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ATTACHMENT 1

Vegetable Oil Manufacturing

INTRODUCTION

Vegetable oil manufacturing generally involves removal of oil from oilseeds (solvent extraction), followed by processing of the "crude" oil recovered from them (oil processing). The Process Description which follows describes specific operations related to soybeans.

PROCESS DESCRIPTION

OILSEED HANDLING/ELEVATOR OPERATIONS

Figure 1 is a schematic diagram of the typical soybean handling/elevator operations that precede preparing of soybeans for the solvent extraction process. Oilseed handling/elevator operations are typically comprised of the following:

- Receiving/storage; and,
- Cleaning/drying.

Each of these is discussed below.

Receiving/Storage

Soybeans that have been received at a facility by truck or rail are first sampled and analyzed for moisture content, foreign matter, and damaged seeds. After sampling/analysis is completed, the beans are weighed and conveyed to large concrete silos or metal tanks for storage to await processing.

Cleaning/Drying

When the facility is ready to process soybeans, the beans are removed from the silo or tank and cleaned of trash, other foreign materials, and loose hulls. Screens are typically used to remove foreign materials such as sticks, stems, pods, tramp metal, sand, and dirt. An aspiration system is used to remove loose hulls from the soybeans. The beans are then passed through dryers to reduce their moisture content to approximately 10 to 11 percent moisture by weight, and conveyed to Process Bins for temporary storage and tempering to facilitate dehulling.

PREPARATION OF SOYBEANS FOR SOLVENT EXTRACTION

Figure 2 is a schematic diagram of the process for preparing soybeans for the solvent extraction process. The process tends to be fairly well standardized, with the four principal operations being:

- Cracking;
- Dehulling/hull removal;
- Conditioning; and,
- Flaking.

Each of these is discussed below.

Cracking

Soybeans are conveyed from the Process Bins to the mill by means of belt or mass flow conveyors and bucket elevators. In the mill the beans are again aspirated, weighed, cleaned of tramp metal by magnets, and fed into corrugated cracking rolls. The cracking rolls serve to "crack" each bean into 4 to 6 particles to facilitate separation of the hulls from the oil-rich bean.

Dehulling/Hull Removal

The cracked beans are then passed through an aspirator to remove the hulls from the cracked beans. The hulls are processed separately after removal of residual bean chips. The cracked beans and bean chips are conveyed to conditioning.

Conditioning

The cracked beans and bean chips are put into a rotary steam tubed device or in a stacked cooker and heated to "condition" them (i.e., make them pliable and keep them hydrated). Conditioning is necessary to permit the flaking of the chips without their being broken into smaller particles.

Flaking

The heated, cracked beans are conveyed and fed to smooth, cylindrical rolls which press the particles into smooth "flakes" varying in thickness from approximately 0.010 to 0.020 inches thickness. Doing so exposes the soybean flakes' oil cells for easier extraction of the oil.

SOLVENT EXTRACTION

The extraction process consists of "washing" oil from the soybean flakes with a hexal solvent in a countercurrent extractor, and then evaporating solvent from (i.e., desolventizing) both the solvent/oil mixture (miscella) and the solvent-laden, defatted flakes separately (see Figure 3). The oil is desolventized by exposing the solvent/oil mixture to steam (contact and non-contact), after which the solvent is condensed, separated from the steam condensate, and reused. The desolventized oil, called "crude" soybean oil, is stored for further processing.

Flakes, on the other hand, are desolventized in either of two ways, depending on the end use of the flakes - "conventional" desolventizing, and specialty or "flash" desolventizing. In the conventional desolventizing process, the flakes are desolventized by steam (contact and non-contact), and the solvent is condensed, separated from the steam condensate, and reused. The desolventized, defatted flakes are dried, cooled, and ground for use as soybean meal - a protein source in animal feeds (see Figure 4).

