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AGRICULTURAL MATERIALS HANDLING MANUAL

PART 3 PROCESSING EQUIPMENT

SECTION 3.4

MOLASSES AND FAT

Agriculture Canada

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MOLASSES AND FAT

The Agricultural Materials Handling Manual is produced in several parts as a guide to designers of materials handling systems for farms and associated industries. Sections deal with selection and design of specific types of equipment for materials handling and processing. Items may be required to function independently or as components of a system. The design of a complete system may require information from several sections of the manual.

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SECTION 3.4 MOLASSES AND FAT

3.4.1 MOLASSES

3.4.1.1 General

Molasses is a byproduct of the sugar refining industry. It is a viscous residue left after as much sugar as economically possible has been extracted from the sugar juices.

Molasses for use as a livestock feed is defined in the Canada Feed Act (1) as follows:

"Molasses is the byproduct in the process of manufacturing sugar and which contains not less than 48% of sugar expressed as invert sugar or dextrose. Its solution in an equal weight of water shall test no less than 39.75 degrees Brix*."

3.4.1.2 Types of Molasses

Four types of molasses are used for livestock feed. They are:

1. Cane or blackstrap molasses, a byproduct from the manufacture of sugar from sugar cane.
2. Beet molasses, resulting from the production of beet sugar from sugar beets.
3. Hydrol, a byproduct from the manufacture of corn sugar and corn syrup.
4. Citrus molasses, produced from the skins and pulp of citrus fruits.

3.4.1.3 Properties of Molasses

The chemical and physical properties of each type of molasses varies over a wide range, depending on weather, soil type, refining methods and the degree of adulteration. Table 3.4.1 is a guide to the properties of the various types of molasses.

Molasses density is usually measured with a Brix hydrometer. The relationship between Brix and specific gravity is shown in Table 3.4.2. Straight molasses is so viscous that it is difficult to get an accurate hydrometer reading. A common practice is to dilute the molasses with an equal weight of water so that the hydrometer will float properly and a reading can be taken. The Brix reading of the diluted sample is then multiplied by two to obtain the standard Brix or full-strength reading.

Because of the nature of molasses its viscosity cannot be accurately predicted. The viscosity is influenced by the amount of gums and resins present, and also varies widely with temperature. For example, an increase of 5 to 8°C will reduce the viscosity of molasses approximately 50%. The viscosity of an average sample of cane molasses is given in Table 3.4.3.

Because of the wide variation that can be expected in the viscosity of commercial molasses it is recommended that for engineering design purposes a figure of 11,000mm^2/s (50,000 SSU) should be used. In some instances where the Brix value is high a viscosity value up to 55,000mm^2/s (250,000 SSU) should be used.

TABLE 3.4.1 Properties of Molasses

	Cane	Beet	Hydrol	Citrus
Standard Brix° (60°F, 15.6°C)	78	76-85	75-80	70-73
Total digestible nutrients, %	67-72	58-61	60	50-54
Total sugars, %	48-56	45-52	43-64	41-43
Crude protein, %	2.0-7.5	6-10	1	3-8
Digestible protein, %	0	4	-	-
Total minerals, %	8-13	8-12	2-8	4-8
Density, kg/L	1.41	1.4	1.38	1.35
Specific heat, kJ/(kg·°C)	2.09	2.09	2.09	2.09

TABLE 3.4.2 Brix Specific Gravity Conversion

Brix	density kg/L	Brix	density kg/L	Brix	density kg/L	Brix	density kg/L	Brix	density kg/L
0	1.00	24	1.101	48	1.220	64	1.314	79	1.410
2	1.01	26	1.110	50	1.230	66	1.326	80	1.420
4	1.02	28	1.120	51	1.238	68	1.340	82	1.430
6	1.02	30	1.130	52	1.244	70	1.351	84	1.440
8	1.03	32	1.140	53	1.249	71	1.357	86	1.460
10	1.04	34	1.150	54	1.255	72	1.364	88	1.470
12	1.046	36	1.160	55	1.261	73	1.370	90	1.480
14	1.057	38	1.170	56	1.267	74	1.376	92	1.500
16	1.066	40	1.180	57	1.272	75	1.383	94.	1.510
18	1.074	42	1.190	58	1.278	76	1.389	96	1.530
20	1.083	44	1.200	60	1.290	77	1.396	98	1.540
22	1.092	46	1.210	62	1.302	78	1.403	100	1.560

*Brix - an arbitrary hydrometer graduation selected so that a 1 percent solution of sugar = 1 degree Brix.

TABLE 3.4.3 Typical Viscosities for 79.5° Brix Molasses*

Temperature	Viscosity	
°C	mm^2/s	SSU
15	7920	36000
20	3960	18000
25	1980	9000
30	990	4500
35	506	2300
40	253	1150

*Modified from ref. (6)

3.4.1.4 Heating

Molasses cannot be readily mixed at temperatures below 20°C, and handling at temperatures below 15°C can be difficult. Heating molasses above 45°C may cause carmelization or charring, rendering the molasses unfit for livestock feed and possibly fouling the handling system. It is recommended that molasses never be heated above 38°C. If molasses is stored in a warm room where temperatures are around 20°C no heating should be necessary.

