NFPA

36

SOLVENT EXTRACTION PLANTS 1978

NATIONAL FIRE PROTECTION ASSOCIATION
470 Atlantic Avenue, Boston, MA 02210

3M-12-78-FP
Printed in U.S.A.

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See Official NFPA Definitions at the back of this pamphlet.

SC-FM-78

Standard for

Solvent Extraction Plants

NFPA 36 — 1978

1978 Edition of NFPA 36

This revised edition of NFPA 36 supersedes the 1974 edition. This Standard was prepared by the Technical Committee on Solvent Extraction, approved by the Correlating Committee on Flammable Liquids, and adopted by the National Fire Protection Association on November 14, 1978 at its Fall Meeting in Montreal, Quebec, Canada. It was released by the Standards Council for publication on December 4, 1978.

Origin and Development of NFPA 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, 1972, 1973, and 1974.

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 1978 Edition

Amendments, other than editorial, are indicated by lines in the margin of the pages in which they appear.

Committee on Flammable Liquids

Correlating Committee

Paul C. Lamb, *Chairman*

Martin F. Henry,† *Secretary*

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Donald M. Johnson, Standard Oil Co. of California (rep. Western Oil & Gas Assn.)

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W. J. Smith, Underwriters Laboratories Inc.

E. C. Sommer, Exxon Research & Engineering Co. (rep. American Petroleum Institute)

Nonvoting Member

Dr. Ing. Gert Magnus, Branddirektor, Mannheim, Germany

Sectional Committee on Solvent Extraction

Paul C. Lamb, *Chairman*
Consultant, Fire and Accident Prevention

Martin F. Henry,† *Secretary*

F. M. Bloomberg, Riceland Foods (rep. National Council of Farm Cooperatives)

L. J. Hall, The Mill Mutuals (rep. Assn. of Mill & Elevator Mutual Insurance Co.)

J. Heilman, Continental Grain Co. (rep. National Soybean Processors Assn.)

Stephen R. Hoover, Kemper Insurance Companies

C. L. Kingsbaker, Jr., Chemical Plants Div. — Dravo Corp. (rep. American Oil Chemists' Society)

Stephen J. Lockhart, A. E. Staley Mfg. Co., Inc. (rep. Corn Refiners Assn., Inc.)

La Rue Medders, Lloyds, New York

N. Hunt Moore, N. Hunt Moore & Associates, Inc.

B. L. Shaw, Hartsville Oil Mill (rep. National Cottonseed Prod. Assn., Inc.)

R. I. Spencer, Industrial Risk Insurers

Alternates

G. W. Moore, Industrial Risk Insurers (Alternate to R. I. Spencer)

W. T. Trinker, The Mill Mutuals (rep. Assn. of Mill & Elevator Mutual Ins. Cos; Alternate to L. J. Hall)

Nonvoting Member

H. V. Keepers

†Nonvoting

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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Solvent Extraction Plants

NFPA 36-1978

Chapter 1 Introduction

1-1 Purpose.

1-1.1 This Standard is intended to:

1-1.1.1 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.

1-1.1.2 Provide a means by which fire protection directors and supervisory process personnel may evaluate the operations under their authority.

1-1.1.3 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.

1-1.1.4 Provide a workable set of standards for the use of design engineers, architects and others in planning and designing new installations.

1-1.2 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 as a base from which higher standards of loss prevention and fire protection may be achieved.

1-1.3 **Units.** Metric units of measurement in this Standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (kilogram and square centimeters), outside of but recognized by SI, are commonly used in international fire protection. If a value for measurement as given in this Standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate. The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

1-2 Scope.

1-2.1 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.

1-2.2 This Standard shall apply to all equipment and buildings within 100 feet (30.5 meters) of the extraction process except as provided in 1-2.3, 1-2.4 and 1-2.5.

1-2.3 This Standard also shall apply to the unloading and storage of solvent regardless of distance from the solvent extraction process.

1-2.4 Where the preparation department is housed separately and located a clear distance of 100 feet (30.5 meters) 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.

1-2.5 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.

1-2.6 This Standard does not include raw stock storage. Where grains or seeds are used, reference may be made to NFPA 61B, *Standard on Grain Elevators.*

1-2.7 Processes employing oxygen active compounds, such as organic peroxides, which are heat or shock sensitive are prohibited within the area described in 1-2.2.

1-3 Existing Plants.

1-3.1 The provisions of this Standard pertaining to design, layout and construction do not apply to existing plants. However, any major modification or expansion made to an existing plant shall enhance safety to life and property. Such major modification or expansion shall not be prohibited because of space limitations provided that an equivalent degree of protection, approved by the authority having jurisdiction, is achieved, and all other provisions of this standard are complied with.

1-4 Enforcement.

1-4.1 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

American Petroleum Institute (API), 2101 L St., N.W., Washington, D.C. 20037

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*, 16 volumes.

NFPA 10, *Portable Fire Extinguishers.*

NFPA 11, *Foam Extinguishing Systems.*

NFPA 13, *Installation of Sprinkler Systems.*

NFPA 15, *Water Spray Fixed Systems.*

NFPA 24, *Outside Protection.*

NFPA 30, *Flammable and Combustible Liquids Code.*

NFPA 61B, *Grain Elevators and Bulk Grain Handling Facilities.*

NFPA 61C, *Prevention of Fire and Dust Explosions in Feed Mills.*

NFPA 68, *Guide for Explosion Venting.*

NFPA 69, *Explosion Prevention Systems.*

NFPA 70, *National Electrical Code.*

NFPA 77, *Recommended Practice on Static Electricity.*

NFPA 78, *Lightning Protection Code;* NBS Handbook 46.

