Finished Oil Handling and Storage

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ABSTRACT

A finished oil is defined as that fat or oil product ready for use alone or as an ingredient without further processing. It represents the culmination, and carries the costs, of all the processing steps required to present it for use in its final desired form. The goal of finished oil handling and storage is to maintain the quality obtained through previous processing. Possible effects on quality through exposure to air, moisture, light, storage temperature, storage times, type of container, and physical movement of product are discussed. Also included will be a discussion of bulk handling of edible oil products.

FINISHED OIL HANDLING AND STORAGE

Margarines, in general, are not amenable to bulk handling due to their composition while shortening and oils may be handled either in smaller containers or in bulk. The factors that affect oils handled in bulk also apply to smaller containers, such as bottles, tins, cubes or drums. The one factor opperative in bottles and generally not in other containers is exposure to light. Such exposure can and will cause deterioration of an oil product; therefore, precautions should be taken to minimize such exposure. Elimination of oxygen and use of appropriately colored glass will both be of help in prevention of light-induced deterioration.

ADVANTAGES AND DISADVANTAGES OF BULK HANDLING

In making the decision whether to bulk handle or not, due consideration must be given to the disadvantages as well as the advantages. Bulk handling can be a virtual "must" for some customers and a practical impossibility for others. In practice, most users of fats and oils want to bulk handle because of potential cost savings.

Advantages of Bulk Handling

Some of the cost advantages of bulk handling are:

1. Elimination of shipping containers.
2. In most situations a reduced shipping rate is obtained.
3. Reduced labor cost due to more efficient unloading and handling of shortening within the user's plant.
4. Reduced waste of product. When using plastic shortenings, some product may adhere to cube liners or drums. However, some product is also lost when bulk handling as some oil will adhere to the side of shipping tanks or be lost in the unloading lines. This loss approximates 1/2 of 1% for most products.
5. The cost and sanitary problems associated with the disposal of used cubes, cube liners, cans or drums are eliminated.
6. The smaller storage area for bulk handled products can be of economic importance in some plants.
7. Generally improved sanitation throughout the plant.

Disadvantages of Bulk Handling

Some of the possible disadvantages of bulk handling to the customer are:

1. A rather sizeable capital investment required to purchase and install tanks, pumps and other essential equipment.
2. Possible higher costs in the purchase of the non-bulk handled fats and oils also purchased by the customer which can result in LTL shipments. With increased availability of compartmentized tank cars and trucks, this situation has been alleviated.
3. Bulk handling generally requires the attention of more skilled personnel for pumping, temperature control, metering, etc., than are generally used for simple unloading and handling of cubes or drums of product.
4. The customer, in the interest of economy, ordinarily purchases larger quantities when buying in bulk than when buying packaged products.
5. The possibility of deterioration of melted products if held too long or under the incorrect conditions before being used. Melted products are, generally, more susceptible to deterioration than are packaged products.

WHO SHOULD AND SHOULD NOT BULK HANDLE

Any users of fats and oils can bulk handle provided the product is suitable for handling this way and if a minimum sized shipment can be used within the storage life of the particular shortening. Thirty thousand pounds is ordinarily considered to be a minimum size bulk shipment. The storage life of shortenings varies with the type of fat involved and with handling and storage conditions. For example, lard conaining the proper antioxidants may be held in melted form for a longer time than if made without antioxidants. It is, therefore, suggested that a potential bulk handler discuss the storage life of his specific type of shortening with his supplier.

Shortening users who require a variety of different types of fats and oils may find bulk handling unsuitable for their operation. In such an operation, the customer may not use a sufficient quantity of any one type of fat to justify the installation of a bulk system.

Other customers may make types of product which require that the shortenings be in proper plastic form. This type of operation would require a more complex bulk handling system that could include chilling, tempering and other equipment. The expense and complexities of such an installation can be prohibitive in most situations.

FATS THAT CAN AND CANNOT BE BULK HANDLED

Almost all edible fats or oils can be bulk handled if the conditions are right.

Fats and Oils that Can be Bulk Handled

1. All salad and cooking oils.
2. Frying fats of all types.
3. All types of bread shortenings, whether hydrogenated or not; meat fat or vegetable fat emulsified or nonemulsified.
4. All products normally fluid and pumpable at ordinary temperature such as "fluid bread shortenings" or "fluid cake shortenings."
5. Shortenings to be used in most prepared mixes.
6. Cake shortenings containing high levels of some of the newer emulsifiers.

