



Property Risk Consulting Guidelines

XL Risk Consulting

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VEGETABLE OIL MANUFACTURING

INTRODUCTION

Vegetable oils and their derivatives are widely used, not only as foods or in food preparation, but in manufacturing of many products, including plastics, paints, resins, lubricants, surfactants, soaps, pharmaceuticals and fuels.

Many plants yield oils, but only a few are farmed on a large scale for that purpose. By far, the largest single oil producer is the soybean crop.

For thousands of years vegetable oils were extracted by pressing or “expelling.” Solvent extraction began around 1850 and now accounts for most vegetable oil production.

Solvent extraction can present a severe hazard because the process normally uses a flammable solvent, such as hexane. Other hazards of vegetable oil manufacturing include storing, cleaning, drying and processing the oil seeds. NFPA 36 addresses these hazards and its Appendix A provides a complete description of the process.

PROCESSES AND HAZARDS

Figure 1 shows the process flow for a typical soybean oil extraction and finishing plant.

Handling

The raw materials (seeds) are received at unloading stations from ships, barges, railroad cars or trucks. The seeds are moved by belt or drag conveyors and elevators. Dust collectors are used extensively to control the dust resulting from seed handling.

Depending on their moisture content, the seeds may require drying. This is done by blowing hot air over the seeds in a fluidized bed or vertical column dryer. These units are either steam heated or gas fired.

Cleaning

Seeds contain foreign matter from harvesting, making cleaning essential. The seeds are cleaned and sorted by passing them over vibrating or gyrating screening devices or stationary gravity screens. A positive air aspiration system is used to remove the dust generated by seed movement within these screening devices.

The hazards in this area include explosion of seed dust, fire in the combustible vegetable oil, and mechanical breakdown of the press.

Preparation

Dehulled seeds or cake from prepressing are softened by heat in a continuous oven or drier and are then flattened into thin flakes [0.010 in. – 0.014 in. (0.25 mm – 0.36 mm)] in a flaker mill. This ruptures the oil cells and increases the surface area of the seed to aid in the extraction process.

This process area presents dust explosion potentials from the flaking mill and the associated dust collection systems. The oven or dryer integral to this process also poses a fire and explosion hazard.

Extraction

The extraction process can be either percolation, total immersion or a combination of the two. The percolation process is the most widely used. Hexane is the most commonly used extraction solvent. A steel conveyor continuously brings the flakes to the extractor. Solvent percolates through the flakes, extracts oil, and is pumped to another area of the extractor. Most extractors have six or seven stages of percolation. The flow of solvent is counter to the flow of flakes. Fresh solvent is added near the discharge end. The discharged solvent contains about 25% oil and is called miscella. The extractor generally operates at either atmospheric pressure or a slight vacuum of ½ in. (12.5 mm) water gauge.

The solvent-saturated solids (spent flakes) are then sent to the desolventizer.

Solvent extraction poses the most severe hazard in the plant because large quantities of solvents are handled above their flash points [hexane -7°F (-21°C), heptane 25°F (-4°C)]. Fire and explosion are the most common losses associated with this portion of the process. Such incidents cause both large property damage and business interruption losses.

Desolventizing

Spent flakes are saturated with solvent, which must be driven off by heat, direct steam and/or vacuum. This process occurs in a unit which sends the solvent vapors through a scrubber to remove entrained solids. The solvent and water vapors are recovered by condensers in the solvent recovery unit. The solvent-free spent flakes are further processed for use as food for animals or humans. If spent flake handling is interrupted, the entire extraction process must be stopped.

The hazards are similar to extraction but the quantities of flammable solvents are much less.

Evaporation

The miscella is subjected to multiple stages of distillation by heat and vacuum to remove the solvent, which is condensed and recycled to the extractor. Distillation hazards are discussed in PRC.9.6.2.1.

Evaporation does not have as great a quantity of flammable solvents as extraction but in all other respects possesses the same hazards.

Solvent Recovery

Solvent vapors from the desolventizing process and from various breather vents are also passed through condensers and returned to the extractor. Tail gases from these various recovery units are usually passed through one last recovery step before being vented to atmosphere. This is typically a mineral oil absorption system with steam stripping, but it can also be a carbon bed absorber.

These units have the same fire and explosion hazard as extraction. Activated carbon absorption systems are particularly prone to fire and are discussed in PRC.9.6.2.2.

Once the solvent has been removed, the flammable liquid hazard changes to a combustible liquid hazard, which requires lower levels of protection in accordance with PRC.12.2.1.2. To take advantage of the lower protection requirement of combustible liquids, the two parts of the process, including their drainage systems, must be separated.

Vegetable Oil Processing

Degumming removes impurities called phosphatides, which have a particularly high concentration in soybean oil. The process consists of a batch hydrolysis reaction with water, followed by centrifugal separation. The product separated is called lecithin, which has considerable commercial value as an emulsifying, dispersing, wetting or penetrating agent. It is also an antioxidant.

Alkali refining removes fatty acids from vegetable oils by reacting them with a slight excess of sodium hydroxide solution to form soap. The soap is removed by settling or centrifuging. Refining makes the oil unsaturated (pure).