NFPA 91, *Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.*

NFPA 101, *Life Safety Code.*

NFPA 327, *Standard Procedures for Cleaning or Safeguarding Small Tanks and Containers.*

NFPA 704, *Standard System for the Identification of the Fire Hazards of Materials.*

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

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

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.)

1-4.2 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 Research 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.

1-5 Definition of Terms.

1-5.1 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 (15.3 meters) and 100 feet (30.5 meters) 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 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 (15.3 meters) 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 2 Basic Rules

2-1 General Requirements.

2-1.1 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.

2-1.2 Operating and maintenance employees shall be instructed in plant operations in general.

2-1.3 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.

2-1.4 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.*)

2-1.5 Sources of Ignition.

2-1.5.1 Electrical installations shall conform to the requirements of the *National Electrical Code* as hereinafter specified.

2-1.5.2 Provisions shall be made for protection against static electricity and lightning as required in other chapters of this standard.

2-1.5.3 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 restricted or controlled areas.

2-1.5.4 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.

2-1.6 Housekeeping.

2-1.6.1 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.

2-1.6.2 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.

2-1.6.3 Dust originating from material in process shall be kept to a minimum.

2-1.6.4 Except as provided in 5-2.7.2, 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.

2-2 Emergency Procedures.

2-2.1 All employees shall be trained in the necessary action to be taken in time of emergency including emergency shutdown procedures.

2-2.2 Personnel shall be thoroughly indoctrinated as to the location of exits.

2-2.3 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.

2-2.4 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.

2-2.5 Periodic drills shall be held in order that employees will carry out the above procedures.

2-2.6 Emergency safety devices or systems provided in the plant shall be periodically tested in accordance with established procedures and a record made thereof.

2-3 Repairs in Restricted and Controlled Areas When Plant Is in Operation or Unpurged.

2-3.1 **Power Tools:** Maintenance operations involving the use of power tools which may produce sources of ignition shall be prohibited.

2-3.2 **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.

2-3.3 **Welding and Cutting Operations:** Welding and cutting, including brazing and soldering operations shall be prohibited.

2-4 Repairs in Restricted and Controlled Areas When Plant Is Shut Down and Purged.

2-4.1 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.*)

2-4.2 Prior to initiating purging the following steps shall be taken.

2-4.2.1 Empty the tanks, vessels, piping and traps of all materials. All such material shall be removed to a safe location.

2-4.2.2 Disconnect, plug or blank off all piping and other connections to storage facilities.

2-4.3 Purging shall be accomplished by one or a combination of the following methods.

2-4.3.1 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 2-4.3.2 shall be followed when hot work is to be performed.

2-4.3.2 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.

2-4.3.3 Vapor freeing may be accomplished by purging with inert gas and then ventilating with air which minimizes the hazards inherent to passing through the flammable range.

2-4.4 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.

2-4.5 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 2-5.1.*)

2-5 Extractor Start-up.

2-5.1 Procedures for extractor start-up shall be established to minimize the hazard incident to passing through the flammable range. This may be accomplished by inerting to reduce the oxygen content.

2-6 Solvent Transfer Equipment.

2-6.1 Pumps.

2-6.1.1 Pumps shall be designed for the solvent, the working pressures and the structural stresses to which they will be subjected.

2-6.1.2 The use of air pressure as the solvent transferring medium shall be prohibited.

2-6.1.3 Where practicable all pumps handling flammable liquids in the processing equipment shall be located on the first floor level.

2-6.1.4 Pump houses, if used, shall be of noncombustible construction and ventilated.

2-7 Piping, Valves and Fittings.

2-7.1 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.

2-7.2 Pipe Systems: Pipe systems shall be substantially supported and protected against physical damage caused by expansion, contraction and vibration.

2-7.3 Process Piping.

2-7.3.1 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.

2-7.3.2 Aboveground flammable liquid pipe sections two inches (50 millimeters) in size or over shall be welded and flanged. Welding shall conform to good welding practice.

2-7.4 Drain Valves. Drain valves shall be provided with plugs to prevent leakage.

2-7.5 Pipe Connections: Pipe connections, two inches and over, to all tanks and vessels shall be bolted flanges that can be opened and blanked off.

2-7.6 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 (0.4 $Kg/centimeters^2$) at the highest point in the system. Tests shall continue for not less than 30 minutes without noticeable drop in pressure.

Exception: Vapor lines operating at less than 20 inches (50 centimeters) of water column.

2-7.7 Identification of Piping and Equipment: All piping and equipment shall be coded for identification.

2-8 Controls.

2-8.1 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.

2-8.2 Positive displacement pumps shall be provided with by-passes with pressure relief valves discharging back to the tank or to the pump suction.

2-9 Exits.

2-9.1 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.

2-10 Fire Protection.

2-10.1 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 NFPA 13, Standard for the Installation of Sprinkler Systems, NFPA 15, Standard on Water Spray Systems,* and *NFPA 16, Standard on Foam-Water Sprinkler Systems.*)

2-10.2 An approved system of automatic sprinklers shall be provided in the preparation building when within 100 feet (30.5 meters) of extraction process. (*See NFPA 13, Standard for the Installation of Sprinkler Systems.*)

2-10.3 A system of yard hydrants shall be provided in accordance with accepted good practice. (*See NFPA 24, Standard for Outside Protection.*)

2-10.4 Approved portable fire extinguishers of appropriate size and type shall be provided. (*See NFPA 10, Standard on Portable Fire Extinguishers.*)

2-10.5 Where standpipe and hose protection is installed, combination water fog and straight stream nozzles shall be provided. (*See NFPA 14, Standard on Standpipes and Hose Systems.*)

2-10.6 Fire alarm signals shall be relayed or sent to a constantly supervised point on or off the premises.