Methods of heating molasses include the following:

1. Use of coils or jackets with hot water or low pressure steam. Steam pressures should not exceed 103 kPa (15 psi). Heater surface temperatures should be kept below 120°C. Where direct steam heat is used, the coils or jacket should never be kept hot unless the molasses pump is in operation to maintain some circulation within the tank. Maddox (6) suggests the typical overall heat transfer coefficient for molasses heated by coils in a tank is $284 W/(m^2 \cdot °C)$

2. Electric immersion heaters such as used to heat water are not satisfactory for direct heating of molasses as they become too hot. Indirect steam or electric heating is used to heat water which in turn is circulated through coils to warm the molasses.

3.4.1.5 Storage

Molasses can be stored in steel or concrete tanks. Since the pH of molasses is above 5.5 it is not corrosive to steel. Water vapor collecting on the inside of steel tanks can, however, cause rusting. This can be controlled by ventilating the tank. Two 3-in. or larger diameter pipes should be used.

Concrete tanks should be of monolithic steel reinforced construction. The inside should be sealed with a plastic liner or a good concrete sealer.

Steel tanks should be constructed from 12 or 14 gauge material. Portable tanks should be of heavier construction, 10 or 12 gauge material is suggested.

Storage tanks should be fitted with top openings for gauging and cleaning. The bottom should slope 4% to the discharge pipe or sump.

For prolonged storage the total sugar content of molasses should be above 43% and the temperature below 28°C. If the sugar content falls below 43% and the temperature is above 23°C fermentation can occur. Fermentation spoils molasses for feeding and also spoils feed with which it is mixed. It is important to ensure that water cannot leak into a molasses storage tank. Frequently some surface fermentation occurs when condensation forming inside the tank runs back into the molasses, forming a dilute surface film. This film will not damage the rest of the full-strength molasses in the tank.

Occasionally air or carbon dioxide is entrained in molasses. Air may be entrained from a leak in the pumping system or by open air transfer if molasses is allowed to drop 5 to 10 m into a storage tank. Carbon dioxide may be present as a result of the sugar extraction process or from fermentation. Up to 20% gas by volume may be entrained, which can cause pumping problems and errors in volumetric measurement.

3.4.1.6 Handling

Pumps: Because of the viscosity, positive displacement pumps of the gear, vane or screw type are much more effective than centrifugal pumps. For low cost and serviceability, bronze or bronze-fitted gear pumps are frequently used on farms.

To allow for proper filling of rotary pumps they should be run at slow speeds, preferably at ½ to ¼ the speed recommended for water. Since there is practically no slip when pumping viscous materials ample pressure can be developed and the capacity will be proportional to speed.

Pumps should be located as close to the molasses supply tank as possible and preferably below it so that the pump suction remains flooded. The suction pipe from the storage tank to the pump inlet should be large, preferably twice the diameter of the pump inlet and as short and straight as conditions will permit.

The power required to pump molasses will vary with the discharge quantity and pressures. Average power requirements for rotary pumps are given in Table 3.4.4. Results of tests with molasses conducted by Fairbank and Tavernetti (2) are shown in Table 3.4.5.

TABLE 3.4.4 Average Power Requirements for Rotary Pumps

Pump Size	kW	Horsepower
1 in.	0.746-1.12	1-1½
1½ in.	1.49-2.24	2-3
2 in.	2.24-3.73	3-5
3 in.	3.73-5.60	5-7½
4 in.	7.46-11.19	10-15

TABLE 3.4.5 Gear Type Molasses Pump Performance

	Pump Size	
Molasses Temp. 10°C	1.5 in.	2 in.
Litres pumped per 100 revolutions	30	64
Kilowatts required at 100 rpm & 520 kPa discharge pressure	0.87	1.31
Pump efficiency	30	40

For speeds above 100 rpm the power should be increased 0.37 kW for each 50 rpm increase in speed for the 1.5-in. pump and 0.56 kW for the 2-in. pump.

Suction line vacuum should not exceed 50 kPa (15 in. Hg) otherwise allowance for expansion of entrained gas is required. Data on the effect of entrained gas are contained in the Standards of the Hydraulic Institute (4).

Molasses pumps should have a spring loaded pressure relief valve. An oversized unit installed in the piping system is preferred over the small unit built into the pump. This valve should be set to open at 10 to 15% above normal operating discharge pressure. In addition to the relief valve it is desirable to have a hand controlled bypass valve on the discharge line so that part of the molasses can be returned to the supply tank or pump inlet when the pump supplies more molasses than is required. This manual valve can also be opened before starting the molasses pump motor to reduce the discharge pressure when the molasses is cold.

Piping and Valves: A source of trouble with molasses handling systems is the use of pipes which are too small. Pipe friction tables are published in the Pipe Friction Section of the standards of the Hydraulic Institute (4). Worcester (8) suggested the following equation to estimate the pressure loss for laminar flow in clean smooth pipe:

$$p = \frac{4.08 \times 10^9 \mu q}{d^4} \quad \text{(SI units)}$$

$$p = \frac{2.73 \mu q}{d^4} \quad \text{(British units)}$$

Where,

	Units	
	SI	British
μ = viscosity	Pa·s	Poise
q = flow rate	L/s	gal(US)/min
d = inside pipe diameter	mm	in.
p = pressure loss in pipe	kPa/100m	psi/100ft

Table 3.4.6 lists the recommended pipe sizes for the suction and discharge pipes of a molasses handling system.

