NFPA No.

36

SOLVENT EXTRACTION PLANTS 1973

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NATIONAL FIRE PROTECTION ASSOCIATION
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Official NFPA Definitions

Adopted Jan. 23, 1964; Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

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*Among the laboratories nationally recognized by the authorities having jurisdiction in the United States and Canada are the Underwriters' Laboratories, Inc., the Factory Mutual Research Corporation, the American Gas Association Laboratories, the Underwriters' Laboratories of Canada, the Canadian Standards Association Testing Laboratories, and the Canadian Gas Association Approvals Division.

LISTED: Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

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AUTHORITY HAVING JURISDICTION: The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Statement on NFPA Procedures

This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

Standard for
Solvent Extraction Plants

NFPA No. 36— 1973

1973 Edition of No. 36

This revised edition of NFPA No. 36 supersedes the 1972 edition. This Standard was prepared by the Sectional Committee on Solvent Extraction, approved by the Correlating Committee of the Committee on Flammable Liquids, and adopted by the National Fire Protection Association at its Annual Meeting in May 1973.

Origin and Development of No. 36

This Standard was adopted tentatively at the 1957 Annual Meeting of the Association and a revised edition was adopted as a continued tentative standard at the 1958 Annual Meeting. At the 1959 Annual Meeting this Standard was officially adopted and then revised in 1962, 1964, 1967, and 1972.

This Standard was developed at the request of individuals in the solvent extraction industry who felt that there was a need for greater uniformity on fire protection for solvent extraction plants. The purpose of this Standard is to provide reasonable guides for the design and operation of solvent extraction plants.

Changes in 1973 Edition

In general most of the changes in this edition were made for editorial clarity. However, there are some substantive changes including the following: 2160, 2410, 2632, 2650, 2670, 2710, 2910, 2960, 2970, 3010, 4020, 4140, 4331, 4340, 4350, 5020, 5150 (b), 5320, 5330, 5716, 5721, 5723, 5740, 5775, 5782 and 5792.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

FOREWORD

In the preparation of this Standard the members of the Committee recognized some fundamental differences between the operation of solvent extraction plants and the processing of flammable liquids in large scale establishments.

Many solvent extraction plants are relatively small units in isolated locations operated without the benefit of overall fire protection measures such as usually are customary in large flammable liquids processing installations.

The operator of a solvent extraction plant must establish and maintain fire safety *esprit de corps* among a small number of employees as opposed to relying on established customs in large scale operations.

There are certain inherent hazards in the combining and separating of solids and flammable liquids which are peculiar to this industry. Also serving as a complicating problem is the potential dust explosion hazard in some areas of a typical plant. Therefore, it was felt desirable to give consideration to practices which would be applicable to either potential dust laden or flammable vapor atmospheres.

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Standard for

Solvent Extraction Plants

NFPA No. 36 — 1973

CHAPTER I. INTRODUCTION.

10. Purpose.

1010. This Standard is intended to:

1011. Prescribe reasonable requirements for safety to life and property from explosion and fire in the design, construction and operation of solvent extraction processes involving the use of flammable solvents.

1012. Provide a means by which fire protection directors and supervisory personnel may evaluate the operations under their authority.

1013. Provide a guide by which inspectors may readily and impartially determine whether or not an existing installation is being operated in accordance with good practice.

1014. Provide a workable set of standards for the use of design engineers, architects and others in planning and designing new installations.

1020. This Standard shall not be construed as limiting new ideas of equipment design to the present state of the art but rather shall be considered a base from which higher standards of fire protection may be achieved.

11. Scope.

1110. This Standard applies to the commercial scale solvent extraction processing of animal and vegetable oils and fats by the use of flammable solvents except extraction processes employing liquefied petroleum gases.

1120. This Standard shall apply to all equipment and buildings within 100 feet of the extraction process except as provided in Section 1130, 1140 and 1150.

1130. This Standard also shall apply to the unloading and storage of solvent regardless of distance from the solvent extraction process.

1140. Where the preparation department is housed separately and located a clear distance of 100 feet or more from the extraction process, this Standard shall begin with and include the means of conveying material from the preparation department to the extraction process.

1150. This Standard shall include the means of conveying extracted desolventized solids or oil from the extraction plant to the vessels and bins storing such material.

1160. This Standard does not include raw stock storage. Where grains or seeds are used, reference may be made to the *Standard on Grain Elevators, NFPA No. 61B.*

1170. Processes employing oxygen active compounds, such as organic peroxides, which are heat or shock sensitive are prohibited within the area described in Section 1120.

12. Existing Plants.

1210. The provisions of this Standard pertaining to design, lay-out and construction do not apply to existing plants. However, modifications to existing plants shall comply with this Standard.

13. Enforcement.

1310. The authority having jurisdiction shall follow nationally recognized standards for fire prevention and fire protection which have been prepared in such a way that they may be taken to represent the best informed judgment available on the subject and which are in such published form as to be available for reference.

Notes in the text of this Standard indicate publications applicable to specific subjects. The names and addresses of organizations to which reference is made are listed following, the abbreviation by which the organization is identified being shown in parenthesis following its name:

National Fire Protection Association (NFPA), 470 Atlantic Avenue, Boston, MA 02210

Canadian Underwriters Association (CUA), 460 St. John St., Montreal, P.Q., Canada.

American Petroleum Institute (API), 1801 K St., N.W., Washington, D. C. 20006

American Society of Mechanical Engineers (ASME), 345 East 47th St., New York, N. Y. 10017

American Society for Testing and Materials (ASTM), 1916 Race St., Philadelphia, Pa. 19103

American National Standards Institute (ANSI), 1430 Broadway, New York, N. Y. 10018

(Some of the organizations preparing standards submit certain ones to the American National Standards Institute (ANSI) for designation as an ANSI Standard. In such cases the ANSI identifying number is given in parenthesis.)

American Welding Society (AWS), 2501 N.W. 7th Street, Miami, FL 33125

Association of American Railroads (AAR), American Railroads Bldg., 1920 L St., N.W., Washington, D. C. 20036

National Bureau of Standards (NBS), Washington, D. C. 20230.

PUBLICATIONS

Standards prepared by committees of the National Fire Protection Association are published by the NFPA in pamphlet form, and are also published in an annual compilation, the National Fire Codes, 10 volumes.

Portable Fire Extinguishers, NFPA No. 10; NFC 8.

Foam Extinguishing Systems, NFPA No. 11; NFC 7.

Sprinkler Systems, NFPA No. 13; NFC 6.

Water Spray Fixed Systems, NFPA No. 15; NFC 7.

Outside Protection, NFPA No. 24; NFC 6.

Flammable and Combustible Liquids Code, NFPA No. 30; NFC 1.

Grain Elevators and Bulk Grain Handling Facilities, Prevention of Dust Explosions, NFPA No. 61B; NFC 3.

Flour and Feed Mills, Prevention of Dust Explosions, NFPA No. 61C; NFC 3.

Guide for Explosion Venting, NFPA No. 68; NFC 9.

Explosion Prevention Systems, NFPA No. 69; NFC 7.

National Electrical Code, NFPA No. 70; NFC 5.

Static Electricity, NFPA No. 77; NFC 9.

Lightning Protection Code, NFPA No. 78; NBS Handbook 46, NFC 4.

Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA No. 91; NFC 4.

Life Safety Code, NFPA No. 101; NFC 4.

Procedures for Cleaning or Safeguarding Small Tanks and Containers, NFPA No. 327; NFC 1.

Recommended System for the Identification of the Fire Hazards of Materials, NFPA No. 704M; NFC 1.

American Standard Scheme for the Identification of Piping Systems, (ANSI A13.1) ASME.

American Standard Code for Pressure Piping, Sections 1–7, (ANSI B31.1) ASME.

Rules for Construction of Unfired Pressure Vessels, Section VIII of ASME Boiler and Pressure Vessel Code, ASME.

American Standard Wrought-Steel and Wrought-Iron Pipe, (ANSI B36.10) ASME. (This is also an ASTM standard, but is not included in ASTM Book of Standards. ASTM circulates ASME edition.)

1320. Where these standards require the authority having jurisdiction to approve process or protective equipment, he may require the applicant for such approval to submit information necessary to properly judge the suitability of the equipment for its intended purpose. In performing this function the authority having jurisdiction may require examination and tests to furnish such information or he may accept listings or approvals of equipment by laboratories or testing agencies which have an established procedure, the necessary facilities, and qualified personnel for examinations and tests appropriate for the particular equipment. In the absence of such established examination and test procedure for any item on which approval is necessary, the authority having jurisdiction may specify what examinations and tests shall be made.