2-10.7 Where service is available a public fire alarm box shall be located nearby.

Chapter 3 Bulk Solvent Unloading and Storage

3-1 Location.

3-1.1 Unloading Site: These sites shall be located so that ignition sources presented by locomotives or tank vehicles are at least 100 feet (30.5 meters) from the extraction process and shall be at least 25 feet (7.6 meters) 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 (7.6 meters) from the extraction process.

3-1.2 Storage Tanks.

3-1.2.1 Bulk storage tanks shall be outside of any building. Underground tanks shall be located a minimum of one foot (30.5 centimeters) from existing building foundations and supports and at least three feet (9.2 centimeters) 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 (7.6 meters) from any important building or line of adjoining property which may be built upon.

3-2 Design and Construction.

3-2.1 Unloading Stations.

3-2.1.1 Unloading structures and platforms shall be constructed of noncombustible material and shall be designed and installed in accordance with accepted practice.

3-2.2 Storage Tanks.

3-2.2.1 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 NFPA 30, *Flammable and Combustible Liquids Code.*

3-3 Sources of Ignition.

3-3.1 Electrical Equipment: All electrical equipment and its installation shall conform to Class I Group C or D (depending on solvent used).

3-3.1.1 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.

3-3.1.2 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 (7.6 meters) horizontally from such racks or tanks, and upward from adjacent ground level to a height of 15 feet (4.6 meters). (*See NFPA 70, The National Electrical Code.*)

3-3.2 Static and Stray Currents.

3-3.2.1 All storage tanks, solvent transfer equipment, tank cars or tank trucks and unloading structures shall be effectively bonded.

3-3.2.2 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.

3-3.2.3 Static protection shall be installed in accordance with accepted good practice. (*See NFPA 77, Static Electricity.*)

3-3.3 Smoking and open flames shall be prohibited and appropriate "No Smoking" and "Keep Fire Away" signs shall be posted in conspicuous locations.

3-4 Fire Protection Equipment.

3-4.1 Approved portable fire extinguishers of appropriate size and type shall be provided. (*See NFPA 10, Standard for Portable Fire Extinguishers.*)

3-4.2 Additional fire protection for the unloading structure and bulk storage tanks shall be provided where an exposure hazard exists.

3-5 Unloading Procedures.

3-5.1 Adequate precautions shall be taken to relieve excessive pressure in cargo tanks before unloading.

3-5.2 Tank cars shall be unloaded in accordance with accepted good practice.

3-5.3 Tank vehicles for flammable liquids shall be unloaded in accordance with accepted good practice. (*See NFPA 385, Standard for Tank Vehicles for Flammable and Combustible Liquids.*)

Chapter 4 Preparation Process

4-1 Application.

4-1.1 The provisions of this chapter shall apply to preparation processes located within 100 feet (30.5 meters) of the extraction process.

4-1.2 Where the processing operations do not involve the generation of combustible dusts, 4-2.2 through 4-4.5 do not apply.

4-2 Construction of Building.

4-2.1 The building shall be of fire resistive or noncombustible construction and shall be without basement or pits below grade.

4-2.2 The building shall be designed to provide explosion relief of at least one square foot (1 sq. meter) for each 50 cubic feet (15 cubic meters) of volume.

4-2.3 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 hatches.

Reference may be made to NFPA 68, *Guide for Explosion Venting.*

4-2.4 Heating, if required, shall be provided by steam [15 psig (1 Kg/cm^2) maximum], hot water, or other devices approved for the location.

4-3 Electricity.

4-3.1 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 NFPA 70, National Electrical Code.*)

4-3.2 Static protection shall be provided in equipment located in areas where combustible dust presents a hazard. (*See NFPA 77, Static Electricity.*)

4-4 Dust Removal.

4-4.1 A dust collecting system shall be provided where necessary. (*See NFPA 91, Standard for Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.*)

4-4.2 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.

4-4.3 When fabric filters are used for the collection of dust, they shall be located either outside of the building, or in a fire resistive room along an outside wall inside the building. The inside room shall be explosion resistant and the outside walls or roof shall have explosion relief in the ratio of 1 square foot of relief area for each 30 to 50 cubic feet (1 sq meter of relief area for each 9 to 15 cubic meters) of room volume. (*See NFPA 61C, Standard for the Prevention of Fire and Dust Explosions in Feed Mills.*)

4-4.3.1 Automatic sprinklers shall be installed within fabric type dust collector housings.

4-4.4 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.

4-4.5 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 5 Extraction Process

5-1 Location of Extraction Process.

5-1.1 The solvent extraction process equipment shall be located in the open or in a building suitable for the purpose.

5-1.2 An industrial type fence shall be placed at a minimum of 50 feet (15.3 meters) from the extraction process. A controlled area shall extend from 50 feet (15.3 meters) to at least 100 feet (30.5 meters) 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.

5-1.3 Basements, tunnels, pipe trenches, and pits, except separation sumps, shall be prohibited within 100 feet (30.5 meters) of the extraction process.

5-1.4 Except as permitted in 5-1.5, the extraction process shall be at least 100 feet (30.5 meters) from any public thoroughfare, any building or line of adjoining property that may be built upon. The slope of the terrain and the prevailing winds shall be given consideration in locating the extraction process.

5-1.5 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 (30.5 meters) but more than 50 feet (15.3 meters) from the extraction process, provided a vapor barrier erected in accordance with the following requirements is provided.

5-1.5.1 The barrier shall be located between the extraction process and the possible source of vapor ignition and at least 50 feet (15.3 meters) from the extraction process.