Black iron pipe is usually used for handling molasses. Where the pipe is exposed to weather galvanized pipe should be used. Plastic pipe may be used provided it is rated to withstand the pressure at the operating temperature. Pipe lines should be installed as straight as possible. Where bends are required, use two 45-degree elbows rather than one 90-degree elbow. Data for the equivalent length of pipe and pipe fittings may be obtained from Section 2.5, *Liquid Conveyors*.

Molasses Metering: Flow meters should be incorporated into a system to show the amount of molasses being incorporated into feed and the total amount handled. Because errors in metering can occur with gas entrainment or changes in the viscosity of the molasses, provision should be made in the piping system to draw off molasses into a container so that the meter calibration may be checked against the weight of molasses discharged. Figure 3.4.I shows two types of positive displacement molasses meters that register the amount of molasses delivered. The meter to the right has an automatic stop feature that stops flow when a preset quantity has been delivered. For farm applications a weight tank can be used with a batch mixing process

TABLE 3.4.6 Recommended Sizes for Suction and Discharge Pipe to Pump Undiluted Molasses at a Temperature of 10°C with a Maximum Suction of 68 kPa (20 in. Hg) and a Maximum Discharge Pressure of 500 kPa (72.5 psi).

Pipe Length	Flow Rate, L/m			
m	0-7.5	7.5-20	20-40	40-80
Suction Pipe	Pipe Size (in.)			
0-1.2	2	2.5	3	4
1.2-2.5	2.5	3	4	5
2.5-6.0	3	4	5	6
Discharge Pipe				
0-1.5	1.25	1.5	2	2.5
1.5-3.0	1.5	2	2.5	3
3.0-7.5	2	2.5	3	4
7.5-15	2.5	3	4	5

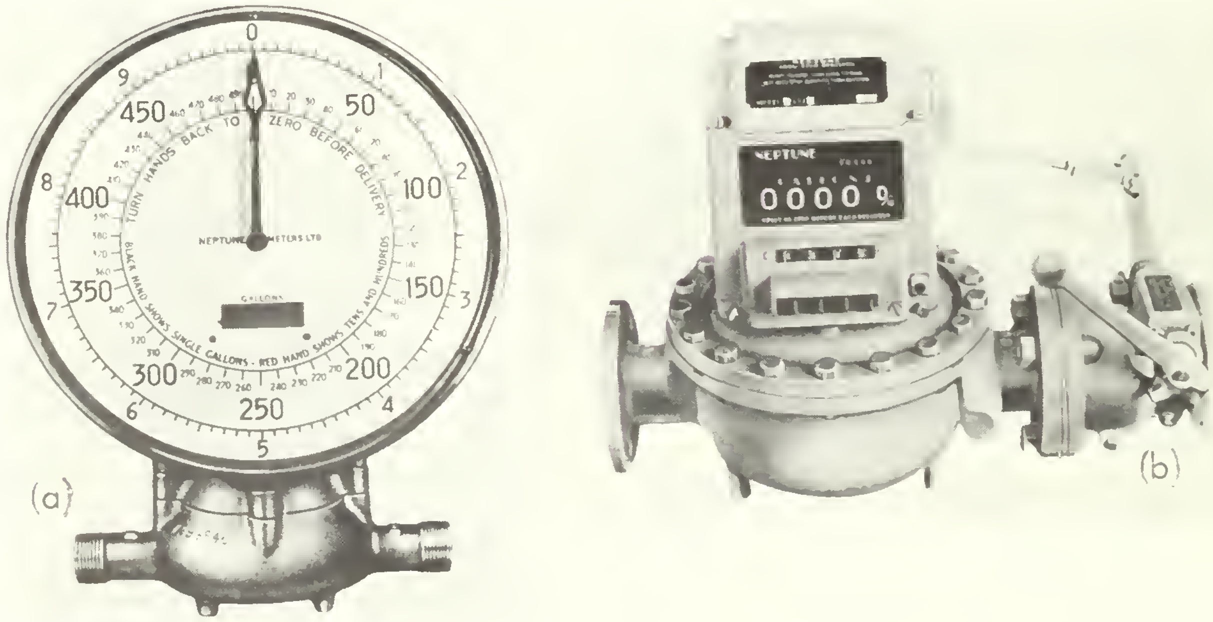

Figure 3.4.1 Molasses meters

where molasses is weighed on a scale and then pumped or allowed to flow by gravity into a mixer.

Meters indicating flow rate are also available. These usually consist of a generator activated by the flowing molasses. The output from the generator is indicated on a meter calibrated in some convenient flow-rate units.

3.4.1.7 **Dilution of Molasses**

Dilution with water is a simple way to reduce the viscosity of molasses to facilitate mixing and handling. Molasses dissolves readily in water and will not separate once mixed. Mixtures of 10 to 25% water by weight can be used.

Fermentation and spoilage can occur if molasses is diluted in the main storage tank, or if diluted molasses is mixed with feed to be stored for more than a few days.

