Special Problems in Small Scale Operations

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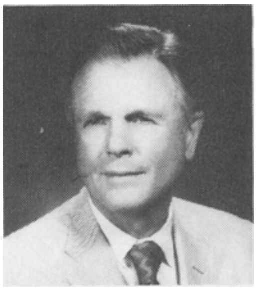


ABSTRACT

Initial design, start-up, processing, and inventory control problems in small scale refineries are discussed, together with suggested solutions.

Typical control forms for vegetable oil processing plants are illustrated, and suggestions are given on how to avoid common pitfalls and inefficiencies caused by lack of experienced personnel.

INTRODUCTION

This paper deals primarily with some of the planning and operational problems that a small scale refinery will encounter. For our purpose, a small refinery is defined as a plant processing anywhere from 10 to 50 tons of vegetable oil per 24 hr day. To the experienced processor, many of the problems described will be quite familiar, but, for the small operator, as well as those just going into business, this paper may be very helpful.

PROBLEMS IN PLANNING, DESIGN, AND INSTALLATION

Unfortunately, many problems start at the time the plant is first conceived and put into operation, and it would be expedient to quickly review them.

Plant Location

The refinery should be located close to the consumer market, usually a large city. However, to avoid traffic problems, to permit easier disposal of waste water, to have access to good roads and electric utilities, and to allow for urban growth, we suggest that the plant should not be closer than 3 miles to the city limit. However, to facilitate commuting by technical personnel, it should be located no farther than 15 miles.

Area Size

This should be sufficient to allow for future expansion. We recommend that there be enough ground to permit doubling the buildings on the refinery site at a later date. The minimum size of any small refinery should be at least 2.5 acres, or ca. 1.1 hectares, with an option to purchase an equal amount of ground at some future time.

Water

Refineries consume a considerable amount of water; therefore, there must be an adequate source, preferably well water, on the property. Assuming cooling towers are used, a rough figure of water make-up requirements would be 2 GPM per ton of oil to be processed. At the same time, there should be adequate provision for discharge of waste water into drainage systems.

Building Design

The general size and type should be based on the recommendations of the process engineers. However, local architects must handle and be responsible for the civil design. The buildings can be a steel frame or all concrete construction. In either case, the side walls should be nonsupporting so that they can be knocked out for expansion. The floor to ceiling height should be generous to allow for piping runs as well as to permit greater ventilation. We suggest 4.5 meters for each floor height.

Installation and Start-Up

The most common problem is the lack of qualified personnel. To avoid this, the future manager or plant superintendent, preferably with vegetable oil processing experience, should be hired at least a month prior to the arrival of the equipment at the plant site, or, even better, he should be employed at the time the equipment is purchased. This assures someone being at the plant site who is familiar with the overall process and the purpose of each item of equipment. Too many companies rely on local contractors without process experience to build and install their plant. Therefore, installation time is longer and serious errors in piping can result. Also, the lack of a qualified start-up man or commissioning engineer can have disastrous results for a small operator whose own personnel lack the essential know-how to get the plant running.

OPERATING PROBLEMS

Operating problems vary from plant to plant depending upon local conditions and the equipment being used. Nevertheless, certain problems are common to every vegetable oil refinery, so let's look at some of them.

Crude Oil Section

Problems start the moment crude oil arrives at the storage tank. Improper storage will either cause an increase of fatty acid in the oil or actual physical loss. To keep these problems manageable, the following precautions must be made:

1. Oil storage tanks should be cleaned and free of foreign matter. Tanks should be located on a concrete pad to keep free from surface water.
2. There should be a cleanout manhole on ground level starting ca. 6 in. from tank bottom.
3. Horizontal side entering agitators are needed to blend crude oils to assure uniformity.
4. For proper inventory control, oil in each crude oil storage tank must be measured at least once a day.
5. Once a week, samples should be taken to determine if there is any deterioration in quality.

Neutralizing Section

In a small plant, it is very possible that batch neutralizing is being used. Here, the skill of the refiner is most important; even so, problems may still occur.