5-1.5.2 The barrier shall be of noncombustible vapor tight construction without gates or other openings. The barrier shall be at least four feet (1.3 meters) in height and designed so that there is at least 100 feet (30.5 meters) of vapor travel around its ends to possible sources of ignition.

5-1.6 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

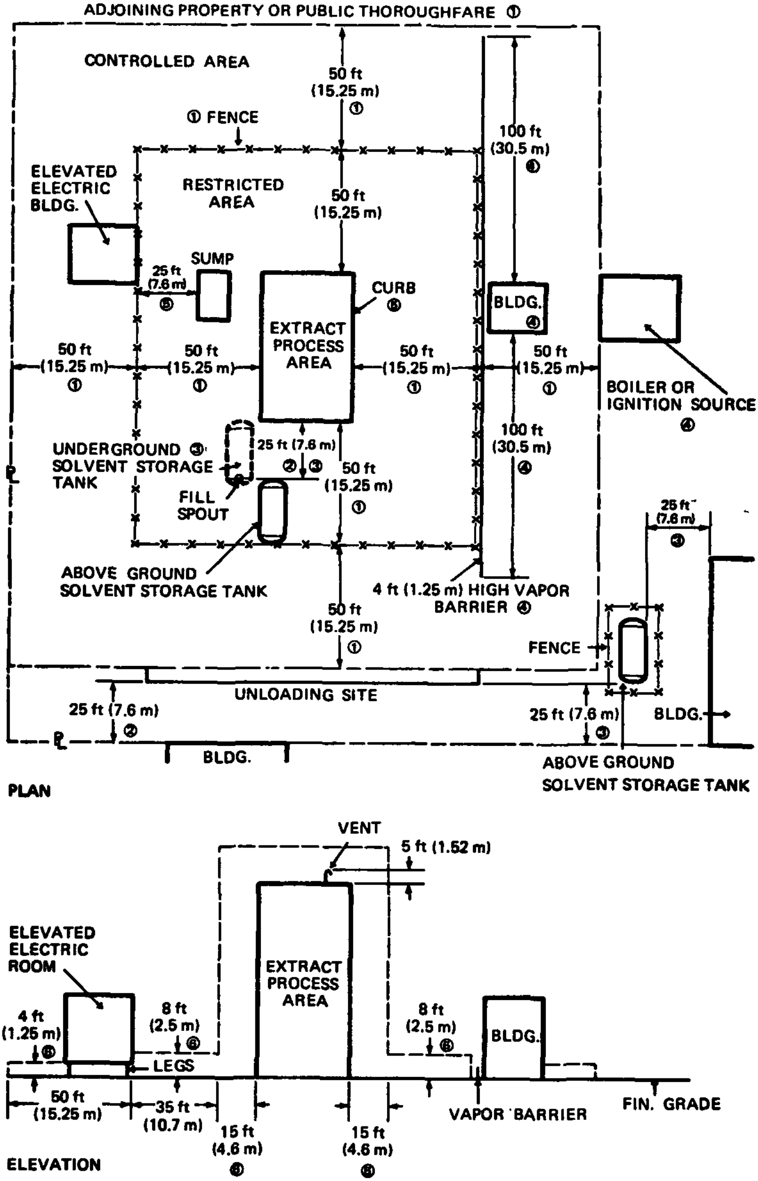

Figure 1. A typical distance diagram.

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1. 5-1.2, 5-1.4	3. 3-1.2	5. 5-2.4
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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.

5-2 Construction of Extraction Process.

5-2.1 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. Drainage lines under the ground floor slab of the extraction process are prohibited.

5-2.2 Explosion relief of at least one square foot for each 50 cubic feet (1 sq. meter for each 15 cubic meters) 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 NFPA No. 68, Guide for Explosion Venting.

5-2.3 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.

5-2.4 A sump shall be provided to effect separation of water from oils, solvents or miscella except possibly under fire conditions.

5-2.4.1 The separation sump shall be located within the fenced area but not closer than 25 feet (7.6 meters) to such fence.

5-2.4.2 The sump shall be concrete or equivalent noncombustible construction and influent and effluent lines shall be trapped.

5-2.4.3 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 percent of this amount.

5-2.4.4 Approved fixed automatic fire protection shall be provided above this sump when the sump is located adjacent to the extraction process.

5-2.5 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 a combination of the following methods:

(a) For other than pneumatic conveyors: by providing on the extraction end, continuous air aspiration to the outside and with a visual and audible 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 continuous 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 (2.5 meters) above the grade level.

5-2.6 Conveyors and spouts may be enclosed in adequately supported, noncombustible bridge structures equipped with open grate floor sections for ventilation.

5-2.7 A cooling tower, if provided, shall be located based on its construction and fire protection. (*See NFPA 214, Water Cooling Towers.*)

5-2.7.1 If the tower is noncombustible throughout, it may be located in the restricted area.

5-2.7.2 If the tower is of noncombustible exterior construction and protected by automatic sprinklers per NFPA 214, *Water Cooling Towers*, it shall not be located in the restricted area.

5-2.7.3 If the tower is combustible and unprotected, it shall not be located in the restricted or controlled area.

5-3 Ventilation of Extraction Building.

5-3.1 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.

5-4 Ignition Sources and Heating.

5-4.1 Except as provided in 2-1.5.4 and 5-1.5, no ignition sources shall be used within the building or within 100 feet (30.5 meters) of the process unless the unit and building are purged.

5-4.2 Heat, if required, shall be provided by indirect means. Steam, if used, shall be 15 psig (1Kg/cm² gage) maximum.

5-4.3 Power transmission belts shall not be used in or within 50 feet (15.3 meters) of the extraction process. V belts may be used for process blower drives only if provision is made for automatic shutdown in the event of motor overload or loss of normal airflow.