3.4.1.8 **Molasses Feeding Systems**

Molasses can be fed in the following ways:

1. Free choice.
2. Sprayed or poured on the surface of feed.
3. Mixed with ground feed.
4. Used in pellets as a binder.
5. Used as a silage preservative.
6. Dried and granulated.

Free Choice: This is probably the simplest method of feeding molasses to cattle. A self-feeder may be constructed from an open trough into which molasses is poured either from a drum or a storage tank. Large tanks equipped with a float valve have been used to maintain the level of molasses in a shallow feeding trough. When molasses is fed free choice in tanks or troughs a metal grate or wooden floats should be used to prevent wastage by the animals. The grates or slats should have 50 to 80 mm spacings to allow the animals to lick the molasses from the opening. Smooth round wooden or metal floats 100 to 120 mm in diameter floated on top of the molasses have been used. These floats revolve when licked by the animals. Figures 3.4.2 and 3.4.3 illustrate the type of equipment used. A commercial feeding unit, (Figure 3.4.4) consists of a plastic ball about 120 mm in diameter set into a plastic sleeve and mounted in a shallow covered tank. The ball is trapped in the sleeve and free to rotate when licked by livestock.

Sprayed or Poured on the Surface of Feed: Molasses can be poured or sprayed on feed in bunks by hand or with molasses spray equipment.

Molasses for spraying is generally diluted at the rate of one volume of water to two volumes of molasses. Dilution allows for easier pumping, better coverage and absorption and more accurate control of the application rate. A simple spray rig is illustrated in Figure 3.4.5. The elements of a molasses handling system are illustrated in Figure 3.4.6. Note the external pressure-relief valve and the three-way valve used to direct molasses back to the pump intake.

Mixed with Ground Feed: Molasses is used in mixed feed to improve palatability, control dust, act as a binder and as a source of carbohydrate. The quantity of molasses that can be used in feed is limited by several factors:

1. The maximum for safe and economical feeding to animals.

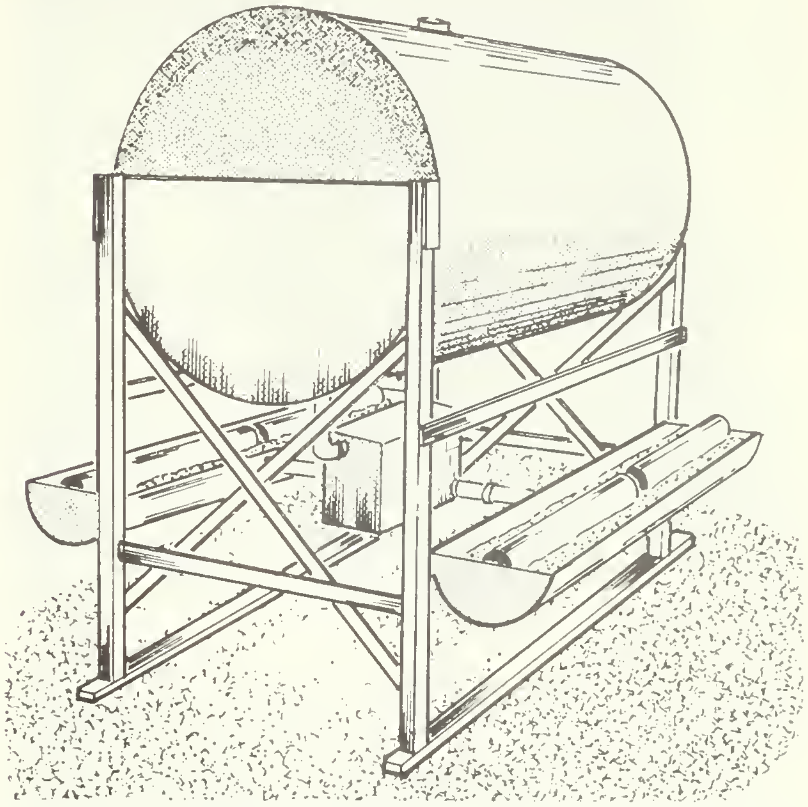

Figure 3.4.2 Molasses storage tank with roll floats placed in a trough

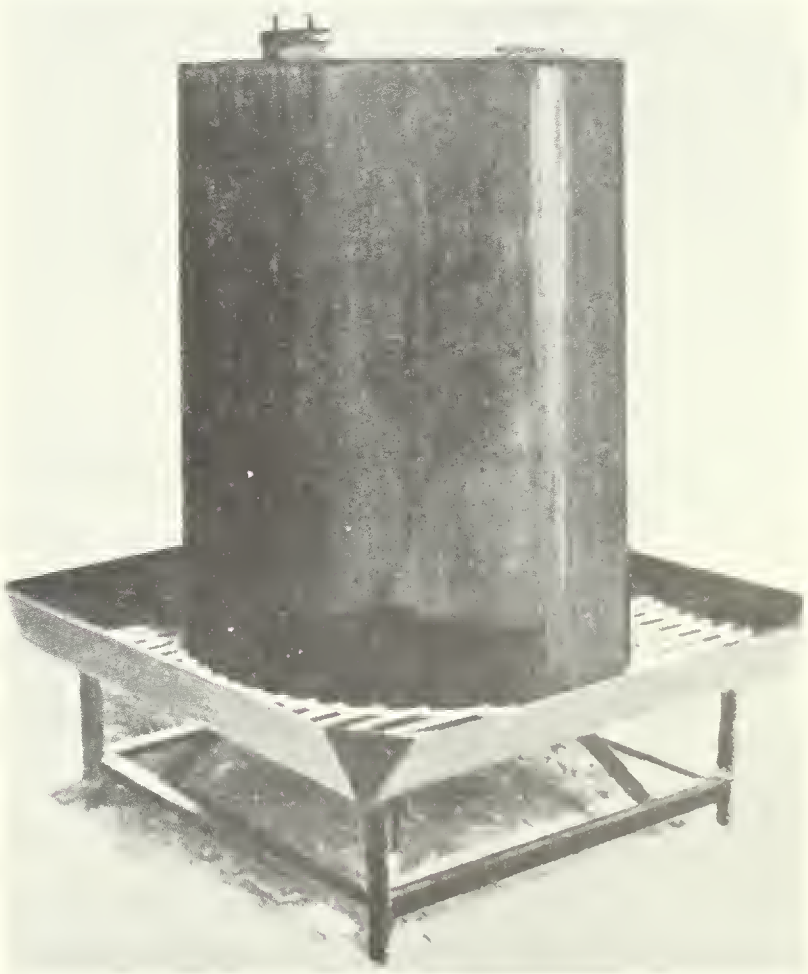

Figure 3.4.3 Molasses tank and feeder equipped with a grate

Figure 3.4.4 Plastic ball feeder

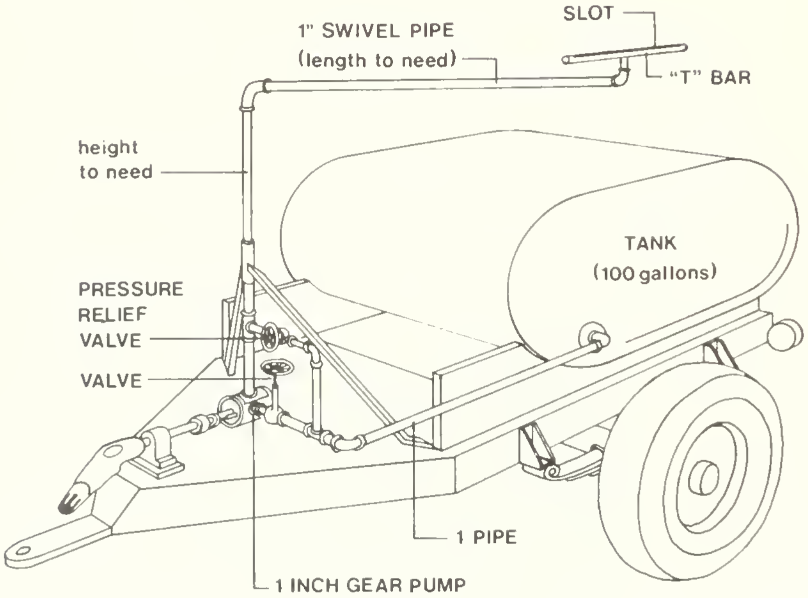

Figure 3.4.5 Portable molasses spray rig

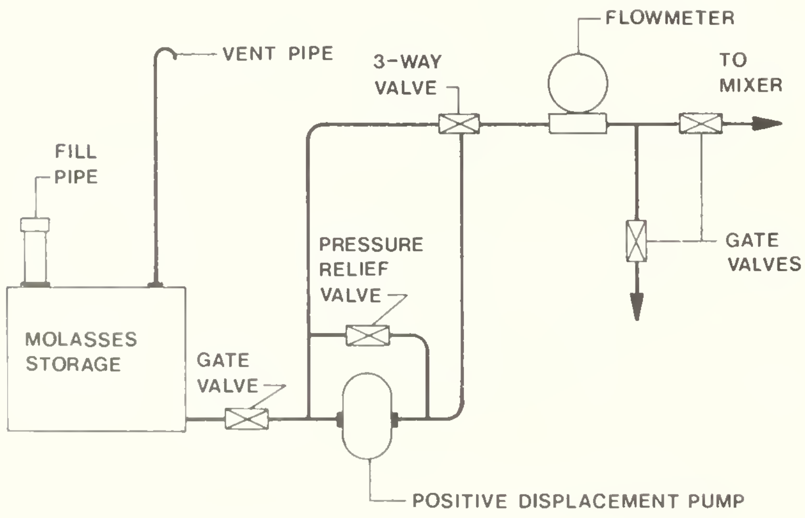

Figure 3.4.6 Molasses handling system

2. Caking, bridging, fermentation and molding in bulk storage.

Except in pellets, feed containing molasses should be fed quickly after processing. Caking can be reduced by allowing mixed feed to stand 12 hours and then remixing. Damp feeds or dilution of the molasses contributes to fermentation and molds.

3. Molasses absorptivity of the feed (see Table 3.4.7). Absorptivity also depends on feed moisture and temperature; heating the feed to about 70°C by steam-jacketing the mixer improves absorptivity.

TABLE 3.4.7 Approximate Amount of Molasses Which Feed Ingredients Will Absorb at 20°C.