Bleaching treats the refined oils with bleaching earths, activated earths and/or activated carbon. Vacuum bleachers can be either batch or continuous processes. Batch units have agitators and are generally steam heated. Continuous bleachers have a series of heated trays. The temperature of bleachers is generally 194°F – 230°F (90°C – 95°C) with a bleaching time of about 15 min. Following bleaching, the “spent” earth has to be filtered from the bleached oil. This is done using a conventional plate and frame filter press or a semi-automatic filter.

The vegetable oil, a Class IIIB combustible liquid, can be ignited resulting in a serious fire. Any fire at this stage in the process will be intense, spreading beyond the point of origin. The oil-laden “spent” bleaching earth can be subject to spontaneous ignition. The purer the oil in the earth, the higher the likelihood of spontaneous ignition.

Vegetable Oil Modification

The refined vegetable oil can be modified for its intended use by any or all of the following methods:

- Hydrogenation is done after bleaching to “harden” the oil. In this process, the unsaturated oil has hydrogen molecules added to their double bonds to make them more saturated (harder). The process takes place in a reactor using a catalyst (usually finely divided nickel), a temperature of 248°F – 356°F (120°C – 180°C), hydrogen at 15 psi – 90 psi (1.0 bar – 6.2 bar), and vigorous agitation.
- Interesterification (also known as ester interchange) cross-links molecules in heated, refined, hydrogenated oil in a solution of 0.2 parts of sodium hydroxide in 20 parts of distilled glycerol. A pressure of about 2 in. (50 mm) of mercury is maintained in the vessel and the mixture is heated and agitated vigorously with dry steam until a temperature of 374°F (190°C) is reached.
- Fractionation separates different weight oils by crystallization (freezing). The oil is dissolved in a solution of methanol or acetone, then is passed through crystallization tubes and continuous filters. From there, the fractions are fed separately to stripping stills for solvent removal.
- Deodorization is a process of steam distillation in which the nonvolatile oil is maintained at a high temperature under reduced pressure while it is stripped of the volatile constituents responsible for flavor and odor. Free fatty acids in the oil are usually reduced to 0.01% – 0.03% if originally present in greater amount. Vegetable oils and their products also undergo a considerable reduction in color. In the manufacture of edible products, deodorization is the last step in processing before finishing and packaging. All hydrogenated fats intended for edible use must be deodorized to free them of a typical flavor and odor imparted by hydrogenation. A heat transfer oil system is generally required due to the high temperatures needed.

These processes have the same hazards as vegetable oil processing. In addition, handling hydrogen requires special precautions. The heat transfer oil system used in deodorization requires special protection. See PRC.7.1.5.

Storage

Bulk vegetable oils are stored in tanks either inside buildings or in tank farms. Finished product vegetable oils are normally packaged in plastic (polyethylene) containers (1 qt – 5 gal) in cardboard boxes. Warehouses could contain either rack or palletized storage.

Fires in storage areas will damage inventory and buildings. If the warehouses adjoin the manufacturing or processing areas, they will be damaged either by fire or smoke contamination. Because food grade materials are particularly sensitive to smoke damage, there is usually no salvage. Fires will be severe and difficult to control and extinguish.

LOSS PREVENTION AND CONTROL

These protection guidelines are not all inclusive, because they were written for a typical hazard level. More severe hazards warrant increased protection.

Management Programs

Management program administrators should report to top management through the minimum number of steps. They should also institute adequate loss prevention inspection and audit programs to communicate program effectiveness to top management. This management feedback is a key feature of *OVERVIEW*, AXA XL Risk Consulting's total management program for loss prevention and control. In developing management programs for solvent extraction plants, pay particular attention to the following important areas.

Process Hazards Evaluation Program

Establish routine procedures for testing physical and chemical properties of all incoming raw materials, intermediates and final products to confirm properties required for safe operating conditions. For instance, soybeans with excessive impurities are more prone to ignition while being dried.

During process design, try to minimize the quantities of solvents and oils in holdup. Improved equipment may require less of these materials, and consequently, the amount that may be involved in a fire will be less.

Determine the safe operating and potential upset conditions of all new or existing processes used by the plant. For example, introducing air into the extractor (or releasing solvent from it) could create an explosive air-vapor mix.

Limit the amount of materials released from equipment failure by closing block valves, dumping liquid to emergency drain tanks, and purging equipment with a nonhazardous gas. Actuate these shutdown measures with combustible vapor detectors where appropriate.

When designing safety features, assume a minimum of two consecutive errors, one of which may be misinformation because of a faulty instrument or a misunderstanding of instructions.

Operator Training Program

Train the operators to operate the plant in accordance with NFPA 36 at all times. Educate all operators in the hazards involved and in functions of the safety control equipment. Forbid operators to run the process when any of this equipment is out of order. Train operators in manual emergency shut down procedures. Forbid deviations from the written procedures.

Schedule periodic retraining at least annually. Include testing to assure proper performance of all assigned duties with particular emphasis on emergency shutdowns.