1. Poor yield of refined oil can usually be traced to improper analysis or excessive use of caustic. If this is not the case, poor oil yield may be nothing more than careless operation of the swing pipe in the neutralizing tank. The operator cannot guess but must actually observe the oil being drawn off from the top of the tank. Also, poor formation of soap particles or soapstock in the oil will reduce the oil yield. If soap particles are soft and muddy, it usually indicates that the final refining temperature is too high—over 150 F— or that the lye used is too weak.
2. Soapstock in the oil is another problem. This can be the result of too short a settling time. One suggestion is to schedule the batch operation to start in the afternoon so

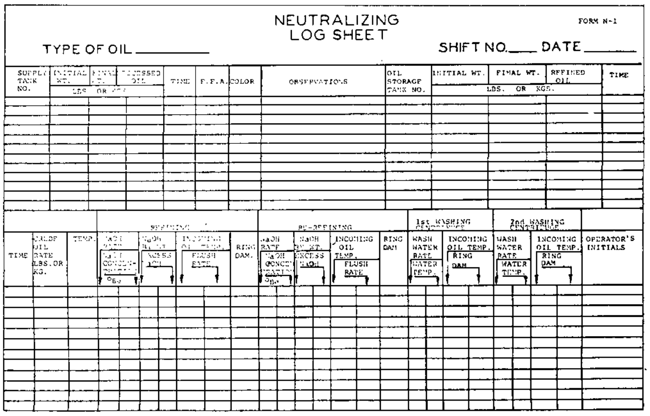


FIG. 1. Neutralizing log sheet (Form N-1).

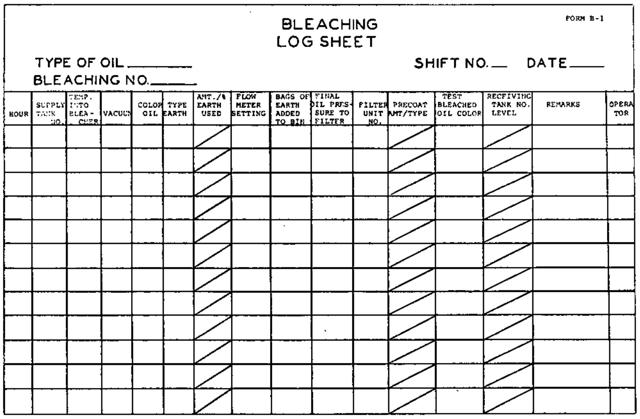


FIG. 2. Bleaching log sheet (Form B-1).

that the settling of the soapstock can take place overnight.

3. Deterioration of neutralized oil may occur if the oil is stored. This risk can be reduced by washing and drying the oil immediately after the refining process. Drying can be done either in a separate vacuum vessel or in the vacuum bleacher. (Oil should be dried down to <0.1% of moisture.) If any excess moisture remains, it will increase the chances of deterioration.

For those plants with a daily capacity of 20 tons or more, continuous centrifuges are generally used. Proper determination of caustic required must be made by laboratory tests on the oil to be processed. It goes without saying that efficient proportioning equipment for the controlled supply of oil and caustic must be used to obtain minimum losses. If metering pumps are used, calibration charts should be prepared to check the settings. Typical problems that can arise in the operation of a continuous centrifuge plant are as follows:

1. Motor failures can be due to improper motor selection, as these motors must be totally enclosed to keep out oil vapor which will otherwise quickly damage open type motors.
2. Reduction in refining rate can be the result of failure to backflush or change the bowls every 12 hr. Please note: any vibration of centrifuges must be corrected by immediate shutdown followed by repair or adjustment as required.
3. To minimize refining losses in oils such as cottonseed oil, it is recommended that the oil not be preheated before mixing with caustic.

A common problem in either the batch or continuous operation is the formation of oil emulsions. This is caused when water is mixed with cold oil. The temperature of the oil should be at least 150 F before adding water in the

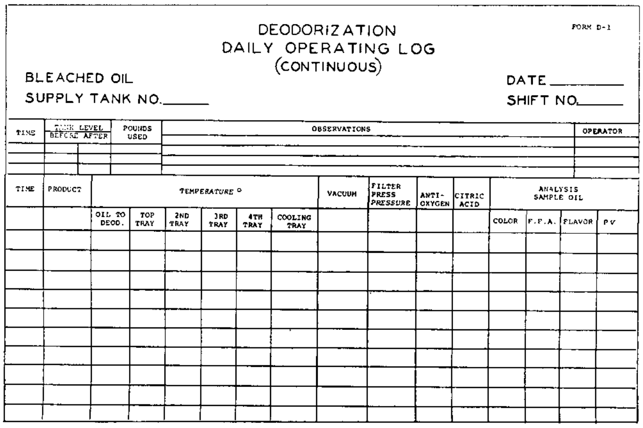


FIG. 3. Deodorization daily operating log (continuous) (Form D-1).

washing process. To assure proper operation of the refining section, a log sheet must be maintained, usually on a "per shift" basis. A typical log sheet is shown in the attached Form N-1 (Fig. 1).