Ingredients	Percent Absorption
Solvent soybean meal	5
Linseed meal	7
Ground corn	8
Ground milo	10
Expeller soybean meal	10
Cotton seed meal	15
Ground barley	15
Ground oats	15
Wheat bran	15
Wheat middlings	15
Chopped hay	20
Brewers dried grain	20
Alfalfa meal	35
Soybean mill feed	35
Oat mill feed	35
Ground corn cobs	40

Pellet Binder: Many feed manufacturers are equipped to produce hard pellets containing up to 35% molasses. This is accomplished by introducing warm molasses in combination with steam into the mixing chamber of the pellet machine. The temperature of the mixed feed in the mixing chamber can be raised to 90 to 100°C prior to passage through the pellet die. Hot pellets can be dusted with bentonite or other powder to reduce caking before conditioning in the pellet cooler.

Silage Preservative: From 2.5 to 5% by weight of molasses can be added to high-protein silage to act as a preservative and increase the carbohydrate content. The molasses supplies the sugar for use by micro-organisms in the fermentation process. While silage may be made without a preservative, the use of molasses gives additional assurance of good quality silage from very early cut grasses or medium-early cut grass-legume mixtures. Table 3.4.8 lists the quantities of molasses required to ensure the proper degree of fermentation for various types of silage.

Dried and Granulated Molasses: Most molasses sold for livestock feed is in the liquid form. However, dried molasses may be obtained. Up to 30% molasses combined with beet pulp can be satisfactorily dried to form a palatable feed additive. The product is bulky, slightly laxative, but keeps well in storage.

TABLE 3.4.8 Suggested Quantity of Molasses to be used in Making Silage

Silage	kg/t	lb/ton
Legumes, fresh green		
Alfalfa, Red Clover	40	80
Soybeans	50	100
Legumes, wilted		
All crops	none	
Legume-grass mixture before grass is headed out		
Fresh green	40	80
Wilted	30	60
Legume-grass mixture after grass is headed out		
Fresh green	30	60
Wilted	none	
Grass and cereals before heading out		
Fresh green	30	60
Wilted	20	40
Grass and cereals after heading out		
Fresh green	20	40
Wilted	none	

3.4.1.9 **Equipment for Adding Molasses to Feed**

The type of equipment used to mix molasses with feed will depend on the quantity of feed handled, the feeding system and the amount of molasses to be added.

Vertical Mixer: This type of mixer is normally not recommended for mixing molasses with feed, chiefly because of the possible build-up of feed on the mixer walls, mixing screw and tube. Gaining access to the interior of the tube and screw for cleaning is difficult. In addition, when the molassified feed is too moist there is always the danger of bridging in the cone, thus stopping circulation of feed in the mixer. While not recommended, some vertical mixers have been equipped with a molasses spray attachment in the form of a ring with spray nozzles located at the top of the mixer. With this equipment up to 5% of molasses by weight can be added to feed.

Horizontal Batch Mixer: When equipped with paddle type agitators this mixer is often used to molassify feeds, particularly where it is desirable to keep fragile ingredients intact. Some batch mixer manufacturers supply molasses injectors which use spray nozzles to spray molasses into the center third of the mixer. These mixers should be equipped with drop bottom doors so that the mixed feed can be discharged quickly to help minimize molasses build-up. Where more than about 5% molasses is added some build-up will occur and periodic cleaning is recommended.

Truck mounted horizontal mixer-feeders using paddle or multi-auger agitators to handle roughage rations in cattle feedlots have been used to blend up to 15% molasses with feed.

Double Agitator Continuous Mixer: This type of mixer has been used by the feed industry for many years. It consists of two rows of mixing paddles operated at 350 to 360 rpm in a double U trough. Pitch of the paddles can be adjusted to vary the intensity of the mixing action. Sizes range from small units handling 2 to 4 t/h to those capable of handling 30 to 40 t/h. The use of double agitator feed mixers is common where high capacity continuous mixing of 10% or more molasses is required. The unit should be equipped with drop bottom doors and a spring-clamp top to facilitate easy cleanout.

Single Agitator Continuous Mixer: This type of mixer is similar to the double agitator type but has only one row of mixing paddles.

High Speed Molasses Blender: This unit consists of a single rotor with paddles. It operates at speeds of 1000 to 1200 rpm and is used to apply molasses to all types of mill feed. The mixer is capable of molassifying finely ground material which tends to ball unless mixing speeds are high.

Application of Molasses to Silage: French (3) suggests two methods of metering molasses into silage to be stored in upright silos. Figure 3.4.7 shows a simple, inexpensive piping arrangement for injecting molasses directly into the forage blower housing. To prevent plugging and molasses build-up in the blower and pipes, molasses must be stopped before stopping the silage flow.

Because of the high viscosity of molasses at temperatures below about 20°C some dilution is desirable. Addition of 10% by weight of water will thin molasses so it will flow through a 1-in. pipe or hose.