Fats and Oils that Cannot be Bulk Handled

There are several categories of edible fat products which are not usually bulk handled because their physical or functional properties are dependent upon proper plasticizing, tempering and resulting crystal structure. Products that we list as unsuitable for bulk handling are:

1. All types of margarines and water-whortening emulsions because the emulsions will "break" under heat, and the water will separate from the oil.
2. Lard or other shortenings intended to be used in the manufacture of pie crusts unless the processor is willing to (a) use extraordinary methods in the mixing of the pie crust dough, or (b) install chilling and tempering facilities.
3. Shortenings to be used by bakers in the manufacture of cakes and icings. The creaming properties (ability to incorporate air into a batter or icing) of these types of shortenings require controlled chilling and tempering conditions. Fluid cake shortenings and melted cake shortenings made with high levels of the newer types of emulsifiers are not included in this category.
4. Shortenings which contain significant quantities of lecithin are not usually bulk handled because they will darken when held melted for periods of time. However, if the product has a sufficiently low melting point, and the product is held at 120 F or lower, no visible darkening will occur.
5. Shortenings used as roll-in fats in the production of such bakery products as Danish Pastry are not suitable for bulk handling as the consistency of the products at the time of use is important.

EQUIPMENT REQUIRED FOR THE BULK HANDLING OF FATS

The discussion of the equipment required for bulk handling is divided into four sections:

D. Tank cars and tank trucks used for bulk shipments.
E. Equipment necessary for the unloading of liquid fats.
F. Equipment required for the storage of fats.
G. Equipment required to deliver the fat to the point of use within the users plant.

This discussion must be of a general nature and no attempt will be made to recommend specific equipment. However, the information can be helpful in visualizing a bulk operation. Copper or brass must not be used in the construction of any of the equipment that will come into contact with the fat or oil. Copper and brass have a deleterious effect upon the stability of fats and oils and accelerate their deterioration. The importance of accurate and continuous temperature control must be emphasized. Precise temperature control must be maintained in processing equipment, such as tank and frying kettles, at all times.

TANK CARS AND TANK TRUCKS

Rail Cars

Tank cars are usually rented by the shortening supplier from companies in the business of building and leasing this type of equipment. Railroads do not own or furnish tank cars used to haul liquid commodities such as fats and oils. By leasing the equipment, the shipper is able to maintain a tight control over the suitability, availability and utilization of the tank cars for the loading of edible fats and oils.

A company may, for example, lease a fleet of tank cars which are identified and designated for specific uses such as the hauling of either crude or refined oil products.

Size and Construction of Tank Cars

Tank cars are usually of either the standard size of 8,000 gallons (about 60,000 lbs) or jumbo size of 20,000 gallons (about 150,000 lbs.) capacity. A few small tank cars of about 30,000 lb. capacity are available, but are not generally used because of a higher shipping rate when compared to greater capacity cars. All rail tank cars are of black iron construction with heating coils built in. A few are available with insulation.

All of the various sizes and types of tank cars are constructed or designed to allow for the expansion of the contents during the possible heating before unloading. Standard size tank cars have domes that have a capacity of ca. 250 gallons. This is considered adequate to take care of ordinary thermal expansion of the contents. Jumbo tank cars do not have domes but do have a premanently installed bar marker in the manway. The quantity of product loaded should never reach above this marker allowing for as much as a 2% expansion of the product when heated. The rated capacity of the tank car does not include this 2% expansion space.

Tank Trucks

Except for the rare instance where the customer owns his own tank truck, the shipper provides the tank truck. Tank trucks are obtained from various motor carrier companies who specialize in this field of transporations.

Size and Construction of Tank Trucks

Tank trucks are almost any size up to about 45,000 lb. capacity. Shipments vary in weight up to this 45,000 lbs., but it is important to note that carriers charge for at least 30,000 lbs. for freight revenue.

Tank trucks vary widely in shape and construction and are almost always made of stainless steel. Tank trucks with heating coils should be specified for shipping shortenings that might solidify in transit. Most tank trucks are insulated and carry up to 15 feet of 3-in. hose and proper fittings to make connections at the receiving plant.

Tank trucks are provided with a marker bar to indicate maximum load level. As in the case of jumbo tank cars, this prevents loss of product due to expansion when heated.

Compartmentized Tank Cars and Tank Trucks

Compartmentized tank cars and tank trucks with separate coils and unloading facilities are available. Special arrangements are usually necessary to provide such equipment because it is not generally available. Jumbo tank cars are usually separated into compartments of 60,000, 30,000 and 60,000 lb. capacities or into two compartments of 75,000 lbs. each. Compartmentized standard size tank cars are most difficult to obtain, but when available are separated into two equal 30,000 lb. capacity compartments. Tank trucks are separated into two or three equal size compartments totalling 45,000 lbs.

Responsibility for Cleaning the Shipping Tank

The shipper of fats and oils must inspect all tank cars and tank trucks to make certain that they are clean and that all valves, seals and other associated equipment are in good working order. In the case of leased equipment, the shortening supplier has the responsibility for cleaning the tank car before loading. The cleanliness and condition of a tank truck is the responsiblity of the trucker, but the shortening supplier has the responsibility to inspect and reject any truck if considered unsatisfactory for use.

If a tank car or tank truck shipment of fats or oils should arrive in faulty condition, the buyer should immediately notify the shipper. The shipper shall then make an inspection or arrange with the buyer to correct the faulty condition.