Process and protective equipment for meeting the requirements of these standards are examined and tested by Underwriters' Laboratories, Inc., 207 E. Ohio Street, Chicago, Illinois 60611; Factory Mutual Engineering Corporation, 1151 Boston-Providence Turnpike, Norwood, Massachusetts 02062; and Underwriters' Laboratories of Canada, 7 Crouse Road, Scarborough, Ontario. These testing agencies have standards and procedures which apply to the examinations and tests they make, and the results are published in listings or approvals. Various provisions of these Standards on Solvent Extraction are drawn so that when applied to process and protective equipment meeting the terms of such listings and approvals, the desired results in safety from explosion and fire are obtained. Other approval criteria may be employed, but in such cases the authority having jurisdiction shall determine that equivalent results are assured.

14. Definition of Terms.

1410. For the purpose of these standards the following terms shall be interpreted in accordance with the following definitions.

APPROVED signifies acceptance, by the authority having jurisdiction, of design, equipment, installation, or intended use as required by this standard. Devices having been tested and accepted for a specific purpose by a nationally recognized testing laboratory may be deemed to be acceptable.

CONDENSATE — Any liquid that has been condensed from the vapor to the liquid state.

CONDENSER — A heat exchanger that lowers the temperature of a condensable vapor to the point where the vapor changes to the liquid state.

CONTROLLED AREA — The area between 50 feet and 100 feet of the extraction process.

CONVEYOR — Equipment that transports material other than liquid from one point to another by means such as a moving belt, chain, air, buckets, flights or combinations of the above.

DESOLVENTIZED MATERIAL — Extracted material rendered solvent-free by the process.

DESOLVENTIZER — Equipment capable of removing the solvent from the material in process.

EVAPORATOR — Equipment that will vaporize the solvent from the oil bearing miscella.

EXTRACTED MATERIAL — See Spent Material.

EXTRACTION PROCESS — The operations involving the extractor together with its pertinent equipment such as heat exchangers, evaporators and strippers which are contained in an enclosed building or in an open structure.

EXTRACTOR — Equipment which has as its function the removal of oil from the oil bearing material by the use of a suitable solvent.

FAIL SAFE — Any equipment or operation which upon failure to function becomes less hazardous or remains no more hazardous than when in operation.

FLAKES — Material prepared for extraction, such as soybean flakes.

FLAKING MILL — A crushing roll type device used for the preparation of material for the solvent extraction process.

FLAME ARRESTER — Any approved device which effectively prevents the ignition of flammable vapors on one side of the arrester when the other side of the arrester is exposed to a source of ignition.

HEAT EXCHANGER — A shell and tube bundle designed to transfer heat from one vapor or liquid to another vapor or liquid.

INERT GAS — Any gas which is nonflammable, chemically inactive, and noncontaminating for the use intended and oxygen deficient to the extent required.

INERTING — The use of an inert gas to render the atmosphere of an enclosure substantially oxygen-free or to reduce the oxygen content to a point at which combustion cannot take place.

MISCELLA — A mixture in any proportion of extracted oil and the extracting solvent.

PREPARATION PROCESS — The operations involving the equipment used for the preparation of the material for solvent extraction.

PURGING — The process of displacing the flammable vapors from an enclosure.

RESTRICTED AREA — The area within 50 feet of the extraction process.

SEAL, PRODUCT OR MECHANICAL — A device designed to prevent the transmission of liquid or vapor from one portion of the extraction process to another.

SEPARATION SUMP — An open pit used for the separation of mixtures of solvent and water based on the principle of the immiscibility and the differences in the specific gravity between the solvent and water.

SOLVENT — Any flammable liquid, such as pentane, hexane and heptane, with suitable characteristics for the extraction of animal and vegetable oils and fats.

SPENT MATERIAL — The material after the oil or fat has been extracted and before it is further treated or processed.

STRIPPER — The bubble cap, sieve plate, disc and donut or porcelain ring packed column or tower, usually operated under vacuum, designed to remove residual solvent from the oil.

TOASTERS — Equipment capable of producing the desired cooking, toasting and modification of protein by means of heat and moisture.

VAPOR RECOVERY — The process of condensing, absorbing or adsorbing solvent vapors.

VAPOR SCRUBBER — A tower or column capable of washing the dust from vapor by the use of hot liquid sprays.

VAPOR SEAL — Any equipment or material which prevents the escape of flammable vapors from a tank or container.

CHAPTER II
BASIC RULES.

20. General Requirements.

2010. Safe operating practices, including but not limited to start-up and shut-down procedures, shall be the responsibility of management operating the solvent extraction plant.

2020. Operating and maintenance employees shall be instructed in plant operations in general.

2030. Applicable plant regulations shall apply to all visitors and others who may enter the plant, both during operating periods and during shut-down periods. Further information on the control of visitors may be found in Appendix B.

2040. When necessary to make repairs to the plant, the work shall be authorized by the individual in responsible charge of the plant before the work is started. See Appendix B for a suggested safety work permit.

2050. Sources of Ignition.

2051. Electrical installations shall conform to the requirements of the National Electrical Code as hereinafter specified.

2052. Provisions shall be made for protection against static electricity and lightning as required in other chapters of this standard.

2053. There shall be no smoking or other sources of ignition within the restricted and controlled areas. Lighters and matches shall not be carried into the extraction process.

2054. Powered vehicles, unless approved for such locations, shall be prohibited within the controlled or restricted area except by special permission of the individual in responsible charge of the plant.

2060. Housekeeping.

2061. Flammable liquids not contained in process equipment shall not be stored in the extraction process area except small quantities which shall be stored in approved safety cans.

2062. Waste materials such as oily rags, other wastes and absorbents used to wipe up solvent, paints and oils, shall be

deposited in approved waste cans and removed from the premises not less than once each day.

2063. Dust originating from material in process shall be kept to a minimum.

2064. The space within the restricted and controlled areas shall be kept completely free of dry grass, weeds, trash, and all combustible materials. Any spills of oil, solvent or deposits of solvent bearing material shall be cleaned up immediately and removed to a safe place. The discharge or removal of solvent bearing material shall be recognized as a severe hazard and operating procedures established to minimize such occurrences.

21. Emergency Procedures.

2110. All employees shall be trained in the necessary action to be taken in time of emergency including emergency shutdown procedures.

2120. Personnel shall be thoroughly indoctrinated as to the location of exits.

2130. All personnel shall be thoroughly trained in the use of and limitations of each type of fire fighting equipment on the premises including control valves for the water spray systems.

2140. A fire brigade composed of the operating crew on each shift shall be trained as a unit and each man shall have his own definite responsibilities in case of emergency.

2150. Periodic drills shall be held in order that employees will carry out the above procedures.

2160. Emergency safety devices or systems provided in the plant shall be periodically tested in accordance with established procedures and a record made thereof.

22. Repairs in Restricted and Controlled Areas When Plant Is in Operation or Unpurged.

2210. Power Tools: Maintenance operations involving the use of power tools which may produce sources of ignition shall be prohibited.

2220. Electrical Equipment: Repairs on live electrical wiring or equipment shall be prohibited. If necessary to replace or repair electrical wiring or equipment, the power shall be completely disconnected and the switch locked in an open position.

2230. Welding and Cutting Operations: Welding and cutting, including brazing and soldering operations shall be prohibited.

23. Repairs in Restricted and Controlled Areas When Plant Is Shut Down and Purged.

2310. Repairs or alterations to equipment or buildings which may produce ignition sources shall be performed only when the plant has been shut down and completely purged, and declared safe by the individual in responsible charge. See Appendix B for a suggested work permit form.

2320. Prior to initiating purging the following steps shall be taken.

2321. Empty the tanks, vessels, piping and traps of all materials. All such material shall be removed to a safe location.

2322. Disconnect, plug or blank off all piping and other connections to storage facilities.

2330. Purging shall be accomplished by one or a combination of the following methods.

2331. The vapor freeing may be accomplished by the introduction of steam into the equipment. The equipment shall be adequately vented to prevent damage from excessive pressure or vacuum. Steam supply lines shall be bonded to the equipment. The rate of supply of steam should be sufficient to exceed the rate of condensation so that the equipment is heated close to the boiling point of water. The equipment shall be steamed long enough to vaporize the residues from all portions. After the steaming the procedures outlined in Paragraph 2332 shall be followed when hot work is to be performed.

2332. Vapor freeing may be accomplished by purging with air and a safe atmosphere may be sustained by continued ventilating. When fixed ventilating equipment is not provided, air movers may be attached so that air is drawn in and discharged through the air mover or air may be introduced through the air mover and discharged through another opening. Discharge shall be to a safe location. Air movers shall be approved for such locations. In air purging the concentration of vapor in air usually will go through the flammable range before a safe atmosphere is obtained; therefore, precautions shall be taken to insure that the air mover is bonded to the equipment in order to minimize the hazard of ignition by static electricity.