Bleaching Section

In this section, whether it be batch or continuous, the selection of bleaching earth is of paramount importance. The processor will rely upon the recommendations of the suppliers of bleaching earth and upon the advice of his laboratory technician. To avoid other problems in bleaching:

1. Oil to be bleached must be dry, or it will reduce the efficiency of the bleaching clay and cause blinding of the filter cloth.
2. During the start-up cycle of the filter press or the tank type filter, care must be taken to see that the initial cloudy oil is returned to the bleaching unit rather than pumped to the bleached oil storage tank.
3. One of the most unsuspected causes of fire hazards can be from spent bleaching earth which, with some types of oil, can be self-combustible, especially if the material is piled in large heaps. This spent earth should be removed from the refinery building as soon as it is taken out of the press.

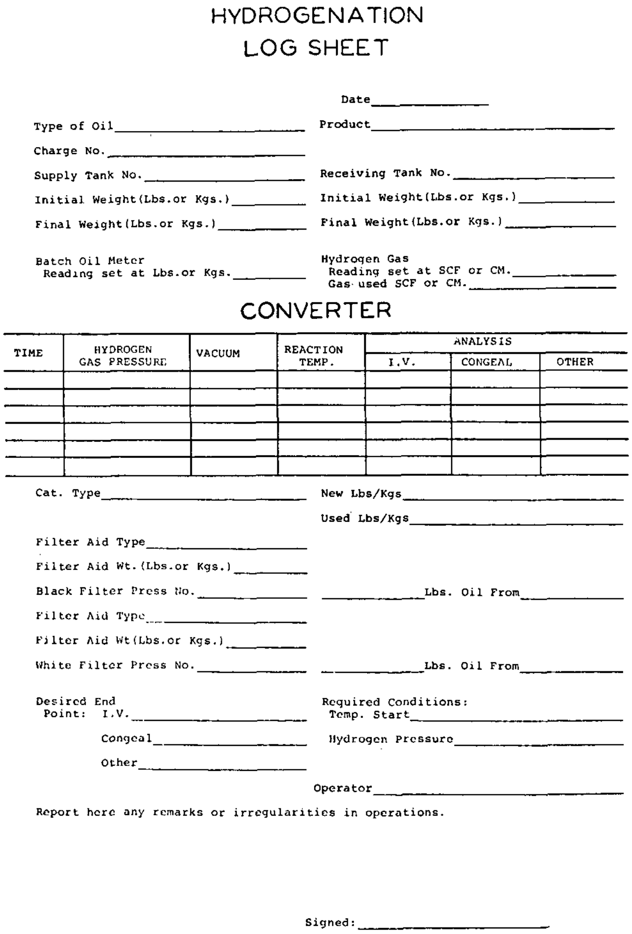
Again, log sheets should be used to avoid faulty operation and catch any errors. A suggested log sheet is shown in the accompanying Form B-1 (Fig. 2).

Deodorizing Section

The deodorizer for small plants also can be either batch or continuous. In both cases, the problems are similar, and among them are the following:

1. Loss of vacuum due to the drop in steam pressure serving the vacuum ejector system is usually caused by a sudden demand load on the boiler by other departments. This can be overcome by using ejector nozzles designed for an operating pressure of at least 25 lb below the boiler working pressure.
2. The water from the vacuum barometric condenser, which contains fatty acids, should be returned to a separate tower if reused and not mixed with any cooling water or condensate that might be returned to the steam boiler in order to avoid boiler damage.
3. Off-flavor oil quite often indicates that the deodorizer needs cleaning. This should be done every 3-6 months. It is desirable to operate either batch or continuous deodorizing on a continuous 24 hr cycle. Intermittent operation lowers production output because the initial oil in the start-up cycle must be returned for reprocessing due to oxidation which occurs during shutdown periods.