Weights and Rates

If an 8,000 gallon tank car is used, the shipping rate is based on a minimum shipment of 60,000 lbs. and if a jumbo car is used, the 150,000 lb. minimum shipping rate is used. Thus, it becomes important to purchase edible fats and oils in full load shipments to avoid freight rate penalties. Tank truck shipping rates are based on various minimum weight loads of 30,000, 35,000, 40,000 and 44,000 lbs. at incentively lower rates. It is suggested that prospective bulk handlers work out details for both rail and truck deliveries with their supplier well in advance of using a bulk installation. It is better from many points of view to accommodate both rail and truck deliveries. A company should weigh all tank car and tank truck shipments before and after loading on official and/or regularly inspected State scales and furnish such weight tickets to the customer.

Demurrage

Purchasers of fats and oils have 48 hr free time after the first 7 A.M. after delivery in which to unload the product from a rail tank car and release the car to the railroad for return to the supplier. If a longer time is required, a demurrage charge is imposed. In the case of tank trucks, 1½ hr of free time is allowed for unloading after arrival at the customers unloading area. Obviously, close cooperation between the supplier and the buyer is required to avoid demurrage charges.

EQUIPMENT NECESSARY FOR THE UNLOADING OF LIQUID FATS

Hose and Fittings

The unloading of tank cars and tank trucks requires having the necessary fittings and adapters to connect the unloading line to the tank car or truck outlet. Tank cars, generally, require a 4 in. outlet connection. A 3-in. fitting is standard for tank truck outlets. However, either may be standard pipe thread or sanitary fittings. A flexible hose, 3 in. in diameter and of sufficient length, should be supplied by the receiver if none is available with the truck. This hose can be of carbon steel, certain types of rubber, plastic, aluminum or stainless steel (302,303,316).

Filters

A basket strainer should be installed prior to the pump section to prevent damaging the pump with tramp metal. It is also suggested that a filter be installed on the pump discharge to remove any extraneous materials. This filter should be installed so that it may be bypassed if it ever becomes necessary to pump partially solidified fats.

Pump

The unloading pump should be, preferably, of the positive displacement type, though a centrifugal pump may also be used. Stainless steel or carbon steel can be used. The pump capacity should be of sufficient size to unload an 8,000 gallon tank car (60,000 lbs.) in a minimum of two hours. Other factors to be taken into consideration when selecting a pump are: length of line; restrictions (such as elbows, valves, etc.) in the line; the height to which the fat is to be pumped, the type of fat; the temperature of the fat at the time it is pumped and whether the pump is located above or below the fat level in the tank. A relief valve must be installed to prevent damage to a positive displacement pump in case the discharge becomes blocked. This relief valve is not necessary if a centrifugal pump is used.

Utilities

Utilities that should be available close to the unloading station are air (or nitrogen if available) for blowing the lines and hot water or steam for heating. It is advisable to trace or insulate the unloading lines even if the fat is hot and liquid upon arrival. Varying weather conditions can make this necessary in some parts of the country.

Drain Valves

Drain valves should be installed at the lower points in the lines to prevent accumulation of fat which can solidify and cause a blockage.

The Unloading Area

The following are the requirements of the unloading area: the area must be level for tank cars, but for complete drainage, may require a slope towards the unloading end of the tank truck; the area beneath should be concrete and pitched towards a drain in order to drain off wash water and maintain good sanitation. A hot water wash-up hose connection and a steam connection for heating the tank car or tank truck contents in cold weather should be provided. All of these facilities should be within close proximity of the car of truck after spotting at the unloading location. If unloading is required after dark, provision should be made for adequate lighting of both the top and the bottom of shipping car.

TANK CAR AND TANK TRUCK UNLOADING PROCEDURES

Safety Precautions

After a loaded car has been spotted in the unloading position, blue flags or other accepted warning devices should be clamped to the rail in front of and behind the car as a warning to the train crew that other cars should not be switched on this track. The car should then be locked in place with the brake and wheel chocks placed under the wheels to prevent car movement. The car dome may then be opened.

Checking the Valve

At this time an inspection of the inside valve should be made to determine if it is properly seated. This is important in order to prevent loss of product. Normally, operating the valve a few times will seat it properly. Remove the test plug from the bottom outlet closure cap, noticing if there is pressure on the outlet. As a safety precaution, in case the load is released accidentally after removing the bottom closure cap, it is well to have on hand a wooden plug mounted on a board for the purpose of inserting into the tank outlet.

Leakage

If leakage is evident, try to seat the valve by opening and closing it several times. Failure to stop leakage means that the valve is defective and the car cannot be unloaded through the bottom connection. If this is the case, an overhead suction pump can be used to unload the shipment. The dome cover or unloading hatch must remain open during the unloading to prevent collapse of the tank car as product is withdrawn.

Connecting the Unloading Lines

After the valve is seated properly, the unloading suction line can be brought to the bottom opening of the car and connected. Set the unloading line to the correct storage tank and blow nitrogen or air through the line to check for blockage and to make certain that the product will go to the proper storage tank when unloaded. If the product in the car is liquid, unloading can begin. It is understood that there should be enough room in the receiving tank or tanks to hold the entire contents of the car. The tank should preferably be empty and previously inspected for cleanliness.