2333. Vapor freeing may be accomplished by purging with inert gas and then ventilating with air which minimizes the hazards incident to passing through the flammable range.

2340. To insure a safe condition, tests for flammable vapors with a combustible gas indicator shall be made: (1) before commencing alterations or repairs, including welding, cutting or heating operations; (2) immediately after starting any welding, cutting or heating operations; and (3) frequently during the course of such work. All such work shall be stopped immediately when the presence of solvent vapor is indicated. The source of the vapor release shall be located and removed and the procedure outlined above shall be followed before such work is recommenced.

2350. Upon completion of repairs or alterations the plant shall be checked by the individual in responsible charge to see that operations may be resumed safely. *See 2410.*

24. Extractor Start-up.

2410. Procedures for extractor start-up shall be established to minimize the hazard incident to passing through the flammable range.

25. Solvent Transfer Equipment.

2510. Pumps.

2511. Pumps shall be designed for the solvent, the working pressures and the structural stresses to which they will be subjected.

2512. The use of air pressure as the solvent transferring medium shall be prohibited.

2513. Where practicable all pumps handling flammable liquids in the processing equipment shall be located on the first floor level.

2514. Pump houses, if used, shall be of noncombustible construction and ventilated.

26. Piping, Valves and Fittings.

2610. General: All piping, valves and fittings shall be designed for the working pressures and structural stresses to which they may be subjected. They shall be of steel or other material approved for the service intended.

2620. Pipe Systems: Pipe systems shall be substantially supported and protected against physical damage caused by expansion, contraction and vibration.

2630. Process Piping.

2631. Piping shall be pitched to drain to avoid trapped liquids or suitable drains shall be provided. Armored hose may be used where vibration exists or where frequent movement is necessary.

2632. Aboveground flammable liquid pipe sections two inches in size or over shall be welded and flanged. Welding shall conform to good welding practice.

2640. Drain Valves: Drain valves with plugs shall be provided as needed for draining all liquids from the system.

2650. Pipe Connections: Pipe connections, two inches and over, to all tanks and vessels shall be bolted flanges that can be opened and blanked off.

2660. Testing: After installation and before covering or painting, all piping systems, including suction lines, shall be pressure tested to not less than 1½ times the working pressure but not less than 5 psi at the highest point in the system. Tests shall continue for not less than 30 minutes without noticeable drop in pressure.

2670. Identification of Piping and Equipment: All piping and equipment shall be coded for identification.

27. Controls.

2710. Unless solvent tanks are equipped with adequate overflow return lines, solvent flow from bulk storage to the work tank or from the work tank to the bulk storage shall be remotely controlled by momentary switches or other devices which provide for "dead man" controls to prevent overfilling of tanks.

2720. Positive displacement pumps shall be provided with by-passes with pressure relief valves discharging back to the tank or to the pump suction.

28. Exits.

2810. An extraction building or open process structure over two stories in height shall be provided with at least two remotely located means of egress from each floor one of which shall be enclosed or separated from the process by a wall which is blank except for doors. The enclosure or separating wall shall be of masonry or other noncombustible construction. Self-closing noncombustible doors, normally kept closed, shall be provided for access to the protected stairway.

29. Fire Protection.

2910. An approved water spray, deluge or foam-water system, or a combination of these types of fixed protection systems, shall be provided to protect the extraction process equipment and structure. See the Standard on Sprinkler Systems, NFPA No. 13; the Standard on Water Spray Systems, NFPA No. 15, and the Standard on Foam-Water Sprinkler Systems, NFPA No. 16.

2920. An approved system of automatic sprinklers shall be provided in the preparation building when within 100 feet of extraction process. *See Standard on Sprinkler Systems, NFPA No. 13.*

2930. A system of yard hydrants shall be provided in accordance with accepted good practice. *See Standard for Outside Protection, NFPA No. 24.*

2940. Approved portable fire extinguishers of appropriate size and type shall be provided. *See Standard on Portable Fire Extinguishers, NFPA No. 10.*

2950. Where standpipe and hose protection is installed, combination water fog and straight stream nozzles shall be provided. *See Standard on Standpipes and Hose Systems, NFPA No. 14.*

2960. Fire alarm signals shall be relayed or sent to a constantly supervised point on or off the premises.

2970. Where service is available a public fire alarm box shall be located nearby.

CHAPTER III

BULK SOLVENT UNLOADING AND STORAGE.

30. Location.

3010. Unloading Site: These sites shall be located so that ignition sources presented by locomotives or tank vehicles are at least 100 feet from the extraction process and shall be at least 25 feet from a building or the line of adjoining property which may be built upon. The fill connection to the storage tank shall be at least 25 feet from the extraction process.

3020. Storage Tanks.

3021. Bulk storage tanks shall be outside of any building. Underground tanks shall be located a minimum of one foot from existing building foundations and supports and at least three feet from the nearest line of adjoining property that may be built upon. The loads carried by the building foundations and supports shall not be transmitted to the tank. When aboveground installations are made, the tanks shall be located within the restricted area of the extraction process or in a remote fenced area and in both cases at least 25 feet from any important building or line of adjoining property which may be built upon.

31. Design and Construction.

3110. Unloading Stations.

3111. Unloading structures and platforms shall be constructed of noncombustible material and shall be designed and installed in accordance with accepted practice.

3120. Storage Tanks.

3121. **General:** Storage tanks shall be designed, constructed, installed and tested in accordance with accepted good practice.

For information on tank design and construction, venting, foundations and supports, installation of underground tanks, anchorage, spacing, dikes and walls for aboveground tanks, and testing of tanks see Chapter II of the *Flammable and Combustible Liquids Code, NFPA No. 30.*

32. Sources of Ignition.

3210. Electrical Equipment: All electrical equipment and its installation shall conform to Class I Group C or D (depending on solvent used).

3211. Where enclosures are provided which house solvent handling equipment such as solvent pumps or valves or in which solvents are transferred to individual containers, these enclosures shall be considered to be Division I locations.

3212. In outdoor locations, areas adjacent to loading racks or platforms, or to aboveground tanks shall be considered to be Division II locations. Such areas shall be considered to extend 25 feet horizontally from such racks or tanks, and upward from adjacent ground level to a height of 15 feet. *See the National Electrical Code, NFPA No. 70.*

3220. Static and Stray Currents.

3221. All storage tanks, solvent transfer equipment, tank cars or tank trucks and unloading structures shall be effectively bonded.

3222. Transfer or storage tanks, unloading structures, tank cars and tank trucks shall be electrically interconnected with supply piping or containers during the transfer of liquids.

3223. Static protection shall be installed in accordance with accepted good practice. *See Static Electricity, NFPA No. 77.*

3230. Smoking and open flames shall be prohibited and appropriate "No Smoking" and "Keep Fire Away" signs shall be posted in conspicuous locations.

33. Fire Protection Equipment.

3310. Approved portable fire extinguishers of appropriate size and type shall be provided. *See Standard for Portable Fire Extinguishers, NFPA No. 10.*

3320. Additional fire protection for the unloading structure and bulk storage tanks shall be provided where an exposure hazard exists.

34. Unloading Procedures.

3410. Adequate precautions shall be taken to relieve excessive pressure in cargo tanks before unloading.

3420. Tank cars shall be unloaded in accordance with accepted good practice.

3430. Tank vehicles for flammable liquids shall be unloaded in accordance with accepted good practice. *See Standard for Tank Vehicles for Flammable and Combustible Liquids, NFPA No. 385.*

CHAPTER IV
PREPARATION PROCESS.

40. Application.

4010. The provisions of this chapter shall apply to preparation processes located within 100 feet of the extraction process.

4020. Where the processing operations do not involve the generation of combustible dusts, paragraphs 4120 through 4350 do not apply.

41. Construction of Building.

4110. The building shall be of fire resistive or noncombustible construction and shall be without basement or pits below grade.

4120. The building shall be designed to provide explosion relief of at least one square foot for each 50 cubic feet of volume.

4130. The roof and exterior wall construction shall provide explosion relief by one or more of the following methods:

(a) Open air construction with a minimum area enclosed.
(b) Light noncombustible walls and roof lightly attached to steel frame.
(c) Light noncombustible wall panels and roof hatches.
(d) Top hinged windows with explosion relief latches.

Reference may be made to the *Guide for Explosion Venting, NFPA No. 68.*

4140. Heating, if required, shall be provided by steam (15 psig maximum), hot water, or other devices approved for the location.