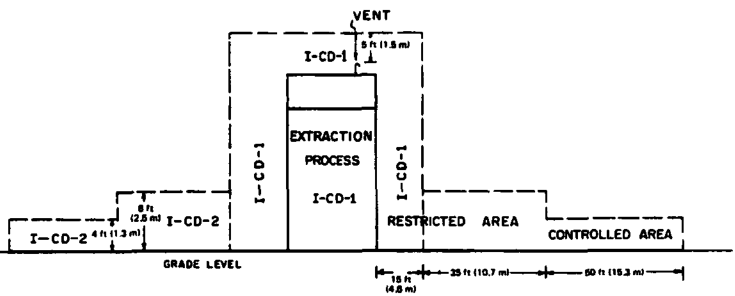
5-5 Electricity.

5-5.1 Electrical wiring and electrical equipment of the extraction process, outward 15 feet (4.6 meters) into the restricted area and vertically at least five feet (1.5 meters) 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 2.*)

5-5.2 Electrical wiring and electrical equipment within the restricted area beyond the 15-foot (4.6 meters) distance and to a height of eight feet (2.5 meters) 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 2.*)

5-5.3 Electrical wiring and electrical equipment within the controlled area and within four feet (1.3 meters) of the extraction process grade level, except the preparation process (see 5-1.5), shall be installed in accordance with the requirements of Class I, Group C or D, Division 2 locations. (*See Figure 2.*)

5-5.4 Permanent lights shall be installed where needed. Flashlights approved for Class I, Group C or D locations shall be provided.



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

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

Figure 2. Type and Extent of Hazardous Areas

5-6 Static Electricity.

5-6.1 All tanks, vessels, motors, pipes, conduit, grating, and building frames within the process shall be electrically bonded together.

5-6.2 Building frames and metal structures shall be grounded and tested periodically to determine electrical continuity. (*See NFPA 70, National Electrical Code, and NFPA 77, Static Electricity.*)

5-6.3 All hose except that used in water service shall be electrically bonded to the supply line and to the tank or vessel where discharge takes place.

5-6.4 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.

5-7 Lightning Protection.

5-7.1 Where needed, approved lightning protection shall be provided for the extraction process. (*See NFPA 78, Lightning Protection Code.*)

5-8 Process Equipment.

5-8.1 Venting.

5-8.1.1 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 (6.1 meters) 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.

5-8.1.2 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.

5–8.1.3 The total capacity of both normal and emergency venting for vessels and tanks in the extraction process which are protected in accordance with 2-10.1 shall not be less than that derived from Table 1. (See Appendix A of NFPA 30, for background information.)

5–8.1.4 All emergency relief vents shall terminate at least 20 feet (6.1 meters) above the ground and be so located that vapors will not re-enter the building or create a hazard from localized overheating of any part of a tank or structure.

5–8.1.5 Shutoff valves shall not be installed in normal or emergency vent lines.

5–8.1.6 Flares or burners from process vents shall be prohibited within the restricted and controlled areas. Flares or burners, if installed outside these areas, shall be equipped with approved devices to prevent flashbacks in the vent piping.

5–8.2 Conveying Systems for Solids.

5–8.2.1 Before entering the process, all solid material shall pass over or through a separator for the removal of tramp metal.

5–8.2.2 Pneumatic systems for handling solids may be used when material and air being handled are solvent-free.

5–8.2.3 Seals designed to prevent the escape of solvent or solvent vapors shall be provided at the point where the solids enter the system.

5–8.2.4 Adequate seals shall be used on the final discharge of material from the extraction system.

5–8.2.5 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.

5–8.3 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. Such equipment shall be protected by extinguishing systems using inert gas, steam or a combination of the two, controlled from a safe remote location. (*See 5–8.9.4.*)

5–8.4 Grinders.

5–8.4.1 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 5-1.5.

Table 5-1

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	Cubic Feet Hour	Exposed Surface Area* Square Feet	Cubic Feet Hour	Exposed Surface Area* Square Feet	Cubic Feet Hour
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				

Table 5-1(a)

Total Minimum Emergency Vent Capacity in Cubic Meters Free Air/Hour (1KG/CM² and 15.5°C) With Approved Automatic Water Spray, Deluge System, or Equivalent

Exposed Surface Area* Square Meters	Cubic Meters Hour	Exposed Surface Area* Square Meters	Cubic Meters Hour	Exposed Surface Area* Square Meters	Cubic Meters Hour
2	200	20	1870	90	4380
3	300	24	2070	100	4570
4	400	28	2260	120	4850
5	500	32	2440	140	5120
6	590	36	2610	160	5350
7	690	40	2780	180	5560
8	780	50	3140	200	5760
9	870	60	3480	230	6070
10	970	70	3820	260	6300
12	1160	80	4100	and over	
14	1350				
16	1540				
18	1730				

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 2-10.1, the flow capacities may be reduced by 50 percent.

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

5-8.4.2 Finished meal grinding of materials as discharged from the desolventizer shall not be permitted.

5-8.5 Miscella Filters: Only totally enclosed filters shall be used. Ventilation shall be provided to remove residual solvent vapors when filters are open.

5-8.6 Waste Water Evaporation: Process waste water shall pass through an evaporator before entering separation sump. (*See 5-8.9.4.*)

5-8.7 Pressure Vessels and Tanks.

5-8.7.1 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.

5-8.7.2 All large vessels shall be equipped with bolted and gasketed plates for inspection or repairs.

5-8.7.3 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.

5-8.7.4 Tanks shall be equipped with manual shutoff valves at the bottom.

5-8.7.5 Armored type liquid level gages shall be used.

5-8.8 Heat Exchangers, Condensers and Flash Drums.