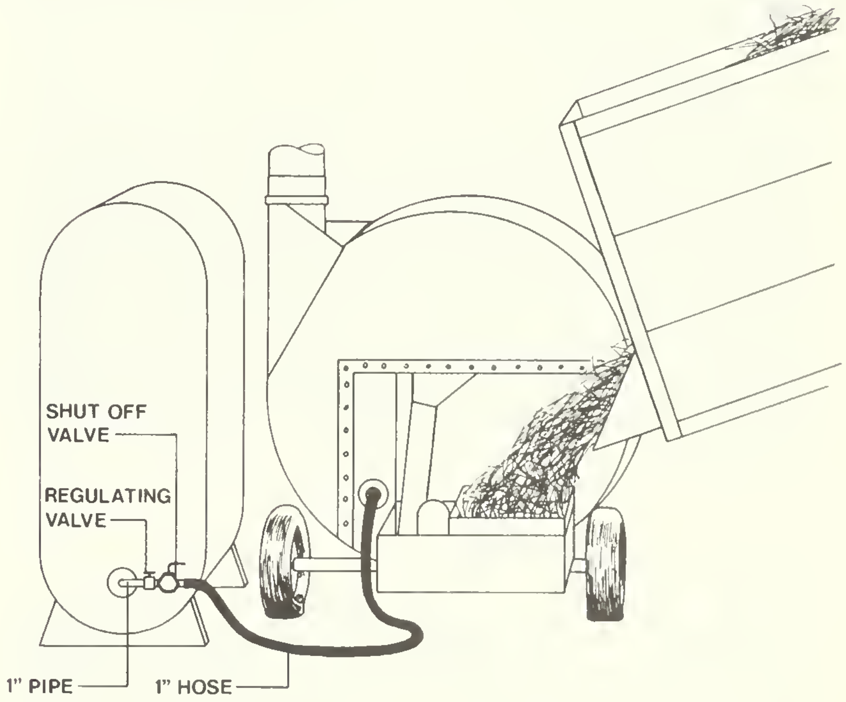

Figure 3.4.7 Simple system for mixing molasses with silage

Figure 3.4.8 shows a more satisfactory method of applying molasses to ensilage to avoid possible plugging of the blower pipe. With this system 3/4-in. pressure rated plastic pipe is used to deliver molasses to the top of the silo. For satisfactory dispersion the molasses should be delivered to the top of the blower pipe through either a fish tail or fan type nozzle. The nozzle can be formed by either cutting the pipe diagonally or flattening the end.

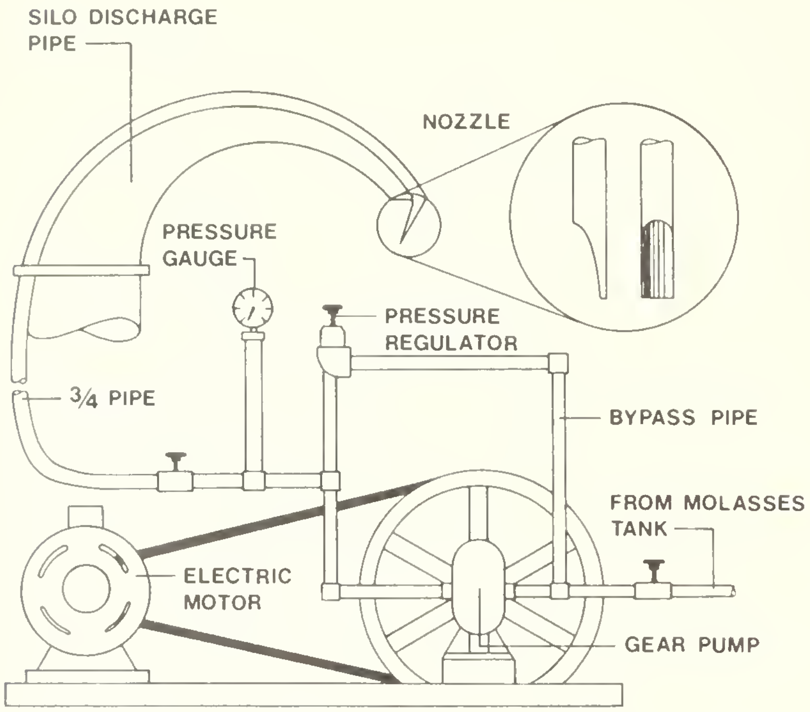

Figure 3.4.8 Piping system to mix molasses with silage at the top of the silo

3.4.2 Fat

3.4.2.1 General

Emphasis on increased energy levels in animal feeds has stimulated the addition of fat to many types of feed. While handling and blending of fat into feed is relatively simple, there are recommendations and procedures which will minimize problems.

The Canadian Feed Act (1) specifies animal fat as that rendered from animal tissues, of a quality suitable for feeding and may contain an anti-oxidant approved by the Food and Drug regulations or by the Health of Animals Branch, Agriculture Canada. The purchaser may impose specifications as to the titer or melting point, free fatty acid content, color, moisture and amount of other soluble materials present. When fat is used in feeds the major factors to be considered are palatability, stability, and availability of a steady supply of the grade selected. All fats used in feeds should be stabilized with a suitable anti-oxidant to control rancidity.

3.4.2.2 Storage of Fat

Vertical or horizontal tanks of either steel or concrete construction are suitable for fat storage. Concrete tanks are satisfactory only if the interior surfaces have been treated with a non-soluble, non-toxic coating. Untreated concrete is porous and warm fat will slowly penetrate and soften the walls of the tank. Coatings should be applied to the clean concrete walls of the tank before any fat has been stored in the tank.