Melting the Shipment

If the load is in a solidified state, proceed to heat the contents with steam. Remove the end cap from the heating coil and connect steam to one opening and a bleeder valve to the other opening. Apply the steam through the coil slowly so as not to place a great deal of stress on the coil during its expansion. Gradually increase the steam pressure through the coil until a high enough pressure is attained to melt the load within a reasonable time. Circulating hot water through the coil is another way to heat the fat, although it will be found that the higher temperature of steam will reduce melting time. In either case, the product should not be heated over 150 F. It may be necessary to provide a means of agitation in order to reduce heating time and to avoid local overheating of the product. This can be accomplished by using either a mechanical agitator lowered through the dome of the car and extending into the fat or by means of recirculating the fat with a pump. After the fat is completely melted, pumping to the storage tank can begin.

Unloading the Fat

During the unloading, check the liquid level in the tank car to see that the pump is removing the fat from the car at the desired rate. Also, observe the liquid level in the receiving tank several times to prevent spills. If the fat is unloaded at a temperature below that at which it will be held in the holding tank, ample space must be provided to allow for the expansion of the fat when it is heated. After the unloading is completed, the inside of the car should be inspected for pools of fat. If they are present, it may be necessary for a man to put on a clean pair of boots, which are used only for this purpose, and to enter the car and push the fats to the suction line with a squeegee. While the man is in the car, a second man must be posted at the car dome as a safety precaution. If light is necessary inside the car, use a flashlight or a 32 volt extension cord. A 115 volt trouble light should *never* be used.

Securing the Car

After completely emptying the car, the inside valve is closed securely and the dome cover is fastened. Blow out the product line with air or nitrogen. Steam lines in the unloading section may then be disconnected. The bottom closure cap is screwed back on. It is preferred that the coil end caps be left off. Next, release the car brake and remove the wheel chocks and remove the flags from the track, thus signifying that the car can be moved.

Care of Equipment

Care should be devoted to the unloading suction line. In most cases it will consist of a special rubber or flexible metal hose. After use it should be disconnected at the wall, thoroughly drained of product and washed out with hot water. After drying, the end should be capped and the hose hung on a rack where it cannot be damaged.

STORAGE EQUIPMENT FOR FATS

Holding Tanks

Product holding tanks can be made of a variety of materials such as stainless steel, stainless clad steel, carbon steel, aluminum or reinforced polyester fiberglass. Wherever possible standard size tanks should be used. One quarter in. plate is usually used for construction. The size and shape of the tank storage room or area usually dictates the particular configuration of the tanks to be installed. For example, in a room with a low ceiling, horizontal tanks are necessary. In rooms where floor space is very limited, vertical tanks are usually installed. Rectangular tanks should be avoided where possible because of the higher fabrication cost and because they are more difficult to clean. Tank bottoms should be sloped toward the outlet valve for complete drainage of the tank.

Compartmentized Tanks

Some users of edible fats may use suitable quantities of two or more types of shortening to justify the installation of more than one holding tank. Others may use a lesser quantity of several types of fat and may find a compartmentized tank suitable for their use. Such a system will probably also require the use of compartmentized shipping tanks for bulk delivery of shortening supplies. The compartmentized tank may have a "hot melted" shortening in one side and, if properly insulated,hold a "room temperature fluid" shortening in the other side. The details of the feasibility of this type of handling system must be worked out with the close cooperation of the shortening supplier.

Tank Supports

Due consideration should be given to the design and strength of the tank supports. The supports can be built of concrete or steel and should be designed to distribute the weight evenly over adequate floor area. The area required, of course, depends upon the load strength of the floor. The tank supports should also be designed so that they can be cleaned easily and do not create sanitation problems.

Tank Openings

When designing a tank, the following openings will be required: two manhole openings, one near the bottom and another near the top; breather outlet; product inlet from unloading pipe; openings for heat circulation line; agitator opening; thermostat entry and product outlet line. It is recommended that the surface of gaskets be made of suitable material such as Teflon.

Heating Devices

After having selected the proper size and shape of the holding tanks, a method must be provided to hold the shortening in the melted or liquid state. It is advisable to hold melted shortenings at a temperature at least 10 F. above the melting point. Generally, a heating coil for either hot water or steam is used for this purpose. Steam at a pressure of 15 lbs. or hot water at a minimum temperature of 150 F. are satisfactory for this purpose. The shortening supplier should be consulted to determine the proper temperature to hold the shortening used.

When considering methods of heating tanks, it is advisable to avoid heating devices which produce surface temperatures above 250 F., as these higher temperatures tend to scorch the fat and deteriorate its quality. Electric immersion heaters can be used satisfactorily if the following precaution is followed strictly; good agitation must be provided by means of a mechanical agitator in order to avoid localized overheating of the fat. If in an operation the fat were to cool and solidify, it is difficult to remelt the fat without doing some damage to the fat unless the electric heat is applied only at short intervals allowing the heat to be distributed throughout the tank and avoiding localized burning of fat.