5-8.8.1 The water side of condensers and heat exchangers shall be kept at a greater distance than the flammable liquid or vapor side.

5-8.8.2 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.

5-8.8.3 All steam condensate from the extraction process that is to be returned to the boiler shall be reduced to practically atmospheric pressure in a vessel where any entrained solvent will be flashed off.

5-8.9 Process Controls.

5-8.9.1 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.

5-8.9.2 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.

5-8.9.3 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.

5-8.9.4 Temperature sensing devices arranged to actuate audible and visual alarms shall be installed in the desolventizer and the water outlet from waste water evaporator to indicate when the temperature drops to a point where solvent carryover could create a hazard.

5-8.9.5 Pneumatic or hydraulic controls and instruments may be used in place of electrical controls.

5-9 Flammable Vapor Detection.

5-9.1 Approved portable combustible gas indicators shall be provided and maintained in good working order.

5-9.2 Provisions shall be made for monitoring the atmosphere in locations where flammable vapors may present a hazard. This may be accomplished by installing an approved combustible gas detection system with audible and visual alarms. 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 predominent 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 A-1 shows the physical properties of n-pentane, n-hexane and n-heptane. Table A-2 shows a distillation analysis of petroleum naphthas of the n-pentane, n-hexane and n-heptane types.

Table A-1

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 Btu/lb.	153.0	143.3	136.8
Heat of combustion, Btu/lb. (gross)	21,120	20,970	20,860
Btu per cubic foot vapor (gross)	4,016	4,762	5,508
Btu 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

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 predominent 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 A-1(a) shows the physical properties of n-pentane, n-hexane and n-heptane. Table A-2(a) shows a distillation analysis of petroleum naphthas of the n-pentane, n-hexane and n-heptane types.

Table A-1(a)

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. C	309	260	233
Flash point Deg. C Closed Cup	−40	−26	−4
Molecular Weight	72.1	86.2	100.2
Melting Point	−132°C	−93.8	−90
Coefficient of expansion per Dec. C	0.002772	0.00243	0.002196
Boiling point at 1Kg/cm² ABS	36°C	68.9°C	97.8°C
Specific Gravity at 15.5°C	0.631	0.664	0.688
A.P.I. Gravity at 15.5°C	92.7	81.6	74.2
Kg per liter at 15.5°C	0.63	0.663	0.687
Vapor density (air equals 1)	2.49	2.975	3.459
Liters vapor per liter liquid at 15.5°C and 1 Kg/cm² ABS	205	190	156
Vapor weight per liter, gms at 15.5°C	3.06	3.48	4.42
Vapor weight, liter per gm at 15.5°C	0.327	0.287	0.226
Latent heat of vaporization at 760 mm Kg cal/Kg	85	79.6	76
Heat of combustion, Kg cal/Kg (gross)	11,734	11,651	11,590
Kg. cal per cubic meter vapor (gross)	35,738	42,377	49,016
Kg. cal per Kg (net)	10,856	10,790	10,745
Vapor Pressure at 37.8°C, mm Hg ABS	801	258	82.7
Specific heat liquid at 15.5°C	0.540	0.531	0.530
Specific heat vapor at 15.5°C	0.409	0.339	0.335
Solubility in water, moles per liter at 15.5°C	0.005	0.0016	0.0005

Table A-2

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

Percent 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

Table A-2(a)

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

Percent Distilled	Pentane	Hexane	Heptane
Initial Boiling Point	31.1°C	63.3°C	87.7°C
5	31.7	64.4	90
10	31.7	64.4	90.6
20	31.7	65	91.1
30	32.2	65	91.7
40	32.2	65	91.7
50	32.2	65	92.2
60	32.8	65.5	92.8
70	32.8	65.5	92.8
80	33.3	66.1	93.3
90	33.9	66.7	94.4
95	34.4	67.2	95
Dry end point	36.1	68.9	97.8

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 A-1, 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 cooking 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.

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 then the basic principle of the extraction itself which is relatively simple. Fig. A-1 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 (63°C to 69°C) and most oils can withstand temperatures up to 250°F (121°C) 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.

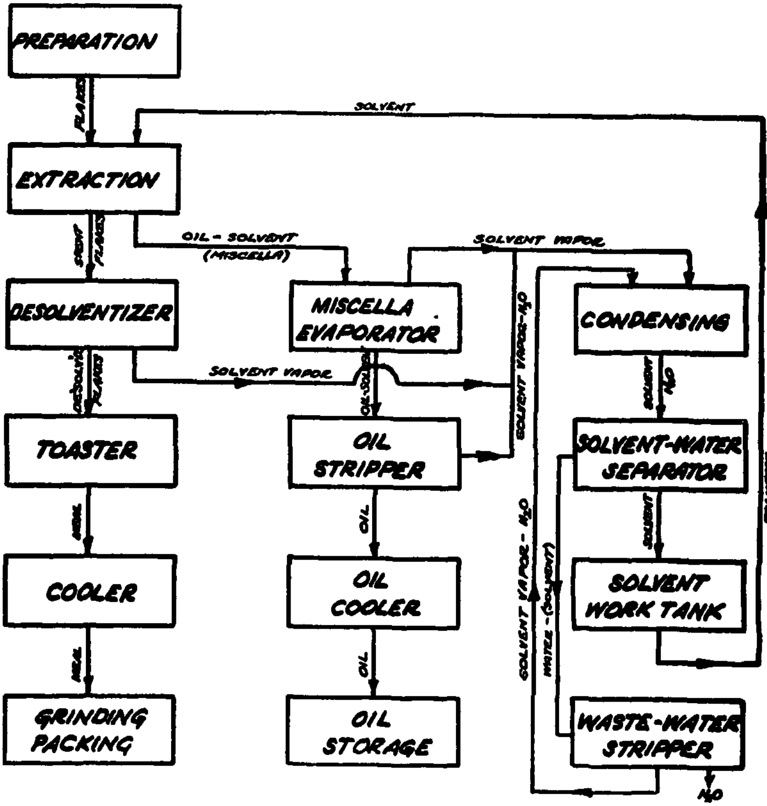


Figure A-1. Generalized Flow Diagram.