42. Electricity.

4210. In areas where combustible dust presents a hazard, all electrical wiring and equipment shall conform to the requirements for Class II Group G Division 1 locations. *See the National Electrical Code, NFPA No. 70.*

4220. Static protection shall be provided in equipment located in areas where combustible dust presents a hazard. *See Static Electricity, NFPA No. 77.*

43. Dust Removal.

4310. A dust collecting system shall be provided where necessary. *See Standard for Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA No. 91.*

4320. Dust collectors of the all-metal type shall be located outside of buildings or shall be equipped with exhaust stacks or ducts leading to the outside.

4330. When fabric filters are used for the collection of dust, they shall be located outside of the building or in a detached noncombustible building used for no other purpose. *See Standard for the Prevention of Fire and Dust Explosions in Feed Mills, NFPA No. 61C.*

4331. Automatic sprinklers shall be installed within fabric type dust collector housings.

4340. Dust accumulations on floors, ledges, structural steel members, machinery, spouting and other surfaces shall be removed concurrently with operations. This shall be done by vacuum cleaning or by other means which will not suspend dust in the air.

4350. The use of compressed air or other means to blow dust from ledges, walls and other areas shall not be permitted unless all machinery in the area has been shut down and all sources of ignition have been removed.

CHAPTER V

EXTRACTION PROCESS.

50. Location of Extraction Process.

5010. The solvent extraction process equipment shall be located in the open or in a building suitable for the purpose.

5020. An industrial type fence shall be placed at a minimum of 50 feet from the extraction process. A controlled area shall extend from 50 feet to at least 100 feet from the extraction process. The restricted and controlled areas shall be posted with signs around the perimeter warning of the possible flammable vapor hazard. All entrances and exits into the fenced area shall be secured to prohibit unauthorized entrance and provision shall be made for emergency ingress and egress.

5030. Basements, tunnels, pipe trenches, and pits, except separation sumps, shall be prohibited within 100 feet of the extraction process.

5040. Except as permitted in Paragraph 5050, the extraction process shall be at least 100 feet from any public thoroughfare, any building or line of adjoining property that may be built upon. It is recommended that the slope of the terrain and the prevailing winds be given consideration in locating the extraction process.

5050. Structures and equipment essential to the operation of the extraction process, other than boilers and other open flame operations, may be located less than 100 feet but more than 50 feet from the extraction process, provided a vapor barrier erected in accordance with the following requirements is provided.

5051. The barrier shall be located between the extraction process and the possible source of vapor ignition and at least 50 feet from the extraction process.

5052. The barrier shall be of noncombustible vapor proof construction without gates or other openings. The barrier shall be at least four feet in height and designed so that there is at least 100 feet of vapor travel around its ends to possible sources of ignition.

5060. Where the circumstances or conditions of any particular installation are unusual and such as to render the strict application of distances specified in this section impractical, the authority having jurisdiction may permit such deviation as will provide an equivalent degree of safety and be consistent

with good engineering practice. Factors having a bearing on this deviation could be topographical conditions, nature of occupancy and proximity to buildings on adjoining property, character of construction of such buildings and adequacy of public fire protection facilities.

51. Construction of Extraction Process.

5110. The building or structure shall be of fire resistive or noncombustible construction with the first floor at or above grade. All solid sections of upper floors of the extraction process and concrete pads under the entire extraction process shall be curbed and sloped to drain and direct connected to an outside separation sump.

5120. Explosion relief of at least one square foot for each 50 cubic feet of volume shall be provided by one or more of the following methods:

(a) Open air construction with a minimum area enclosed.

(b) Light noncombustible walls and roof lightly attached to steel frame.

(c) Light noncombustible wall panels and roof hatches.

(d) Top hinged windows with explosion relief latches.

NOTE: Reference may be made to the Guide for Explosion Venting NFPA No. 68.

5130. Provisions shall be made for the safe discharge of liquids from the process area to guard against the introduction of flammable liquids into sewer systems.

5140. A sump shall be provided to effect separation of water from oils, solvents or miscella except possibly under fire conditions.

5141. The separation sump shall be located within the fenced area but not closer than 25 feet to such fence.

5142. The sump shall be concrete or equivalent masonry construction and influent and effluent lines shall be trapped.

5143. The largest section of such sump shall be adequate to retain all solvent, miscella and oil which could be released by a single break in a vessel or piping, plus an additional fifty per cent of this amount.

5144. Approved fixed automatic fire protection shall be provided above this sump when the sump is located adjacent to the extraction process.

5150. Conveyors and spouts from or to other buildings shall be located and protected to prevent passage of solvent vapors to other areas. This may be accomplished by one or combination of the following methods:

(a) For other than pneumatic conveyors: by providing on the extraction end, positive air aspiration to the outside and with a visual indication of blower operation and failure.

(b) For the raw flake conveying system, by providing a break in the raw flake conveyor system at a point in open air in addition to positive air aspiration as outlined in (a).

(c) For pneumatic conveyors: by locating the air intake in a vapor free area outside the extraction process and a minimum of eight feet above the grade level.

5160. Conveyors and spouts may be enclosed in adequately supported, noncombustible bridge structures equipped with open grate floor sections for ventilation.

52. Ventilation of Extraction Building.

5210. Enclosed plants shall have sufficient ventilation to change the volume of air at least six times per hour. This shall be accomplished by exhaust fans, preferably taking suction at floor levels, and discharging to a safe location outside the building. The arrangement shall be such that all portions of solid floor areas will be subjected to continuous positive movement of air.

53. Ignition Sources and Heating.

5310. Except as provided in 2054 and 5050, no ignition sources shall be used within the building or within 100 feet of the process unless the unit and building are purged.

5320. Heat, if required, shall be provided by indirect means. Steam, if used, shall be 15 psig maximum.

5330. Power transmission belts shall not be used in or within 50 feet of the extraction process.

54. Electricity.

5410. Electrical wiring and electrical equipment of the extraction process, outward 15 feet into the restricted area and

vertically at least five feet above the highest vent, vessel or equipment containing solvent shall be installed in accordance with the requirements for Class I, Group C or D, Division 1 locations. *See Figure 1.*

5420. Electrical wiring and electrical equipment within the restricted area beyond the 15-foot distance and to a height of eight feet above the extraction process grade level shall be installed in accordance with the requirements of Class I, Group C or D, Division 2 locations. *See Figure 1.*

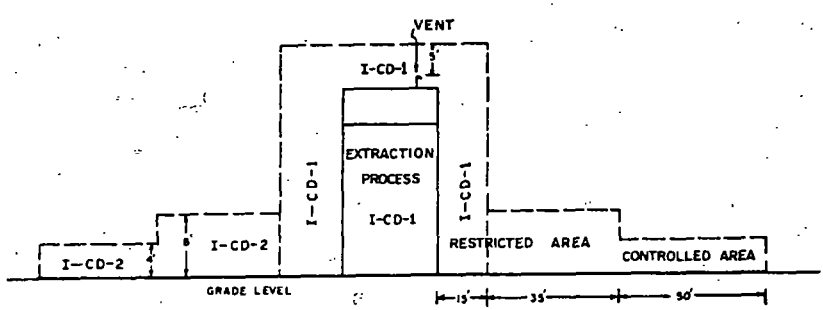
5430. Electrical wiring and electrical equipment within the controlled area and within four feet of the extraction process grade level, except the preparation process (see 5050), shall be installed in accordance with the requirements of Class I, Group C or D, Division 2 locations. *See Figure 1.*

5440. Permanent lights shall be installed where needed. Flashlights approved for Class I, Group C or D locations shall be provided.

55. Static Electricity.

5510. All tanks, vessels, motors, pipes, conduit, grating, and building frames within the process shall be electrically bonded together.

5520. Building frames and metal structures shall be grounded and tested periodically to determine electrical continuity. *See National Electrical Code, NFPA No. 70 and Static Electricity, NFPA No. 77.*



I-CD-1 CLASS I, GROUP C OR D, DIVISION 1

I-CD-2 CLASS I, GROUP C OR D, DIVISION 2

Fig. 1. Type and Extent of Hazardous Areas

5530. All hose except that used in fire service shall be electrically bonded to the supply line and to the tank or vessel where discharge takes place.

5540. Grounding wires or bonding connections shall be provided between any dispensing and any receiving vessel used for the transfer of solvent or mixtures of solvent and oil where bonding is not achieved through fixed connections. This shall include all sampling cocks.

56. Lightning Protection.

5610. Where needed, approved lightning protection shall be provided for the extraction process. *See Lightning Protection Code, NFPA No.* 78.