Heating coils should be installed in all tanks at the time they are made. Shortening users who anticipate using only "room temperature" liquid shortenings would be well advised to install heating coils even though the coils will not be used in the immediate future. Changing marketing conditions may dictate a future switch to "hot melt" shortenings rather than continuing the use of "room temperature" fluid shortenings. Other changing conditions may require that the customer use entirely different types of shortening than he now uses. It is much more economical to install coils into a tank while it is being fabricated than after it has been in use.

Heating coils should be built into the tanks near the bottom so that the coil will always be immersed in the oil. It is preferred that coils be built of 304 stainless steel. The added initial cost for this material is a good investment in minimizing maintenance costs and in assuring the moisture does not enter into the tank of product because of leaks caused by the corrosive action of the heating media. The coil should be made of 2 in. pipe. When steam is used to heat the tank contents, the coil must be installed level inside the tank in order to permit proper condensate drainage.

Insulation

It is advantageous to insulate the tanks in order to cut down heat loss and to eliminate localized chilling and solidification of the fat on the chilled walls of the tank.

Temperature Control

It is essential that a thermostatically regulated temperature control system be installed in all internally heated tanks. Such control systems can be obtained with either a recording or an indicating thermometer. In the latter case, operating personnel must make visual readings of product temperature on a regular basis. A recording type thermometer is recommended, as it provides a record of temperature control at times when supervisory personnel may not be in the plant. This recorder can be installed in a conspicuous location, such as a supervisor's office, to facilitate frequent temperature observations.

Hot Room Tanks

Another successful method of holding shortenings melted is to install the tanks in a room that will be externally heated. In this type of installation, the tanks and lines should not be insulated. Heating coils should be installed in tanks located in hot rooms. In case the room heating system fails, the coils can provide a stand-by system of keeping the fat melted.

Inventory Control

As with other ingredients, it is essential to have some means of knowning at all times how much fat or oil is in the holding tank. For this purpose, one can install either a level indicating device or load cells. Of these alternatives, the load cell is the most reliable. With the load cell type of system, the storage tank is installed on load cells which, in turn, transmit a signal to a weight recording or indicating meter. Thus, it is possible to have a continuous inventory of the tank content.

The simplest level indicating device is the glass gauge. When installed with steam or electrical tracing, satisfactory accuracy should be obtained. However, before taking a reading on a glass gauge, it is important to drain some fat through the bottom valve of the gauge in order to establish that the gauge is not blocked by solidified shortening. For inventory purposes, a calibrated stick or steel measuring tape can be used to obtain an estimation of the quantity of fat remaining in the tank.

Agitation In Tanks

Shortenings, even if held 10 F above their melting points, can stratify or separate. Cold drafts, blowing across part of the holding tank, can cause solidification on the sides of the tank. To overcome these possibilities, it is important that some type of agitation of the shortening be provided. Agitation also promotes efficient heat transfer and eliminates the possibility of localized overheating that can damage the fats' quality. There are several methods of agitating the fat or oil within the holding tank; recirculation with a pump, mechanical agitation either through the top or the side.

The more economical method of agitation is by recirculating the fat with a pump, drawing the product from one end of the tank and returning it to the other. With this type of agitation, as with any type of agitation, precautions must be taken to avoid all aeration of the hot shortening. It is, therefore, suggested that the return line reach near the bottom of the tank. This type of installation avoids the possibility of having a "free fall" of the shortening, resulting in aeration. In the recirculation type of agitation, the pump used for unloading fats from shipping tanks can be piped to do "double duty" by also acting as the recirculating pump.

In selecting the type and location of the mechanical agitator to be used, the size and configuration of the tank must be considered. Generally, a side entering agitator is used in vertical tanks, and middle mounted agitators are used in horizontal tanks. The middle mounted agitator should have a thrust towards the end of the tank. Mechanical agitators should be used only while the propeller is beneath the surface of the fat.

Prior to filling a tank, the agitator should be checked to establish that it is rotating the proper direction to move all of the shortening in the tank. Generally, mechanical agitators are required to keep lecithin from separating from shortening which contains this ingredient. It is suggested that mixer manufacturers be consulted for recommendations as to the size and type of agitator required.

EQUIPMENT REQUIRED TO BRING THE FAT TO THE POINT OF USE

Pump and Lines

The selection of a pump for delivery of fat to the point of use depends on the frequency and quantity of fat to be used in the process. It is recommended that a pump manufacturer's representative be consulted when ready to select a pump. A basket strainer with 1/8 in. openings should be placed into the suction line between the storage outlet valve and the pump. A quick connect-disconnect fitting connection must be tied into the suction line for the purpose of blowing the lines and clearing the lines of product upon shutdown.

Line Tracing

The pipes from the pump room to the point of use should be traced with steam and insulated to prevent solidification. It is always advantageous to install a filter in the line just before delivery to the point of use. In some installations it is desirable to install a loop and return the fat to the storage tank from the point of use, drawing off the fat for use only as required.