Preventive Maintenance and Inspection Program

Emphasize the earliest possible detection of hydrogen embrittlement of metals in hydrogenation service.

Other Management Programs

Give special emphasis to the following within areas handling solvents, hot oils or hydrogen:

- Welding, cutting and other "hot work" permit programs;
- Smoking regulations.

Construction

Design

Keep extraction, desolventizing and solvent recovery areas open and well ventilated. Use open sided or lightweight wall construction with **no** load bearing walls. In hydrogenation areas, ventilate at the **ceiling**.

Layout and Spacing

Design the spacing and layout of the facility in accordance with NFPA 36 and PRC.2.5.2. Maintain good detachment and separation of 100 ft (30 m) between solvent handling areas and adjoining property or major buildings. Confine hydrogenation either to a separate building or a cut-off (4 h rated) area.

Materials

Use only noncombustible construction. Mark hydrogen piping conspicuously.

Fireproofing

Fireproof load-bearing structural building members and equipment supports, which are exposed to flammable or combustible liquids, to a 2½ h rating per UL 1709. See PRC.2.5.1.

Drainage

Provide drainage of flammable and combustible liquids handling areas, in accordance with PRC.2.5.3. Provide liquid warehouse drainage in accordance with PRC.8.1.0.

Electrical Systems

Install appropriately rated electrical equipment per NFPA 70 in areas defined as classified in NFPA 36 and NFPA 496. Ground and bond all equipment.

- Use electrical equipment and wiring UL listed for Class II, Group G, Division 1 for dust hazards.
- Use electrical equipment and wiring UL listed for Class I, Group D, Division 1 for solvent handling areas.
- Use electrical equipment and wiring UL listed for Class I, Group B, Division 1 for hydrogenation areas.

Explosion Protection

Spark Prevention

Provide magnets, pneumatic separators or traps ahead of all cleaners, crackers, shellers, crushers, grinders or mills to remove tramp metal or other foreign materials and to control sparking materials. In hydrogenation areas, make any repairs using nonsparking tools and without open flames of any type.

Explosion Venting

Provide equipment and building explosion venting for the following hazards in accordance with NFPA 68.

- Flammable gas hazards, such as hydrogenation;
- Flammable vapor hazards, such as, extractor, desolventizer and solvent recovery;
- Dust hazards, such as, hoppers, bins, silos, flaker mills and dust collectors.

Explosion Suppression

In lieu of explosion venting for dust hazards, provide explosion suppression systems in accordance with NFPA 69 and PRC.13.5.1.

Water Based Fixed Protection

Provide wet pipe sprinklers, deluge sprinkler systems, or water spray protection throughout the facility as shown in Table 1.

In solvent or hydrogen handling areas, provide vapor gas detection to alarm at 25% of LEL and to actuate ventilation and water spray system or deluge sprinklers at 50% of LEL.

Protect the fire boxes of organic heat transfer heaters with automatic steam snuffing systems designed in accordance with PRC.7.1.5.

TABLE 1
Extraction Plant Protection

Boiler, Electrical and Telephone Rooms, Offices	Sprinklers. Ordinary Hazard occupancy - Group 1
Cleaning and Flaking Areas	Sprinklers. Ordinary Hazard occupancy - Group 2
Extractor, Desolventizing, Solvent Recovery and Other Solvent Handling Areas	Automatic deluge or water spray system. If water only, 0.35 gpm/ft ² over the entire area. If AFFF is added, 0.25 gpm/ft ² over the entire area. Foam preferred. If drainage is inadequate, foam must be used.
Oil Processing, Modification and Other Areas Handling III-B Liquids	Automatic deluge or water spray. Use 0.25 gpm/ft ² over the entire area. Foam must be added if drainage is inadequate.
Dryers, Toasters, Cookers, Heaters	Automatic deluge or water spray systems. Use 0.25 gpm/ft ² over the entire area.
Storage of Empty Plastic Containers	Protect in accordance with NFPA 13 and PRC.12.1.1.0.
Storage of Containers of Vegetable Oil	Protect in accordance with NFPA 30 and PRC.8.1.0.
Organic Heat Transfer Boiler	Protect in accordance with PRC.7.1.5.
Belt Conveyors	Protect in accordance with PRC.9.3.1.
Solvent Recovery Using Activated Carbon	Protect in accordance with PRC.9.6.2.2.
Tank Storage of Vegetable Oil and Solvent	Protect in accordance with NFPA 30 and PRC.8.1.0.

Combustion Controls

Provide proper NFPA and AXA XL Risk Consulting's combustion controls for deodorization heat transfer oil systems in accordance with PRC.7.1.5.

Manual Protection

Provide adequate hydrants around the periphery of the extraction, desolventizing, and solvent recovery processes. If any of these processes are conducted in open structures, provide fixed monitor nozzles also.

Boiler and Machinery Protection

Provide pressure (or vacuum) vessels such as reactors, deodorizers, organic heat transfer boilers, evaporators, etc. with appropriate over (or under) pressure protection in accordance with PRC.7.1.5. Minimize the use of sight glasses and gauge glasses.