57. Process Equipment.

5710. Venting.

5711. Process equipment shall be a closed system and vented to the outside atmosphere through approved flame arresters installed in accordance with the conditions of approval. The manifolding of vents upstream of the flame arrester is permitted. Vents shall terminate at least 20 feet above the ground and be so located that vapors will not re-enter the building. Flame arresters shall be protected against freezing and shall be easily accessible for inspection and repair.

5712. Vessels or tanks containing flammable solvents shall be protected with emergency venting to relieve excessive internal pressure in the event of fire. This applies to such vessels as extractors, solvent work tanks, miscella tanks and solvent-water separating tanks. If the calculated required emergency vent capacity is less than the normal vent requirement, no additional emergency venting is necessary.

5713. The total capacity of both normal and emergency venting for vessels and tanks in the extraction process which are protected in accordance with Paragraph 2910 shall not be less than that derived from Table 1. For background information see Appendix A of *NFPA No. 30.*

5714. All emergency relief vents shall terminate at least 20 feet above the ground and be so located that vapors will not reenter the building or create a hazard from localized overheating of any part of a tank or structure.

TABLE 1

TOTAL MINIMUM EMERGENCY VENT CAPACITY IN CUBIC FEET FREE AIR/HOUR (14.7 PSIA AND 60°F.) WITH APPROVED AUTOMATIC WATER SPRAY, DELUGE SYSTEM, OR EQUIVALENT

Exposed Surface Area* Square Feet	CFH	Exposed Surface Area* Square Feet	CFH	Exposed Surface Area* Square Feet	CFH
20	6,300	200	63,300	1,000	157,200
30	9,480	250	71,700	1,200	167,100
40	12,630	300	79,500	1,400	176,100
50	15,810	350	86,400	1,600	184,200
60	18,960	400	93,600	1,800	191,700
70	22,110	500	106,200	2,000	198,600
80	25,260	600	117,600	2,400	211,200
90	28,440	700	128,400	2,800	222,600
100	31,500	800	138,600	and over	
120	37,800	900	147,900		
140	44,100				
160	50,400				
180	57,000				

NOTE: Interpolate for intermediate values. If tank or vessel is protected by approved insulation in addition to water spray, deluge system or equivalent protection as provided in Paragraph 2910, the flow capacities may be reduced by 50%.

*Exposed surface area means the exterior surface of a vessel or tank less that portion resting on a solid earth or concrete pad.

5715. Shutoff valves shall not be installed in normal or emergency vent lines.

5716. Flares from process vents shall be prohibited due to the possibility of flashback.

5720. Conveying Systems for Solids.

5721. Before entering the process, all solid material shall pass over or through a separator for the removal of tramp metal.

5722. Pneumatic systems for handling solids may be used when material and air being handled are solvent-free.

5723. Seals designed to prevent the escape of solvent or solvent vapors shall be provided at the point where the solids enter the system.

5724. Adequate seals shall be used on the final discharge of material from the extraction system.

5725. Gaskets, if used in these systems, shall be of a material that will not decompose or soften in the presence of oils, solvent or steam.

5730. Extractors, Desolventizers, Toasters, Driers and Spent Flake Conveyors: Extractors, desolventizers, toasters, driers and spent flake conveyors shall be of a design which minimizes the possibility of ignition of product deposits. It is recommended that such equipment be protected by smothering systems using inert gas, steam or a combination of the two, controlled from a safe remote location.

5740. Grinders.

5741. Only totally enclosed filters shall be used. Finished meal grinding after the drying cooling operation shall not be located in the restricted area. Such operations may be permitted in the controlled area only when conforming to the provisions of 5050.

5742. Finished meal grinding of materials as discharged from the desolventizer shall not be permitted.

5750. Miscella Filters: Only totally enclosed filters shall be used. Ventilation shall be provided to remove residual solvent vapors when filters are open.

5760. Waste Water Evaporation: Process waste water shall pass through an evaporator before entering separation sump.

5770. Pressure Vessels and Tanks.

5771. Unfired pressure vessels such as desolventizers and evaporators shall be constructed in accordance with the Unfired Pressure Vessel Code of the American Society of Mechanical Engineers.

5772. All large vessels shall be equipped with bolted and gasketed plates for inspection or repairs.

5773. Where sight glasses are installed they shall be of the high pressure type protected against breakage and loss of product. Hydraulic transmission or hydrostatic gauges shall be used for remote observation of liquid levels.

5774. Tanks shall be equipped with manual shutoff valves at the bottom.

5775. Armored type liquid level gages shall be used.

5780. Heat Exchangers, Condensers and Flash Drums.

5781. The water side of condensers and heat exchangers shall be kept at a greater pressure than the flammable liquid or vapor side.

5782. An emergency gravity water supply tank of sufficient capacity or a connection to an equally reliable water supply shall be provided to operate the solvent condensers to assure safe shutdown in the event of loss of primary cooling water.

5783. All steam condensate from the extraction process that is to be reused shall be reduced to practically atmospheric pressure in a vented vessel where any entrained solvent will be flashed off.

5790. Process Controls.

5791. Provision shall be made for emergency shutoff of steam, other than smothering steam, and shutdown of process equipment other than cooling water to condensers, exhaust fans, and lights. This shall be accomplished through manual operation both near the process equipment and at a safe remote location.

5792. Except where hazardous conditions would be created by stopping process equipment, all motor controls on such equipment shall be interlocked so that the stoppage of any piece of solids handling equipment will stop supplying material to the stopped equipment and so that all equipment conveying material away from the stopped unit will continue to operate. This interlock system shall be designed to require the proper start up sequence and shut down procedures.

5793. Audible or visual alarms or both centrally located shall be provided to indicate abnormal and hazardous conditions such as loss of steam, loss of cooling water pressure, failure of process pumps and aspirating and ventilating fans, fire alarms, and stopped motors.

5794. A temperature sensing device arranged to actuate audible and visual alarms shall be installed in the desolventizer to indicate when the temperature drops to a point where solvent carryover could create a hazard.

5795. Pneumatic or hydraulic controls and instruments may be used in place of electrical controls.

58. Flammable Vapor Detection.

5810. Approved portable combustible gas indicators shall be provided and maintained in good working order.

5820. It is recommended that an approved continuous sampling combustible gas detection system with audible and visual alarms be provided. Where such a system is used it shall be tested at least once each shift and maintained in good working order.

Locations where routine sampling has been found desirable include: raw material conveyor, desolventized material conveyor, finished oil or fat containers, waste water discharge and solvent and miscella pumps. It is important to maintain sampling lines free of deposits. The back blowing of these lines has been found to be effective.

APPENDIX A

GENERAL DESCRIPTION OF SOLVENT PROCESS

Physical Constants of Extraction Solvents.

The hydrocarbon fractions or petroleum naphthas known as normal hexane and heptane have become the predominant solvents for extraction of vegetable and animal oils and fats, because of their low cost, stability, excellent thermal qualities, and selectivity for oils and fats. Table I shows the physical properties of n-pentane, n-hexane and n-heptane. Table II shows a distillation analysis of petroleum naphthas of the n-pentane, n-hexane and n-heptane types.

TABLE 2

Physical Properties of n-Pentane, n-Hexane and n-Heptane

	n-Pentane	n-Hexane	n-Heptane
Flammable limits (per cent by vol.)	1.4–7.8	1.2–6.9	1.0–6.0
Ignition temperature Deg. F.	588	500	452
Flash point Deg. F. Closed Cup	–40	–15	25
Molecular Weight	72.1	86.2	100.2
Melting point	–206°F.	–137°F.	–130°F.
Coefficient of expansion	0.00154	0.00135	0.00122
Boiling point at 14.7 psia	96.9°F.	156.1°F.	208.0°F.
Specific gravity at 60°F	0.631	0.664	0.688
A. P. I. gravity at 60°F	92.7	81.6	74.2
Pounds per gallon at 60°F	5.261	5.536	5.736
Vapor density (air equals 1)	2.49	2.975	3.459
Cubic feet vapor per gallon liquid, 60°F., 14.7 psia	27.5	25.5	20.8
Vapor weight per cubic foot (lb. at 60°F.)	0.191	0.217	0.276
Vapor weight, cu. ft. per pound at 60°F.	5.23	4.61	3.63
Latent heat of vaporization at 760 mm B.t.u./lb.	153.0	143.3	136.8
Heat of combustion, B.t.u./lb. (gross)	21,120	20,970	20,860
B.t.u. per cubic foot vapor (gross)	4,016	4,762	5,508
B.t.u. per pound (net)	19,540	19,420	19,340
Vapor pressure at 100°F., psia	15.5	5.0	1.6
Specific heat liquid at 60°F.	0.540	0.531	0.530
Specific heat vapor at 60°F.	0.409	0.339	0.335
Solubility in water, moles per liter at 60°F.	0.005	0.0016	0.0005

TABLE 3

ASTM Distillation Analysis of Commercial Petroleum Naphthas of the Pentane, Hexane and Heptane Types

Per cent distilled	Pentane	Hexane	Heptane
Initial boiling point....	88°F.	146°F.	190°F.
5	89	148	194
10	89	148	195
20	89	149	196
30	90	149	197
40	90	149	197
50	90	149	198
60	91	150	199
70	91	150	199
80	92	151	200
90	93	152	202
95	94	153	203
Dry end point.....	97	156	208

One of the most important physical properties of pentane, hexane and heptane fractions, insofar as safety work is concerned, is the high density of the vapors. As shown in Table I, the vapor of hexane is 2.975 times as heavy as air and this accounts for the tendency of the vapors to flow across a surface and into low spots and confined areas.