The operator of the deodorizer section should also fill


HYDROGENATION
LOG SHEET

Date________

Type of Oil________ Product________
Charge No.________
Supply Tank No.________ Receiving Tank No.________
Initial Weight(Lbs.or Kgs.)________ Initial Weight(Lbs.or Kgs.)________
Final Weight(Lbs.or Kgs.)________ Final Weight(Lbs.or Kgs.)________

Batch Oil Meter Reading set at Lbs.or Kgs.________ Hydrogen Gas Reading set at SCF or CM.________ Gas used SCF or CM.________

CONVERTER

TIME	HYDROGEN GAS PRESSURE	VACUUM	REACTION TEMP.	ANALYSIS		
				I.V.	CONGEAL	OTHER

Cat. Type________ New Lbs/Kgs________
Used Lbs/Kgs________
Filter Aid Type________
Filter Aid Wt.(Lbs.or Kgs.)________
Black Filter Press No.________ ________Lbs. Oil From________
Filter Aid Type________
Filter Aid Wt(Lbs.or Kgs.)________
White Filter Press No.________ ________Lbs. Oil From________

Desired End Point: I.V.________ Required Conditions: Temp. Start________
Congeal________ Hydrogen Pressure________
Other________
Operator________
Report here any remarks or irregularities in operations.

Signed:________

FIG. 4. Hydrogenation log sheet (Form H-1).

out a log sheet to assure proper operation of the equipment at all times. A typical sheet is shown in the attached Form D-1 (Fig. 3).

Hydrogenation

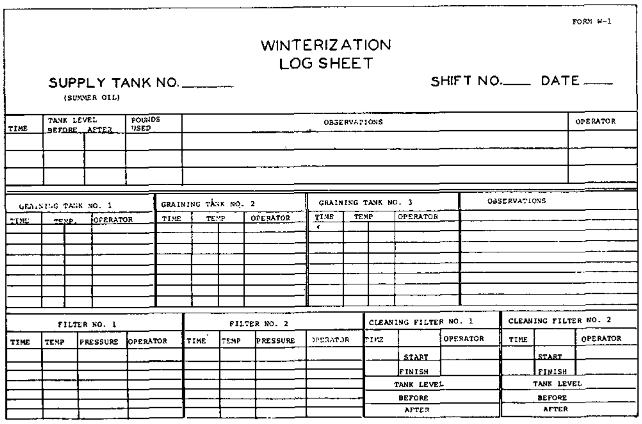
If hydrogenation is undertaken, this step is usually done before deodorization but after bleaching. The techniques are well known, and the individual suppliers of the equipment have detailed operating instructions.

1. For the small processor, the danger of fire or explosion is always present, but the seriousness is apt to be overlooked. To reduce this danger, the following points must be observed:
   a. The room must have a gas monitor, equipment to assure maximum ventilation, also blow-out lines to avoid the possibility of explosion due to the mixing of air and hydrogen. The catalyst filter press should be steam blown, not air blown, to reduce the possibility of a fire in the press.
   b. Before filling the hydrogenator, a vacuum must be pulled to remove all air before introducing hydrogen to avoid an explosion.
   c. Gas storage must be in a restricted, fenced off area.

A suggested log sheet (Fig. 4) is shown in the accompanying Form H-1, and you will see that a considerable amount of information must be recorded for each batch of oil hydrogenated.

Winterizing

This step applies primarily to cottonseed oil or to soybean oil that is partially hydrogenated. Assuming that a properly designed plant is installed, few problems will result. Nevertheless, there are important points to observe if the system is to run properly.

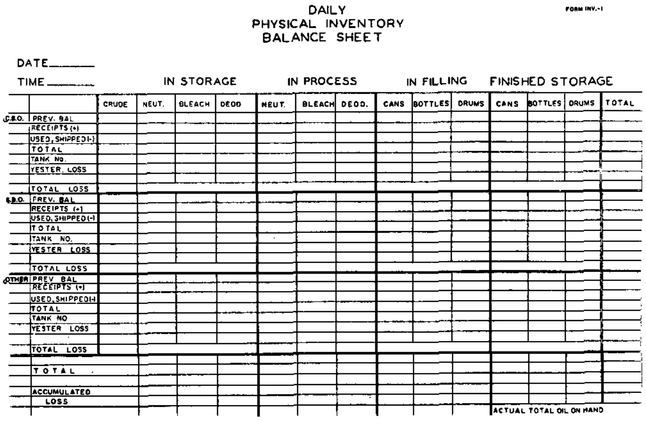

FORM W-1
WINTERIZATION
LOG SHEET
SUPPLY TANK NO.____ (SUMMER OIL) SHIFT NO.____ DATE____

TIME	TANK LEVEL BEFORE	AFTER	POUNDS USED	OBSERVATIONS	OPERATOR

GRAINING TANK NO. 1			GRAINING TANK NO. 2			GRAINING TANK NO. 3			OBSERVATIONS
TIME	TEMP.	OPERATOR	TIME	TEMP	OPERATOR	TIME	TEMP	OPERATOR	

FILTER NO. 1				FILTER NO. 2				CLEANING FILTER NO. 1			CLEANING FILTER NO. 2		
TIME	TEMP	PRESSURE	OPERATOR	TIME	TEMP	PRESSURE	OPERATOR	TIME		OPERATOR	TIME		OPERATOR
									START			START	
									FINISH			FINISH	
								TANK LEVEL			TANK LEVEL		
								BEFORE			BEFORE		
								AFTER			AFTER		

FIG. 5. Winterization log sheet (Form W-1).


