor air change per minute is permanently connected to the bottom of the extractor. With purge valve open but blower off, carbon dioxide is admitted to the top of the extractor, thus displacing the solvent vapor downward. The vapors issuing from the purge line are dispersed by means of a steam jet. When enough carbon dioxide to fill extractor has been added, extractor cover is removed and purge blower is turned on. At same time a quantity of carbon dioxide equal to one-half the volume of the extractor is rapidly admitted to the top of the extractor. In this manner the solvent vapor is displaced with air without going through the explosive range. Atmosphere in extractor is frequently checked with a portable analyzer to be sure atmosphere is free of solvent and solvent vapor before anyone enters the extractor.

In the event of an extractor breakdown in which the flakes cannot be removed, the miscella is allowed to drain and is pumped out of the extractor. Under these conditions a carbon dioxide purge would be ineffective since the flakes would still be saturated with liquid solvent or miscella. Under these conditions the extractor cover is removed, and the purge blower turned on. Rapid evaporation of the solvent causes the temperature to drop quickly. This slows down the evaporation rate, and within about one hour the atmosphere leaving the purge blower is well below the lower explosive limit. The purge blower is kept running, and the atmosphere is checked with the portable analyzer. Usually after 24 hrs. the concentration is below 10% of the lower explosive limit. Any repairs made at this time must be made with the purge blower running, using only spark-proof tools. Flakes may be removed by carefully scraping off top layer and letting solvent in layer below evaporate before scraping off another layer.

With the large volume of air flowing through the extractor there is no immediate explosion hazard. However ignition at the surface of the flakes would undoubtedly cause a serious fire, which could result in a disaster. Under breakdown conditions, using air as the purging medium, time and extreme care are the most important factors. Sufficient time must be allowed to do a reasonable purging job before attempting repairs.

After repair and before start-up, air is removed from extractor by admitting carbon dioxide into the bottom of the extractor and forcing air out through the vent system. After filling extractor with carbon dioxide, solvent is admitted and circulated. With this procedure, going through the explosive range is avoided.

Inspections

A regular monthly safety inspection is to be made at each plant by an inspection committee appointed by the superintendent. An inspection outline proposed by the solvent committee is to be followed, and a written report made covering every item in the outline. Safety features are to be tested to determine that they will work as intended. Continuous solvent-detectors are to be tested quantitatively to be sure that they will give an alarm at the proper concentration.

Monthly inspection reports are to be carefully reviewed and commented on so as to keep them from becoming routine. Inspections are also to be made before starting up after each major shutdown. In addition, inspections are to be made by traveling members of the solvent committee.

The foregoing is a more or less condensed version of the principles laid down by the committee. These principles were taken into account in designing the plants, and detailed specifications were written covering many of the items. With the design of each plant, changes were made as dictated by experience. Thus the purging set-up has been enlorged upon so that in the newer plants it is possible completely to purge the plant in a matter of hours instead of days.

Complete detailed safety instructions were written for each plant, and these are periodically reviewed and revised, as necessary.

A small booklet, entitled "Safety for Solvent Plants," covering the principles involved in our safety program, was prepared and distributed to employees. The main object of this booklet is to stimulate interest in the safety program.

In this paper we have briefly outlined the solvent safety program used at our plants. In conclusion, I would like to quote a paragraph from our safety booklet: "SOLVENT-PLANT SAFETY IS DEPENDENT UPON BOTH MEN AND EQUIPMENT. THE FINEST AND SAFEST EQUIPMENT MAY BE INEFFECTIVE UNLESS OPERATED AND SERVICED BY SAFETY-MINDED MEN.—BE SAFE."

Safety in Design in Solvent Extraction

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WHEN WE LOOK BACK on the solvent extraction industry 15 to 20 years ago, we see that tremendous improvements have been made in safety practices as well as in general operating efficiencies. About 20 years ago, when I was working for Procter and Gamble Company, I was assigned to solvent-extraction operation. I recall that I was struck by the observation that so many of the early workers and inventors in the solvent-extraction field were now deceased. It seemed quite significant to me that most of the patent literature, which I read in order to gain as much information on the new subject as possible, showed that the heirs of the inventor, for the most part, made the patent applications. It appeared that most inventors working in this field did not live long enough to apply for their own patents. I never discovered whether or not they died of old age, but most of us assumed that we were getting into a fairly dangerous operation.

In talking with other old-timers in the industry, it is possible to recall and laugh at many occurrences which took place and which were not at the time laughing matters. My company went into solvent extraction as a brand new venture after a great deal of research and development and economic study. At that time the economic reasons for solvent-extracting