In the specialty or "flash" desolventizing process, solvent is removed from the defatted flakes with superheated solvent or in a vacuum with a small quantity of non-contact steam. The defatted flakes, which have a much higher protein solubility than those from the conventional desolventizing process, are then cooled. Flakes desolventized in this manner are typically used for human foods.

The specific steps in the extraction and desolventizing processes are described below.

Extraction

Soybean flakes are conveyed into the extractor, where they are washed countercurrently with various hexal/oil mixtures and, finally, with pure hexane. The initial oil content of the soybeans is approximately 18 to 20 percent by weight, while the defatted flakes, after extraction, contain approximately 0.5 to 2.0 percent oil by weight.

There are two types of extractors that use the percolation process described above - a "deep bed" extractor and a "shallow bed" extractor. The deep bed extractor is a horizontal unit with pie-shaped mesh baskets that rotate around a vertical shaft. Bed depth in this extractor varies from approximately 6 to 10 feet. The shallow bed extractor, a more recent design than the deep bed extractor, conveys soybean flakes horizontally over closely spaced "vee-bars" while washing them with oil and hexane and, finally, pure hexane. Bed depth in the shallow bed extractor normally varies from approximately 2 to 3 feet.

Desolventizing (Oil)

An oil/hexane mixture is removed from the extractor separate from the defatted flakes. The mixture is first pumped through heaters, then evaporators under vacuum, and finally through a packed stripping column to remove the hexane.

A hexane/water vapor mixture is removed from each oil desolventizing unit and condensed in a "separation" tank to separate the hexane from the water. Once separated from the water, the hexane is reused in the extraction process. Crude oil is cooled and stored in tanks for further processing.

Conventional Desolventizing (Flakes)

The solvent-laden, defatted soybean flakes are conveyed from the extractor to a desolventizer-toaster (DT) where they are desolventized. The DT contains stacked pans with a vertical center shaft equipped with "sweeps" which mix and stir the flakes while they are being heated with both contact and non-contact steam to evaporate the solvent. The resulting steam/solvent vapor mixture is exhausted from the top of the DT, and both are subsequently condensed and put into the same separation tank as that used in the oil desolventizing process. The desolventized flakes, whose moisture content has increased from approximately 10 to 11 percent by weight to approximately 18 to 22 percent by weight, are conveyed to a "dryer-cooler" in sequence to reduce their moisture back to approximately 12 percent.

There are two types of dryer-coolers used by the industry. One type is a horizontal, cylindrical dryer paired with a horizontal cylindrical cooler. The dryer is approximately 6 to 10 feet in diameter, approximately 30 to 50 feet long, contains longitudinal steam tubes, and rotates on a horizontal axis. The cooler is a horizontal cylinder of approximately the same dimensions through which ambient air is circulated to cool the dried flakes.

The second type of dryer-cooler is a stacked pan unit similar in design to the DT discussed above. Each pan in the unit is perforated, and drying/cooling of the flakes is achieved by passing high volumes of air through the perforations and the defatted flakes. Heated air is circulated through the first couple of pans, while ambient air is circulated through the last couple of pans.

Specialty or "Flash" Desolventizing (Flakes)

Flash or specialty desolventizing is used when the objective is to minimize denaturation of the protein in the flakes which occurs with toasting. In this process, flakes are desolventized in a vacuum with a small quantity of non-contact steam or in a pneumatic loop using superheated solvent. This is followed by a final solvent stripping step using very small quantities of steam in a rotary or agitated vessel.

This type of desolventizing is far less efficient than conventional desolventizing in terms of both energy consumption and solvent removal. In addition, equipment used in the specialty desolventizing process is appreciably larger in volume than that for a similarly sized conventional process. Given the above factors, plant solvent emission factors are considerably higher for a specialty desolventizing plant than for a similarly sized conventional desolventizing plant.