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 ex-

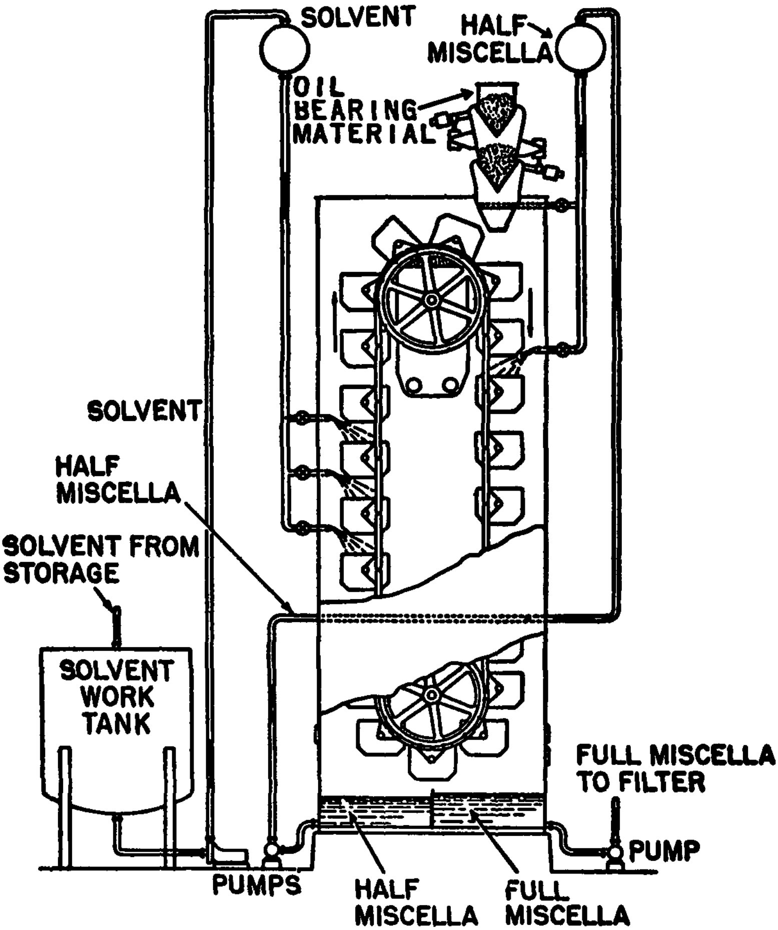


Figure A-2. Vertical Basket Extractor.

tractor (Fig. A-2). 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 inverted 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. 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 as succeeding baskets are positioned under it (Fig. A-2). 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. A-3). 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. A-2). 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. A-4 and A-5 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. At approxi-

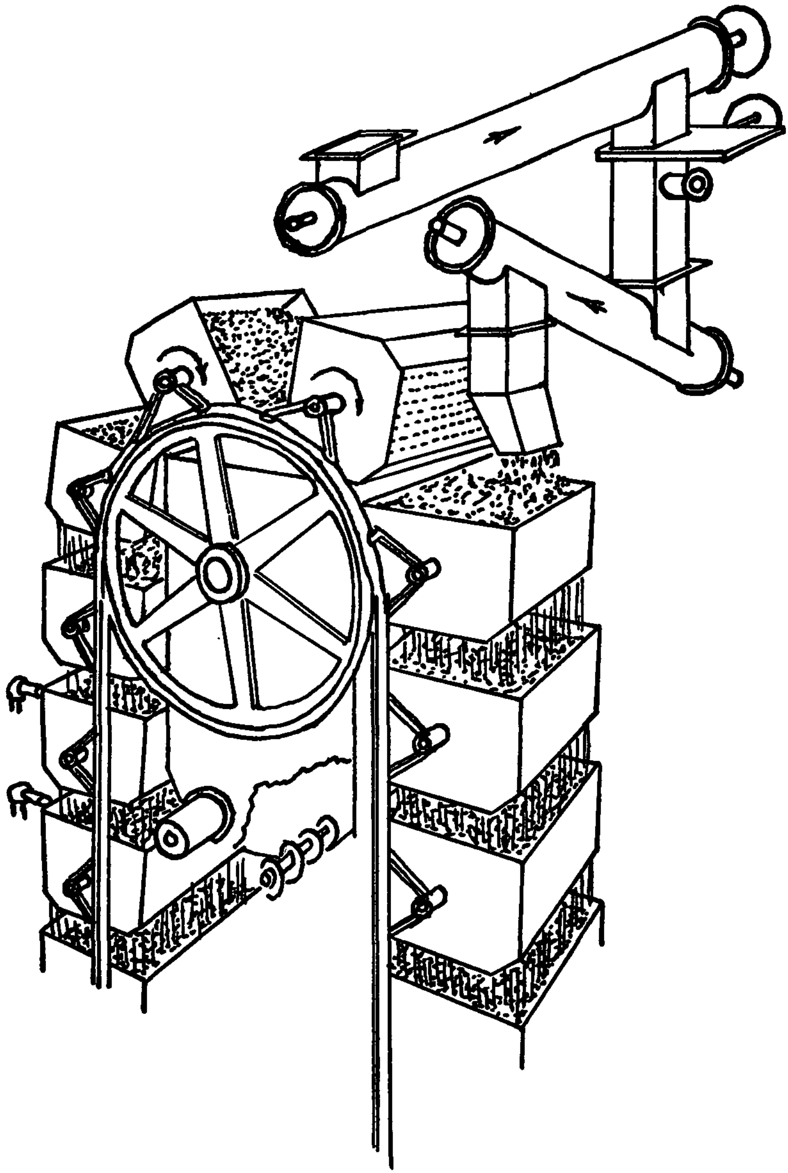


Figure A-3. Feeder and Discharge of Basket Extractor.