Using the Fat

The measurement of the quantity of fat going into process can be accomplished by volumetric containers, scales, meters or other means. If automatic meters are used, they must be calibrated frequently and recalibrated if shortening temperatures change significantly.

Preheater

If it should be necessary to install a preheater (such as is frequently used in frying operations), the usual precautions should be taken to avoid overheating and aeration of the fat at this location.

NITROGEN PROTECTION

When Nitrogen is Needed

Nitrogen protection should be considered in situations where the storage period is rather extensive and when products are held in the hot liquid state. Ordinarily, the stability of hydrogenated liquid oils is sufficient to resist the development of rancidity forming components over the normal period of storage in air. Should it be found repeatedly necessary to hold liquid oils for longer than normal periods, serious consideration should be given to replacing air containing oxygen with an atmosphere of nitrogen above the product in the storage tank.

It should be pointed out that nitrogen protection does not allow storage of product for indefinite periods of time. Other deteriorative processes which occur even in the absence of headspace oxygen necessarily limit the storage time. Also, poor quality fat cannot be upgraded by placing it under nitrogen.

Equipment Needed

In order to implement nitrogen protection, certain specialized equipment must be installed on and near the fat storage tank. Manufacturers of nitrogen gas can advise on the necessary equipment and cost of the nitrogen protection in a particular area. Generally, the necessary equipment consists of a nitrogen supply (usually a bank of high pressure cylinders), a pressure reducing valve with gauges, a gas rate control valve and a gas flow meter called a rotameter. The product holding tank to be blanketed with nitrogen must be protected against two possible occurrences, (1) failure of the pressure reducing valve to hold back the high pressure of the feed gas cylinders, and (2) failure to provide a gas flow. In either case, failure can cause serious damage to the holding tank. A pressure relief valve in a vacuum breaker installed on the tank will give protection against these types of equipment failures.

Safety Precautions

Extreme care should be exercised when personnel must enter any tank where nitrogen may be present. The absence of oxygen could cause injury or death due to suffocation. Consequently, the tank should be thoroughly purged with air in order to insure the safety of the person who is to enter the tank.

RECOMMENDED CLEANING PROCEDURES

In an existing operating plant, there is usually an established equipment cleaning program, with the cleaning compounds being furnished by one or more suppliers. If this is the case, the best procedure to follow in cleaning bulk handling equipment is to obtain technical recommendations from the company or companies providing the cleaning compounds. Part of the purchase price of cleaning compounds includes technical aid and guidance in their use; therefore, full advantage should be taken of this service.

In the situation where the bulk handler wishes to establish his own cleaning methods, the following procedures are suggested.

Cleaning Mild Steel (Black Iron)

For the first cleaning following construction, it is suggested that a chelated caustic type cleaner be used to remove the oils and metallic contamination resulting from construction. This should include not only the tanks but also the lines and pumps by circulating a cleaning solution. After this cleaning and a thorough rinsing, it is suggested that surfaces be treated with phosphoric acid in a concentration as strong as possible - usually about 75%. Circulating phosphoric acid through pumps and lines is not recommended unless it is of very short duration and can be followed immediately by a very thorough rinsing and drying.

Following the treatment with phosphoric acid and thorough rinsing and drying, it is suggested that tank surfaces be wiped down with the product to be stored in that tank. Product should then be pumped through the entire system until no visible discoloration is apparent in the product when discharged. Naturally, this product should be discarded.

The frequency of future cleaning depends upon the condition of the tank. If the tank remains free of objectionable odor after use, then an occasional rinsing with hot water is sufficient. If an objectionable off-odor is detectable, washing with a mild detergent followed by a thorough rinsing and drying is recommended. Pumps and lines usually do not require regular cleaning. This is especially true if they are kept full of product at all times. If the lines are kept full of product, air is excluded and gums and other undesirable films will not form.

The formation of rust in a black iron system can be prevented by completely eliminating moisture and coating all surfaces with oil. It is imperative that surfaces be dried thoroughly and wiped down with product after cleaning. Any possible condensation inside a tank should be prevented, as well as keeping all tanks covered to keep moisture from dripping into the tank from overhead waterlines, or other sources.

Cleaning Other Materials

Systems made from other than black iron may present special cleaning problems. This is not true of stainless steel and polyester fiberglass tanks, which can be cleaned easily using a variety of cleaning materials. Aluminum requires special cleaning compounds because of the corrosive action of alkaline cleaners which will pit the surface.

Cleaning-in-Place

Cleaning-in-place (CIP) should be considered because it eliminates some of the problems associated with cleaning, and it makes an expensive, difficult task much easier. CIP, however, requires special knowledge such as solution strength, velocity of solutions, etc., which are beyond the scope of both this paper and most plant personnel. It is suggested that expert help be obtained in the design of a CIP system.