Preparation and Pre-Cooking.

The preparation of oil bearing materials or solvent extraction varies as to original oil or fat content, physical characteristics of the material, type of extraction system and end products desired. The preparation of dead animal carcasses calls for different preparation technique than cotton seed, flax seed or soybeans.

Probably the simplest of the preparation techniques would be that of preparing dead animals for fat extraction. This can be accomplished by grinding the entire carcass in large grinders which shred the meat and reduce the bones to a consistency that may be handled in the cooker-extractor. After the cooker-extractor is charged with a load of meat, the cooking process is begun and the charge is cooked several hours or until the protein and other coagulable material is set and the moisture content is reduced to a point low enough to allow solvent penetration. After cooking is complete the free grease is usually drained off, the charge is cooled to the proper temperature after which the vessel is charged with the extracting solvent and batch-wise extraction is begun. In some plants the extraction process is accomplished in a separate building.

The end products of this type of process would be inedible fats for soap stock, fatty acids, etc., and tankage for animal feed mixtures. Where butcher shop meat scrap and other similar material is processed, there may be some variations in technique of grinding, prepressing or cooking but generally the process is the same.

In the above preparation process the meat after cooking may be prepressed in screw presses prior to solvent extraction in which case there would be a secondary phase of preparation to reduce the press cake to a consistency suitable for solvent extraction.

The preparation of soybeans for solvent extraction has, through a process of trial and error, become the most standardized preparation system of all of the oil bearing seeds. With variation only in the arrangement of components and method of material transport, all soybean preparation techniques are identical. The beans from storage or day run bin are cleaned, cracked, tempered and flaked. Some slight variation from plant to plant may exist as to whether the beans are metered to the process by means of a variable feeder or whether they are fed to the process through a dump scale or through both. Some plants may dehull during preparation; the beans may be cracked in any type cracking mill that will accomplish the proper reduction in particle size. The cracked beans may be tempered in any of the various tempering driers and there are several types and makes of flaking mills. Nevertheless, the four principal steps in the preparation of the soybeans for extraction invariably follow the sequence of cleaning, cracking, tempering and flaking.

There is still some difference of opinion as to the most efficient method of preparing cotton seed and flax seed for extraction. Some processors claim that efficient extraction of cotton seed or flax seed cannot be accomplished without prepressing as a step in preparation, while others hold that prepressing is unnecessary and costly. No doubt this difference of opinion will be resolved as time goes on but for the moment both methods will be considered.

The preparation of cotton seed for extraction under the direct method, that is without prepressing, consists of cleaning, delinting, dehulling, rolling and cooking. Variations in the above sequence of rolling and cooking have been and are still under experiment to determine the correct combination of particle size, cooking time, temperature, moisture content, etc. The toxicity of cotton seed meats due to their gossypol content is a determining factor insofar as the extent and place in sequence of the cook-

ing stage of the process. The prepressing by the use of screw presses as a stage of the preparation sequence is in itself a high temperature operation due to the cooking prior to prepressing and the frictional heat generated internally. Moisturizing, granulation and/or flaking usually follow prepressing.

The preparation of flax seed for solvent extraction generally follows that for cotton seed. Oil bearing seeds such as castor beans, sunflower, safflower, milo, peanuts, copra, tung nuts, etc., will fall within one or the other above methods.

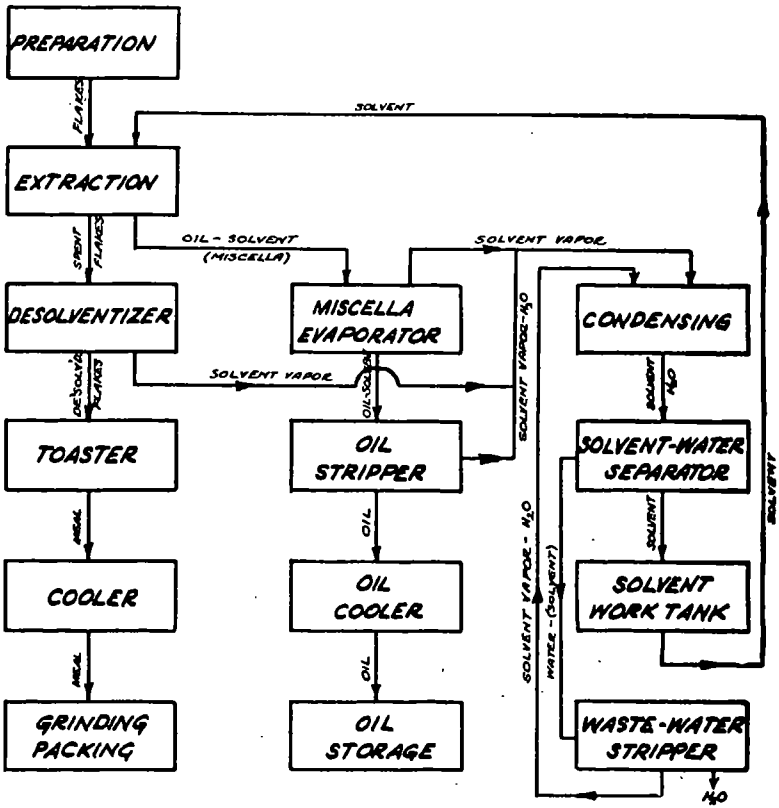


Figure 2. Generalized Flow Diagram.

Extraction.

The extraction of animal and vegetable fats by the use of hydrocarbon solvents as practiced today appears rather complex. This, however, is a manifestation of control, safety and automation rather than the basic principle of the extraction itself which is relatively simple. Fig. 2 is a generalized flow diagram of the solvent extraction process.

Despite the seemingly complicated array of equipment there are just three basic functions of an extraction plant, i.e., extraction, desolventizing and distillation.

In the extraction stage the oil is removed from the oil bearing material but after removal of the oil or fat the material remains saturated with solvent. This is removed by the desolventizer which drives off the solvent by the action of heat from both direct and indirect steam.

The miscella, as oil bearing solvent is termed, goes to the evaporator or distillation system, as it is sometimes called, where the solvent is driven off the oil by the action of heat, direct steam and vacuum.

The evaporation of solvent from vegetable or animal oil poses little difficulty inasmuch as the solvent has a relatively low boiling range, approximately 146° F. to 156° F. and most oils can withstand temperatures up to 250° F. for short periods without undergoing discoloration or polymerization. Thus, a wide temperature differential plus the use of stripping steam and high vacuum in the final stage facilitates desolventizing of the oil.

The function of various components of the extraction process is explained in detail under the specific headings that follow.

Basket Type Extractors.

There are several variations of the basket extractor such as vertical, rectangular and horizontal. In this type of extractor the material is carried through the extractor in individually hung perforated or screen bottom baskets. The baskets are pivoted on a longitudinal shaft located near the center of gravity of the basket. The ends of these are affixed in bearings which are part of endless chains. These endless chains run on sprockets at the top and bottom of vertical extractors and at each end of a horizontal extractor (Fig. 3). Tipping of the baskets is prevented by a system of rollers levered to the ends of the basket shafts and running or sliding in guide tracks fastened to the inside of the extractor. At one location during the circuit the baskets are in-

verted over a discharge hopper where the extracted material falls from the basket. As the basket passes the discharge position it is righted and immediately charged with oil bearing material. The number of baskets in the extractor is determined by desired throughput and design balance; 25 to 30 baskets would be usual.