FIGURE 1. GRAIN RECEIVING, DRYING, STORAGE

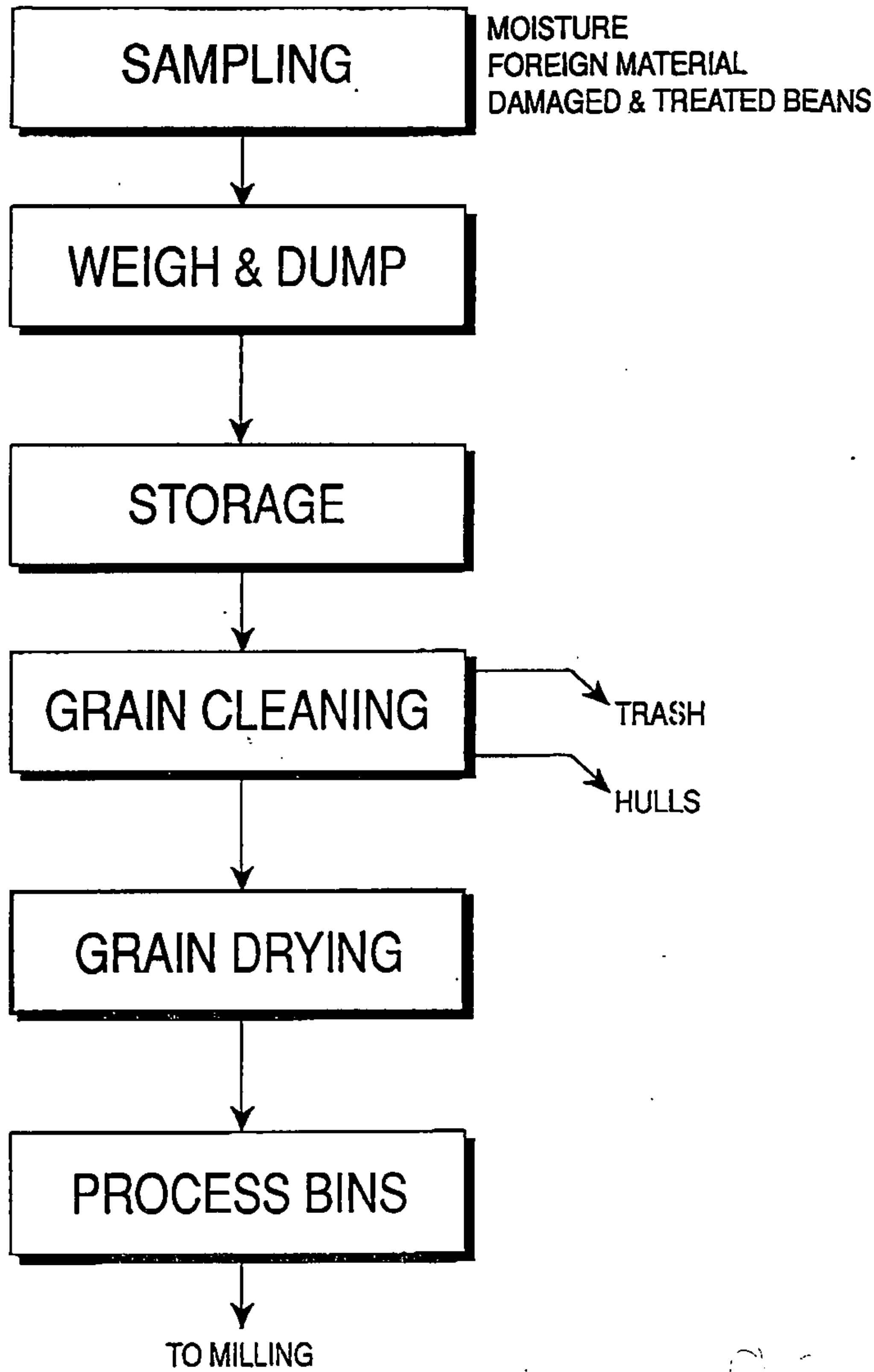


FIGURE 2. MILLING