One very good application of CIP is the installation of spray-type equipment for cleaning tanks. These may be installed permanently, or portable units may be obtained. The job of cleaning the insides of tanks is difficult for personnel, and the use of such equipment will probably do a much more effective job as well as eliminating what may be a personnel problem. Again, if this is contemplated, it is advised that an expert be consulted. The maker of such equipment usually provides technical aid at no extra cost.

GENERAL PRECAUTIONS REGARDING BULK HANDLING

In general, there are four factors that can cause a deterioration of fats and oils. These are (1) oxygen or air, (2) heat, (3) metallic contamination, and (4) time. All of these factors must be considered in the handling and storage of fats and oils. The above four factors are not necessarily listed in the order of their importance, but will be discussed in the order given. It should be noted that these factors are interrelated and their combined effects are more than additive; i.e., the presence of two factors may cause fat to deteriorate faster than twice the rate caused by either one alone.

When referring to deterioration in this discussion, we refer mainly to development of oxidative rancidity. Other forms of deterioration, such as hydrolysis, are usually not of concern in normal bulk handling at the user level.

Oxygen or Air

If one considers the following equation where

$$\text{fat} + \text{air} \xrightarrow[\text{metals}]{\text{heat}} \text{rancidity}$$

it can be seen that the elimination of air prevents rancidity.

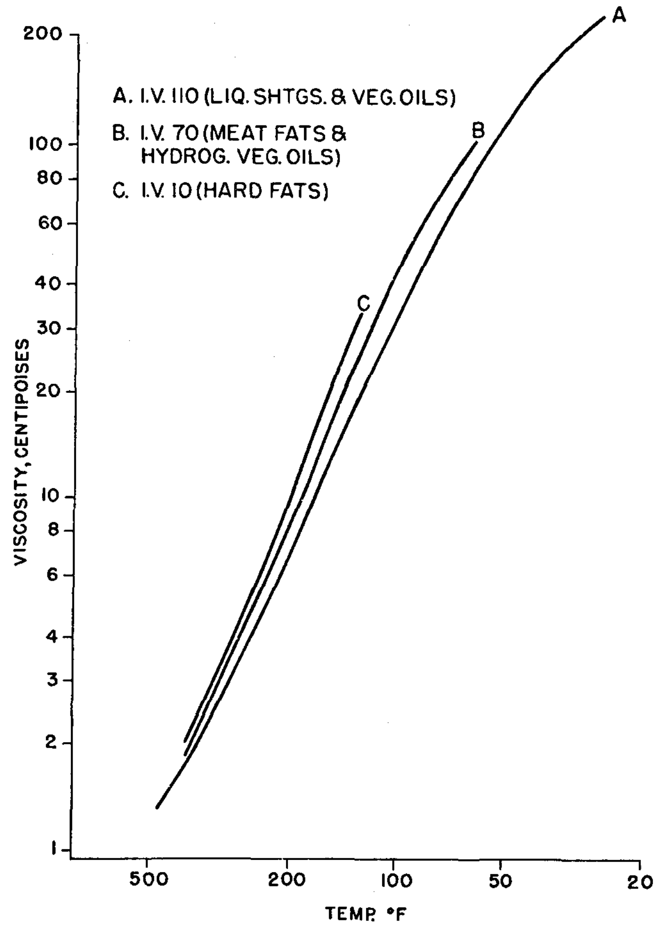

FIG. 1. Viscosity vs. temperature of liquid fats and oils of different iodine values.

Complete elimination of air, however, is not practical, and all that can be done is to minimize the incorporation of air wherever possible. Even when using nitrogen protection, oxygen may already be in the fat, and the product will eventually deteriorate.

For practical purposes, any steps taken to prevent the incorporation of air into the fat will be of help. Some of the more obvious faulty handling procedures to avoid are:

1. "Cascading" of fats, i.e., letting a liquid fat or oil fall through air into a tank. It is better to have subsurface entry.
2. Sucking of air into the suction side of pumps or line through faulty pump seals or fittings.
3. "Whipping" air into a fat by using improper agitation in the holding tank. The creation of a vortex or whirlpool is to be avoided.
4. Minimize the blowing of lines with air which may in turn bubble air through the fat or oil in the tank.

Heat

As in all chemical reactions, heat will increase the rate of the reaction and, therefore, the prudent use of heat becomes important. The best "rule of thumb" is to keep the fat no warmer than is necessary to allow handling in a practical manner. It is usually considered that holding a fat at 10 F above its melting point is sufficient. The design of a system may require variations from this "rule." For example, if the lines, pumps, etc., are all heat traced and are relatively short, a lower temperature may suffice, and, conversely, if lines are long and unheated, a higher temperature may be required. Every effort should be made in the design of the system to make possible the use of the lowest temperatures practical.