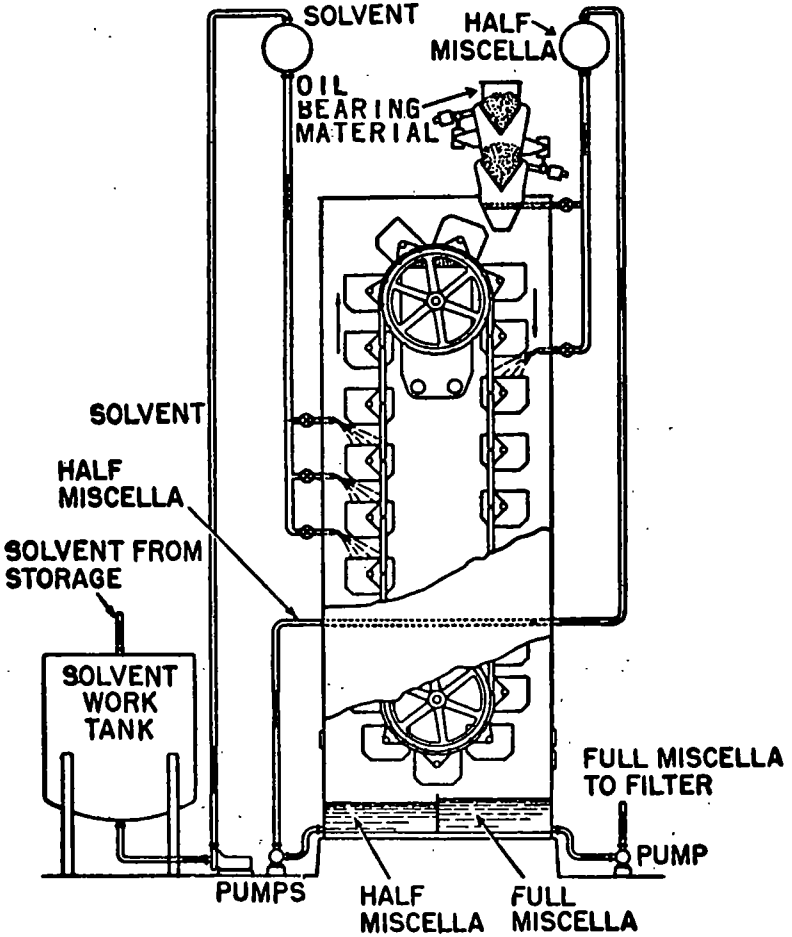


Figure 3. Vertical Basket Extractor.

There are two standard methods of feeding material to these extractors. One type is a double gate volumetric feeder which is timed to the extractor and dumps an even basket load of material

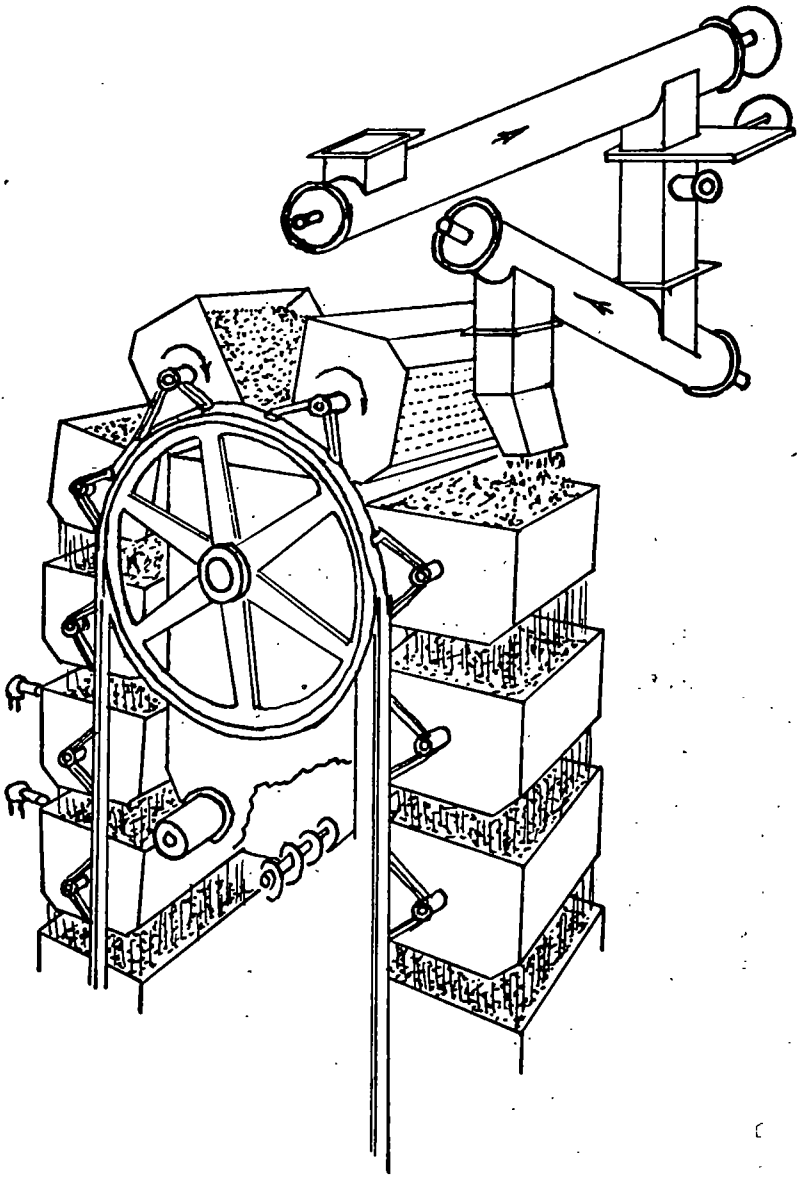


Figure 4. Feeder and Discharge of Basket Extractor.

as succeeding baskets are positioned under it (Fig. 3). The gates of this type feeder may be either mechanically or hydraulically operated. The other type of charging device is a continuous screw type which feeds a mixture of the oil bearing material and half miscella (Fig. 4). The extracted material from the discharge hopper is removed by rotary paddle conveyors or a mass flow type conveyor set in the bottom of the hopper.

Since vertical and rectangular basket extractors have both descending and ascending baskets and the extracting solvent and miscella is all descending, these extractors are known as concurrent-counter-current. The concurrent phase takes place from the time the baskets are charged until they reach the bottom of the extractor. During this phase half miscella from the bottom of the ascending side of the extractor is pumped to a surge tank above the extractor from whence it flows to a basket near the top of the descending side and percolates down through the baskets to the full miscella chamber at the bottom of the descending side (Fig. 3). Raw solvent is sprayed to one or more of the baskets near the top of the ascending side and in true counter flow percolates down through the baskets to the half miscella chamber at the bottom of the ascending side; thus, the cycle of solvent and material is completed.

Rectangular and horizontal basket type extractors are in principle quite similar to the vertical type with the exception that where baskets are running horizontally, a series of stage pumps are used to continuously pump the gradient concentrated miscella to spray pipes above the baskets.

Rotary Extractor.

In principle of operation a rotary type of extractor is quite similar to a horizontal basket type extractor. In construction, however, it is quite different. As Figs. 5 and 6 show, the rotating element consists of a series of concentrically arranged cells with a hinged perforated bottom in each cell. As each cell successively passes under the intake feeding device, a slurry of oil bearing material and half miscella fills each cell. The speed of rotation of the cell element and the continuous feed of material are so regulated that each cell is filled to the desired depth during its passage under the feeding device. While the rotating element is completing a revolution several stage pumps pick up the gradient concentrated miscella from several chambers of drain pans under the cells and spray it back onto the top of the cells.