All tanks should have a weatherproof top vent made from 3-in. or larger pipe. Storage tanks should be completely emptied periodically for cleaning. Two small tanks are preferable to one large, to facilitate cleaning.

3.4.2.3 Storage and Handling Equipment

Pipes, valves and fittings for handling fat should be of iron or steel, since copper or brass can accelerate the development of rancidity in fat.

3.4.2.4 Heating Fat

Avoid overheating or the introduction of water into fat. In order to keep fat in its best condition it should be stored as cool as possible while keeping the fat fluid enough to handle. Where fat is being used daily a temperature of approximately 50°C for storage is sufficient, with a preheat temperature of 60 to 95°C prior to mixing with feed. In large tanks steam coils can be installed near the bottom. Regardless of the shape of the tank the steam lines should be introduced at the top of the tank and run down one side to the coils. This will melt a vertical channel which permits better circulation and faster heating of the fat and also prevents high pressures developing under a layer of unmelted fat.

Steam lines should be tight since moisture in fat is a major factor contributing to sludge formation and corrosion problems in handling equipment.

Where only small amounts of fat are used, barrel storage may be convenient. Waibel (7) described three methods for electric heating of barrels, as follows:

Unit 1. Immersion heaters, - 400 W, 230 v thermostatic control.

Unit 2. Wrap-around heater with 1-in. of fiberglass insulation covered with 1/8 in. asbestos cloth on one side and canvas on the other, - 3000 W, 230 v.

Unit 3. Metal insulated drum with built-in insulation and heating unit - 3200 W, 230 v.

Unit 1 melted all the fat in the barrel in a relatively short time, but depending on the size and shape of the unit it may not be possible to insert it into a barrel with only a bung opening.

Unit 2 was simple and easy to use but during cold weather tests it left an unmelted cone which required considerable mixing to melt.

Unit 3 was easy to use but also left an unmelted cone.

Insulation around the barrel is worthwhile when heating fat in cold weather, especially if the fat is to be kept hot for any length of time.

3.4.2.5 Adding Fat to Mash

In general fat can be mixed with feed in practically any type of mixer. Vertical, horizontal and continuous mixers have been modified for the addition of fat. In large horizontal mixers fat may be added in a small stream at a point where there is considerable feed agitation so as to mix the fat and feed before the fat cools. In vertical mixers Waibel (7) suggests using a 3/4-in. pipe welded in the side of the vertical cylinder and arranged so that the fat is added as the feed moves into the auger screw. In continuous mixers, Kathman (5) recommends adding fat after the other ingredients have come in contact with the mixer screw or paddles.

To avoid fat balls in feed it is necessary, in cold weather, to preheat the fat before it is added to feed. The most common method is to use a small electric or steam heat exchanger with a thermostat located near the mixer where the fat is added. The temperature will vary from mill to mill and with the season, but a range of 60 to 90°C should be adequate.

Waibel (7) using a vertical mixer, found that in the winter months in an unheated room it was impossible to produce a good-textured feed free from fat balls even when the entire batch was well mixed prior to adding hot (93°C) fat. He found that by omitting half of the finely ground corn meal until after adding the fat the formation of fat balls was minimized. In these tests the amount of fat added to the ration was limited to 10% by weight.

3.4.2.6 Adding Fat to Pellets

Adding fat to a pellet mash at levels above 3 to 5% is likely to cause breakage of pellets in handling. The difficulty arises from the fact that the fat lubricates the pellet die, thus insufficient pressure is applied to the mash to form a hard pellet. It is more satisfactory to spray the cooled pellets or pellet crumbles with fat, then hold them in a rotating retention drum until the fat has cooled and hardened. The pellets can then be binned or sacked.

3.4.2.7 Pumps

Positive displacement pumps are recommended for handling fat (Section 2.5 *Liquid Handling*). The pump should be of all iron or stainless steel construction. Iron gate valves or plug cocks should be used to control flow, except where throttling is necessary, here a globe valve should be used.

3.4.3 REFERENCES

1. Canada Governor General in Council. 1962. Feed regulation, P.C. 1962-1266, Canada Gazette, Part 2, SOR/62-351.
2. Fairbank, J.P. and J.R. Tavernetti, 1956. Handling feed molasses on the farm. Berkley, California, Agri. Eng. Info., Series No. 11, University of Calif. Extension Service.
3. French, O.C., circa 1950. Equipment for mixing molasses with hay-crop silage. Ithaca, N.Y., Dept. of Agri. Eng. Extension bulletin No. 380. Cornell University.
4. Hydraulic Institute, 1955. Standards of the hydraulic institute. New York, N.Y. Author.
5. Kathman, A.J., 1959. Fat Handling. Proceedings of the 1959 Feed Production School, Pelleting. Kansas City, Mo. Feed Production School.
6. Maddox, B., July 11, 1970. Molasses handling techniques in the feed mill. Minneapolis, Minn., Feedstuffs, Vol. 42, No. 28, 56-57.
7. Waibel, P.E., V.H. Myers and E.L. Johnson, Nov. 15, 1958. Methods of adding fat to poultry rations. Minneapolis, Minn. Feedstuffs, Vol. 30, No. 46, 38-40.
8. Worcester, W.E., July, 1950. Pumping molasses and other viscous materials. Sugar. Vol. 45, No. 7, 33-5, 40.