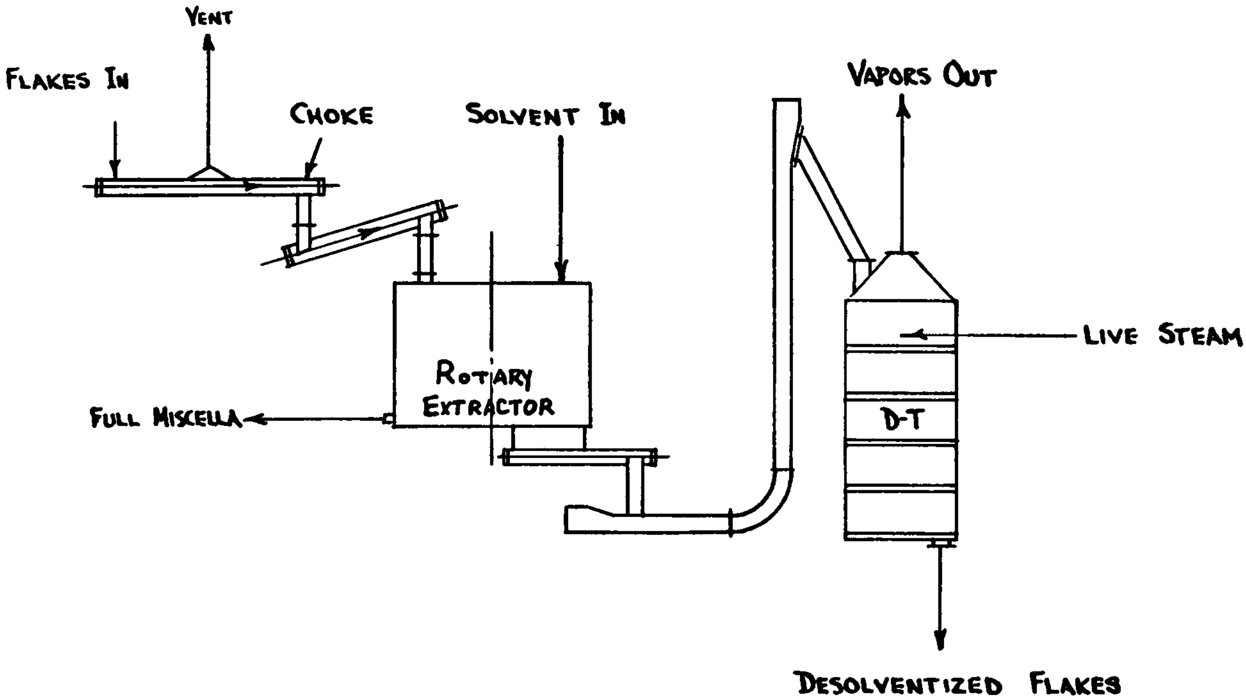


Figure A-4. Rotary System.

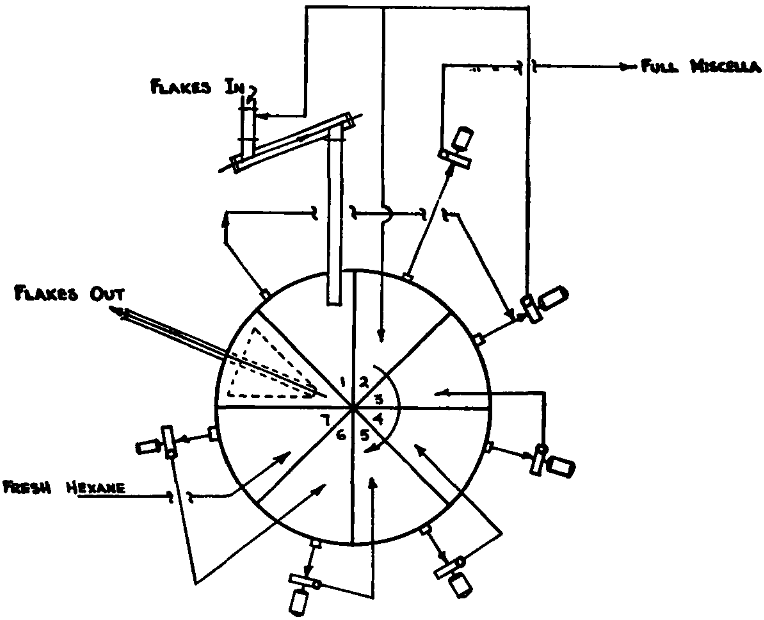


Figure A-5. Rotary Extractor.

mately 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.

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. A-6), 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 pres.ure loaded cones. As material is continuously forced against the plug it continuously feeds past the presure loaded cone in like amount. In this way a solvent impervious plug is maintained at the base of the extractor. Raw solvent is pumped to the bottom of the extractor and flows upward in counter flow relation to the descending oil bearing material. The concentrated miscella continuously overflows from a settling chamber at the top of the extractor.

The other type of material discharge consists of a liquid-tight inclined conveyor that picks up the spent material at the base of the extractor and elevates it to a point above the equalized level of liquid in the extractor. A drain screen as part of the inclined elevator drains the excess solvent from the spent material prior to dis-