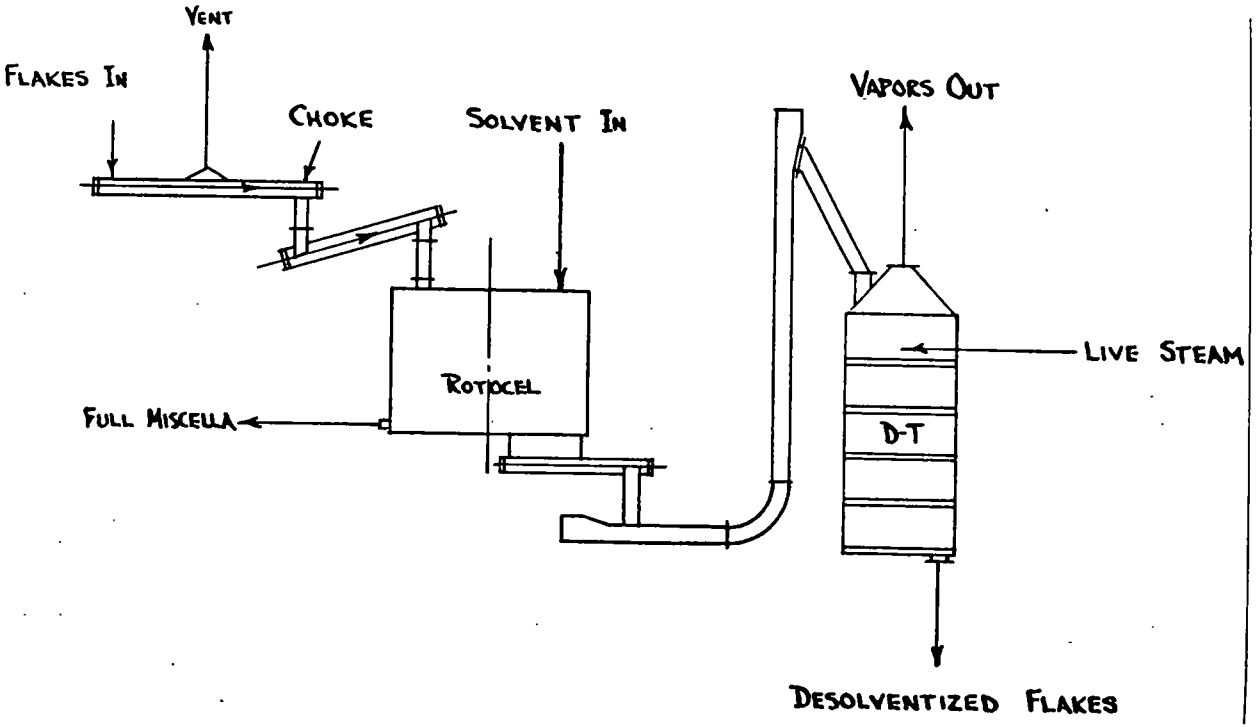


Figure 5. Rotary System.

At approximately two-thirds of the distance around from the intake, raw solvent is sprayed to the top of the cells after which the cells are allowed to drain free of excess solvent. After the draining stage the cells pass over a discharge hopper and as each cell is directly over the hopper, the cell bottom is tripped mechanically and the charge of spent material drops into the hopper. Immediately after passing this position the cell bottom is raised back into closed position mechanically and is ready for another charge of material. The spent material is continuously conveyed from the discharge hopper at a rate so regulated that at the time the hopper is empty another charge of spent material drops in.

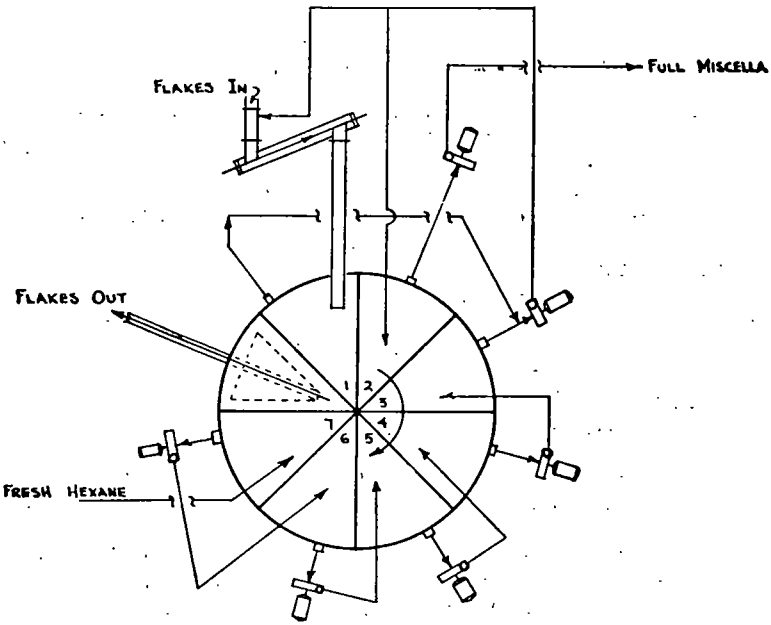


Figure 6. Rotary Extractor.

Perforated Belt Extractor.

A variation of the horizontal and rotary extractor is a horizontal perforated belt extractor in which the raw material is fed in a uniform depth onto one end of the slowly moving perforated belt and during its travel the length of the extractor, gradient miscella is pumped stagewise in very much the same fashion as the horizontal basket and rotary. Mechanically this extractor is perhaps the simplest of the horizontal types. What has been referred to as a perforated belt is in reality two endless chains running on sprockets at each end of the extractor, and attached to the chains and forming a flat surface are a series of perforated plates. Suitable chambers or pans are arranged the length of the extractor for collection of miscella stagewise. The spent material is continuously discharged off the end of the belt to a hopper, thence, continuously conveyed from the extractor.

Vertical Total Immersion Type Extractor.

This type of extractor has as its basic principle, the total immersion of the material in the extracting solvent during the entire extraction phase of the process. In the original U-tube type, total immersion was accomplished by introducing the oil bearing material into the top of one leg of the U-tube wherein it descended against a counter flow of miscella, passed through the horizontal section at the bottom of the U-tube, thence up the other leg and out the top. The oil bearing material was conveyed down, across and up by the use of large perforated flight screw conveyors. The raw solvent was introduced at the spent material end of the U-tube and the concentrated miscella was removed through an annular screen near the point where the oil bearing material was introduced.

In the single tube type, total immersion extractor (Fig. 7), the oil bearing material is introduced at the top of the extractor a short distance below the level of miscella after which it descends by gravity through a series of equally spaced plates with pie cut openings staggered in such fashion that the material cannot fall directly through the extractor but is retained for a short time on each plate. A slowly rotating sweep on each plate and attached to a central shaft maintains a constant rate of material feed down through the extractor. There are two types of spent material discharge devices in use. In one type the spent material enters heavy screw conveyors which push the material through a short tube and compact it against pressure loaded cones. As material is continuously forced against the plug it continuously

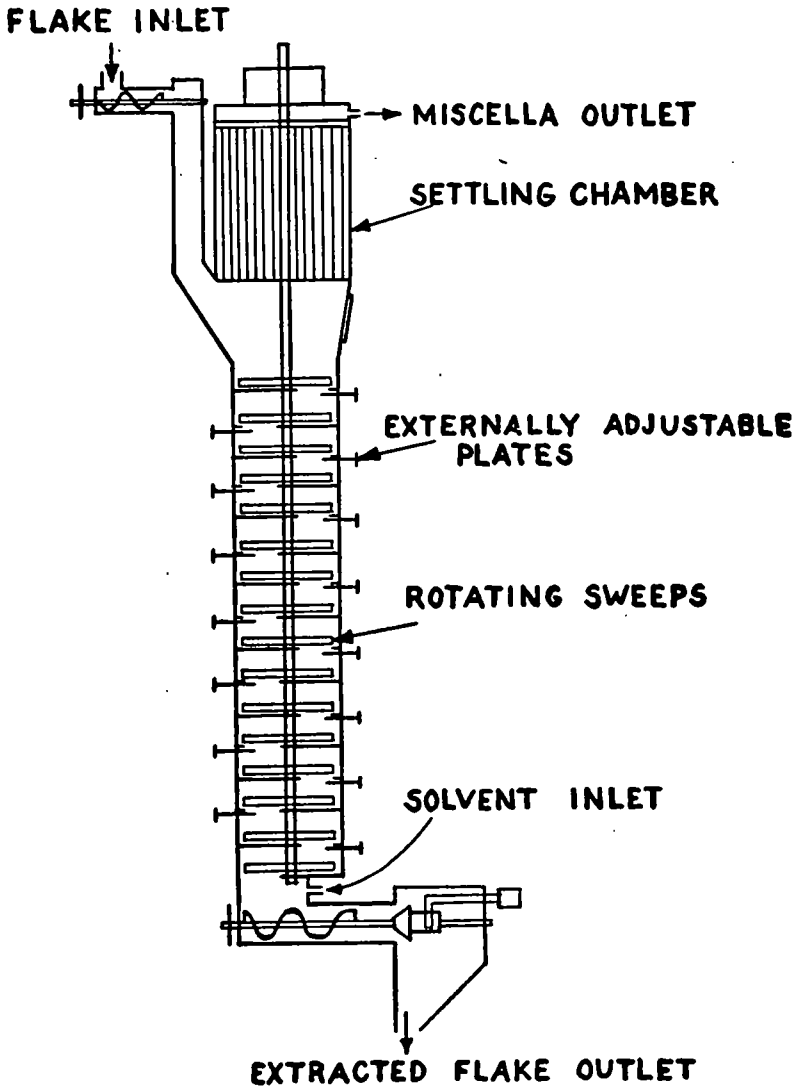


Figure 7. Vertical Total Immersion Extractor.