OR PREPARATION OPERATIONS

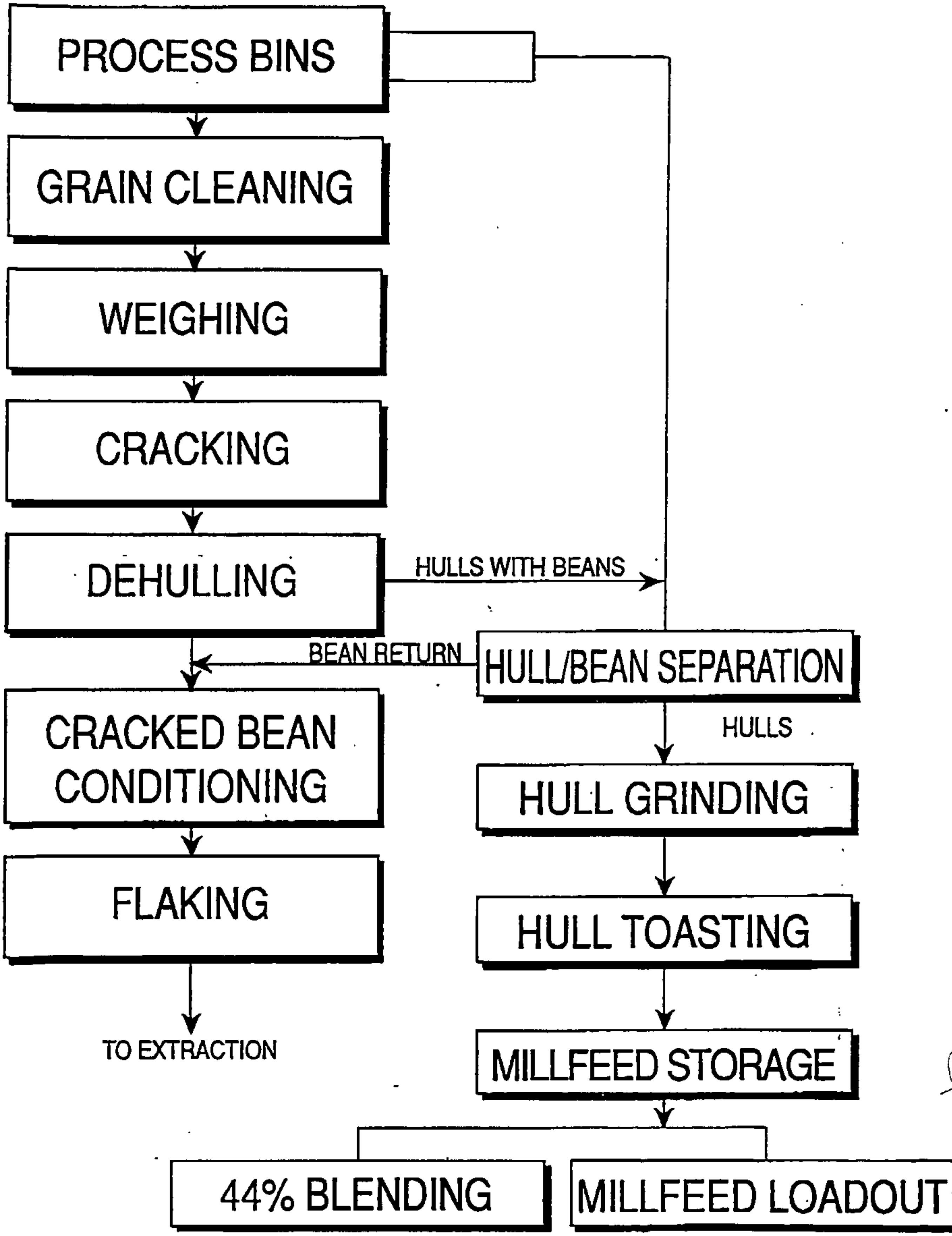


FIGURE 3. EXTRACTION, DISTILLATION, DRYING, COOLING

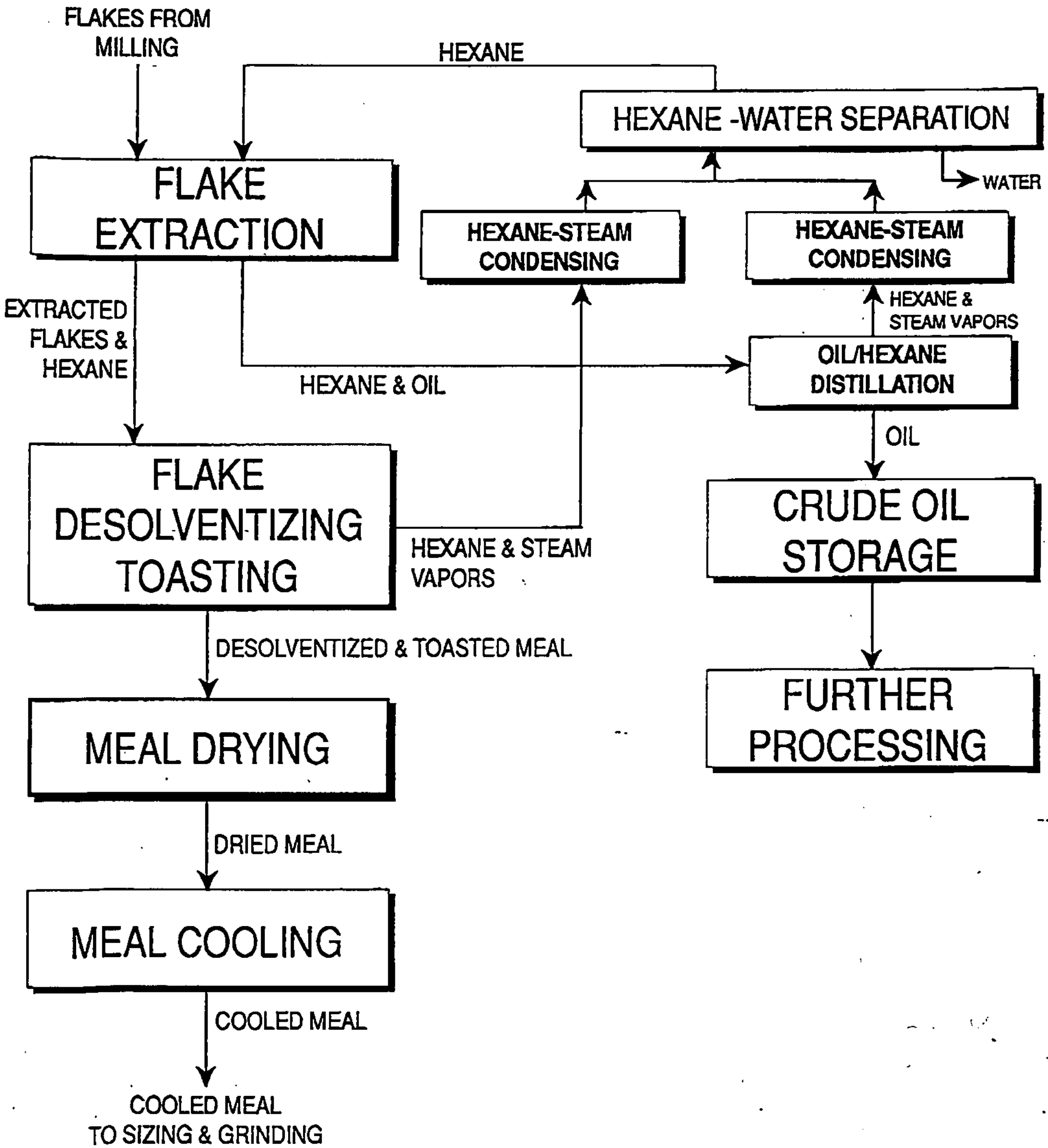
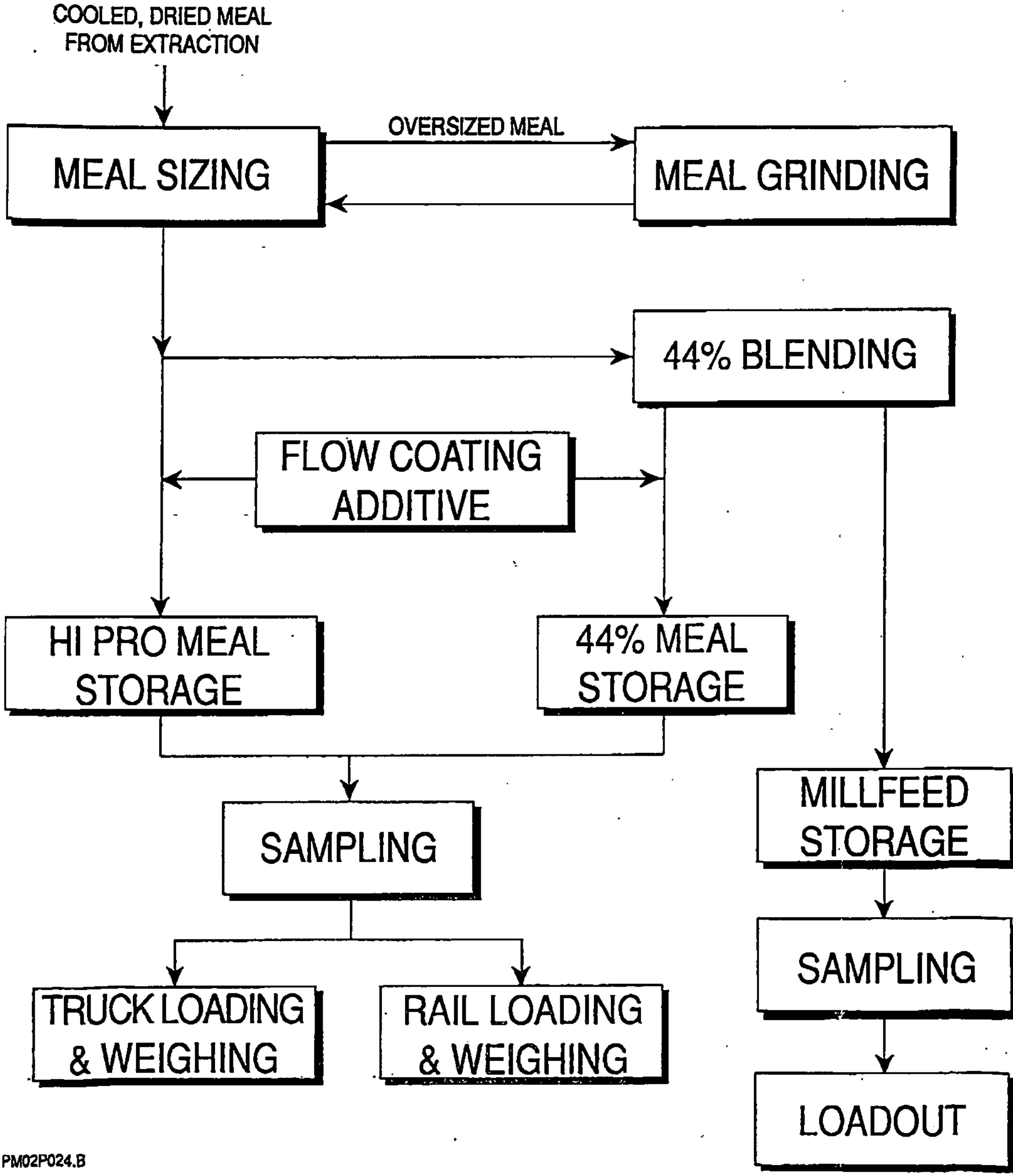


FIGURE 4. MEAL GRINDING, SIZING, BLENDING



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