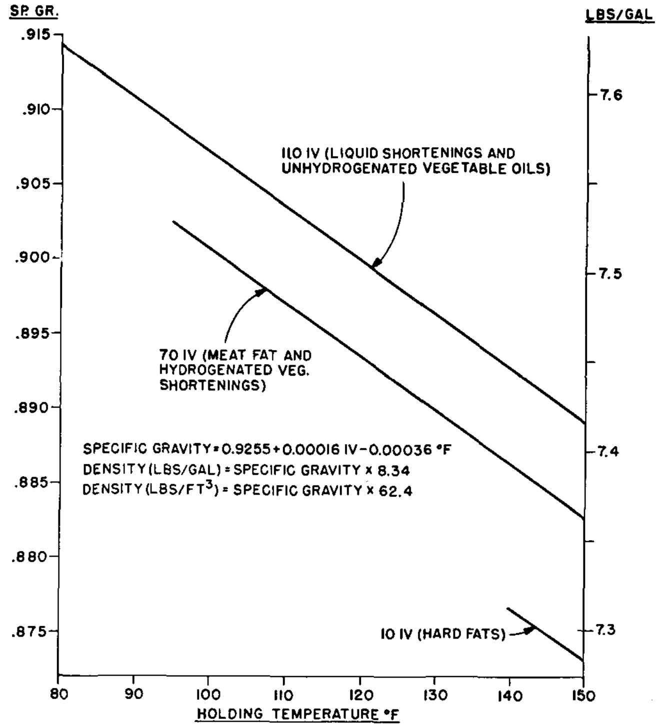

FIG. 2. Specific gravity and density vs. temperature bulk handled fats and oils.

Another practice frequently encountered is the local overheating of a fat or oil. This can be best avoided by providing agitation in all tanks equipped with heating devices. Power agitation will not only minimize fat damage due to local overheating, but will also save time and heating costs. If agitation is temporarily out of service, the temperature differential between the fat and the heating medium must be kept to a minimum.

Metallic Contamination

The two metals of practical concern are iron and copper. These metals are catalysts to fat oxidation and increase the rate of flavor, odor, and color deterioration. Copper is much more reactive than iron. It is likely that all fats and oils contain minor quantities of iron and copper. This content can be held to a very minimum with proper handling. Every effort should be made to prevent pickup of iron and copper, especially copper. In *no* case should copper, or any metal which contains copper, be used in a system where it will come into contact with the fat or oil.

In the case of iron, this prevention is impossible because most of the industry is based on mild steel (black iron) in the construction of tanks, pumps, lines, etc. Through proper treatment and cleaning of black iron, however, iron pickup may be kept to a minimum.

The use of stainless steel, plastic, or aluminum, does help prevent metallic contamination, but may introduce other problems, such as higher initial expense or (in the case of aluminum) cleaning problems, which usually restricts their use.

Time

When given sufficient time, any fat or oil will deteriorate even if handled under ideal conditions. No unbreakable rule can be given to define how long a particular fat or oil may be stored without deterioration. As a general rule, however, most fats and oils will keep under heat in a melted condition for 2 to 3 weeks. It is not considered good practice to repeatedly allow solidification and reheating of a product during use. If it is anticipated that storage be longer than two or three weeks, then the bulk handling system should be designed on a smaller scale so as to use the fat within a reasonable time.

Another major consideration besides holding time of product is to avoid mixing fresh shipments with those already in storage. Small quantities of old product in a tank may hasten the deterioration of new product mixed with it. This is primarily a scheduling problem. If a modified shipping schedule cannot be developed to improve the situation, an auxiliary tank large enough to hold the remainder of the previous shipment should be installed. This will also permit inspection and cleaning of the primary receiving tank.

OTHER PRECAUTIONARY CONSIDERATIONS IN BULK HANDLING

In addition to our previous considerations, there are a few additional precautions that warrant consideration.

The first of these is in pumping. In most cases centrifugal pumps can and are used, but in special cases where a positive pump is used special precautions on both sides of the pump are necessary. On the suction side of the positive pump a double check system should be used to avoid pumping from a closed vessel, thus avoiding danger of collapse of tanks or piping. On the discharge side, checking against closed valves, etc., is also recommended to prevent danger to personnel or less of product from blown fittings.

When necessary to heat product to maintain fluidity in a system, provision should be made to allow application of heat to lines, pumps and tanks. Insulation may be used to accomplish the necessary retention of heat; however, the ability to apply heat in an emergency situation is most desirable.

Another possibility is for a slow seeding out of hard fractions with time, even though the product is being held ostensibly above its apparent melting point. When this occurs the composition of the product changes at different levels in the tank and may even block lines. Application of heat and agitation may be necessary to obviate this problem. It is suggested that experimentation on the product be carried our at the projected temperatures and times to be sure this problem will not occur.

Close control of temperature in a system is necessary since pumping rates are dependent upon viscosity of the product which, in turn, is temperature dependent (Figure 1). Also, where volumetric means are used to control weights, it is absolutely necessary to control temperature. The effects of temperature on specific gravity or density are shown in Figure 2.

A final precautionary comment relates to bulk handling of emulsified systems. With some emulsion combinations, it is possible that the base oil product and the emulation system may separate with time. This should be determined by experimentation. If separation occurs it may be easily overcome by proper agitation.