DAILY
PHYSICAL INVENTORY
BALANCE SHEET
FORM INV.-1

DATE____
TIME____

		IN STORAGE				IN PROCESS			IN FILLING			FINISHED STORAGE			
		CRUDE	NEUT.	BLEACH	DEOD	NEUT.	BLEACH	DEOD.	CANS	BOTTLES	DRUMS	CANS	BOTTLES	DRUMS	TOTAL
C.S.O.	PREV. BAL														
	RECEIPTS (+)														
	USED, SHIPPED (-)														
	TOTAL														
	TANK NO.														
	YESTER. LOSS														
	TOTAL LOSS														
S.B.O.	PREV. BAL														
	RECEIPTS (+)														
	USED, SHIPPED (-)														
	TOTAL														
	TANK NO.														
	YESTER LOSS														
	TOTAL LOSS														
OTHER	PREV BAL														
	RECEIPTS (+)														
	USED, SHIPPED (-)														
	TOTAL														
	TANK NO														
	YESTER LOSS														
	TOTAL LOSS														
	TOTAL														
	ACCUMULATED LOSS														
												ACTUAL TOTAL OIL ON HAND			

FIG. 6. Daily physical inventory balance sheet (Form INV-1).

1. Poor crystal formation can be caused by either excess agitation of the oil while in the graining tank—we recommend for agitation the use of cold air through a sparging coil rather than the use of mechanical agitators or too rapid chilling, which inhibits the formation of large flakes.
2. Poor filtration rates can be the result of blinding or clogging of the filter cloth brought about by a too rapid initial discharge of the graining tanks. We prefer to start the discharge cycle by a gravity flow to the filter, followed by air pressure starting at a minimum 5 psi and ending with a pressure of ca. 30 psi.

As with other sections of the plant, log sheets should be kept. A typical one is shown in Form W-1 (Fig. 5).

Physical Inventory Control

Physical inventory control is a problem far more difficult than first apparent. Material balances are not easily determined, and added to the problem is the fact that most small processors do not have sufficient tank scales and storage tanks available to isolate the different products. If tank scales are not available, we recommend that actual measurements be made of the oil in each tank. Oil meters can be used as a guide or double check for inventory control.

1. Variables in tank contents are frequently the result of careless measurement of oil heights or false measurements due to changes of tank volume caused by bulging of tank sides when filled with oil. To properly measure oil in the tank, a line or stick is used to determine the outage of the oil level from the top of the tank. This is subtracted from the overall tank height. This gives the oil height, and, with the average inside tank circumference along with the oil temperature, the weight of oil is read off from a calibration table. Under no circum-

stances would we rely on float readings.

2. Spillage can be due to improper valve operation, poor piping connection, or overfilling a holding tank. These mistakes are bound to happen in any refinery, but, if it occurs too often, the refinery superintendent must be held accountable.
3. Stock mixing will raise havoc with the best of inventory systems. Again, there is no surefire cure except to be certain that each tank is individually numbered and identified. This will help to eliminate communication errors.
4. Irregular scheduling of inventory increases the chances of inaccuracy. We recommend that each morning, or at the end of the night shift, inventory of all tanks, processing vessels, etc., be carried out just before the day shift takes over.
5. Product losses in the filling and packaging room are brought about by improper operation of the filling and weighing machines. Filling equipment, especially, requires constant checking to see that the weight of the oil being discharged is within the desired tolerances. Hourly checks on separate balance scales are recommended procedure.

A suggested physical inventory report form is shown in Form INV-1 (Fig. 6). Please realize that all the report forms are typical and that each plant must adapt each form to meet its own needs.

OTHER PROBLEMS

There are two other areas which contribute problems: poor quality control and lack of a plant maintenance program. Proper records will reduce these problems too, and we have on hand suggested report forms covering these areas for those who may be interested.

While we only touched on some major problems which a small scale processor will face, this report, we hope, will serve as a guide for the manager or plant superintendent of such a plant.