BEFORE CANTERBURY REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND IN THE MATTER	The Proposed Canterbury Air Regional Plan

STATEMENT OF EVIDENCE OF DONOVAN VAN KEKEM
DATED 18 SEPTEMBER 2015

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1. INTRODUCTION

1.1 My name is Donovan Van Kekem. I am a Principal Air Quality Scientist at AECOM New Zealand Ltd ("AECOM"). I have over 12 years' specialist air quality experience.

1.2 I was engaged in June 2015 by J.Swap Contactors Limited (J Swap) to prepare air quality evidence addressing the issues arising from the submissions on proposed Rules 7.37, 7.38 and 7.39 in the proposed Canterbury Air Regional Plan (pCARP).

2. QUALIFICATIONS AND EXPERIENCE

2.1 I have the following qualifications:

(a) a Bachelor's Degree in Biochemistry from the University of Canterbury; and

(b) a Post Graduate Diploma in Forensic Science from the University of Auckland.

2.2 I am also a current member of the Clean Air Society of Australia and New Zealand.

2.3 Some of my work experience which is relevant to this hearing is as follows:

(a) I have been involved in preparing the air quality assessments and evidence for numerous industrial clients in New Zealand and Australia including Contact Energy, Winstone Aggregates, Anglo Coal, Holcim, Exxon Mobil and many more. I also currently act as an independent processing officer for Environment Canterbury assessing a number of complex air discharge consent applications.

2.4 While this is not a hearing before the Environment Court, I confirm that I have read the code of conduct for expert witnesses contained in the Environment Court Consolidated Practice Note (2014). I have complied with it when preparing my written statement of evidence and I agree to comply with it. I confirm that the evidence and the opinions I have expressed in my evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

3. SCOPE OF EVIDENCE

3.1 I have been asked to present this planning evidence on behalf of J.Swap Contactors Limited.

3.2 My primary focus will be on addressing the planning issues arising from the submissions. I have grouped my discussion according to two main topics, namely:

(a) The definition of bulk solid materials;

(b) Permitted activity rules;

3.3 In preparing this evidence I have read and familiarised myself with:

(a) The Canterbury Regional Policy Statement 2013 (RPS)

(b) The notified Proposed Canterbury Air Regional Plan (Proposed Plan)

(c) The predecessor to the Proposed Plan, Chapter 3 of the Natural Resources Regional Plan (NRRP);

(d) The Section 32 and 42A reports;

(e) The evidence prepared by Mr Daniel Murray.

4. DEFINITION OF 'BULK SOLID MATERIAL'

4.1 Rules 7.37 and 7.38 refer to 'bulk solid materials' which is a term which has not been defined in the pCARP. This has been addressed by a number of submitters and a definition has been proposed by two of these submitters (SDC and WDC). The proposed definition has been adopted and recommended in the s42a reports as follows:

"Bulk solid materials include all materials consisting of fragments or particles that could be discharged as dust or particulate. These materials include, but are not limited to: gravel, quarried rock, fertiliser, coal, cement, flour, rock aggregate, grains and wood chips.

4.2 While this definition looks to be suitable at first glance it has potentially and unnecessarily caught the grain, seed, and stock feed industry.

4.3 The process and potential dust emission sources associated with the grain processing industry is well described and summarised in the USEPA AP42 section 9.9.1 (attached as Exhibit A).

4.4 In my experience I would expect that the activities associated with the handling and storage of grain, seed, and stock feed to have a lower potential for nuisance dust emissions and therefore off-site effects than that of other bulk solid material handling industries due to the following factors:

(a) In general these products are required to be maintained in a dry state to preserve product quality and therefore nearly all handling activities occur within enclosed buildings, conveyors and storage silos. This enclosure greatly reduces the potential for nuisance dust emissions from common sources associated with other industries caught within the definition of ‘bulk solid materials’ (quarries, mines, fertiliser industry, etc) such as stock pile erosion, exposed surface erosion, open conveyors and drop points, etc. Furthermore, enclosure limits product loss and contamination due to birds, rodents and other pests.

(b) In general there is no or little processing of the grain, seed, or stock feed. The product is harvested from farms then transported to bulk storage facilities and then on-transported to end users. Therefore the dust emission points are generally limited to loading and unloading activities, bulk storage, and transport. Some products do require drying, screening, or mixing phases but this is generally limited in scale. As the storage is usually enclosed, emissions from the storage facility are generally easily and well managed. The loading and unloading are activities often conducted with enclosed screws or conveyors or through the use of front end loaders within large buildings. Transport via truck or ship is through the use of covered vehicles. Therefore through the life cycle of handling and bulk storage of these products the dust emission points are limited and therefore potential off-site nuisance risk is low.

(c) Due to the explosion and fire risk associated with excessive dust production with enclosed silos the grain, seed, and stock feed industry has very tight controls on dust production from the handling and storage facilities. This explosion and fire risk is a strong incentive for the industry to control dust emissions from all activities and therefore historically and currently there are a number of dust control technologies routinely employed by the industry. These include; misting, fabric filters, cyclones, belt wipes, baffles, choke unloading, and use of deadboxes or specially designed spouts for loading.

5. PARTICLE SIZE DISTRIBUTION

5.1 Generic particle size distributions of dust generated in grain elevators indicates that the percentage of dust with a diameter of greater than 100 µm is generally between 34-51%[1]. The AP42 Appendix B2 states that particulate emissions from grain handling activities contain a low percentage of particulates less than 10 µm in diameter (PM_{10}) (generally less than 25%). Based on these observations the likelihood that dust generated from this activity will travel far from the emission point is low, as larger/heavier particles have faster settling velocities. In general particulates of this size distribution would typically not travel greater than 100-200m from the emission.

6. RULES

6.1 My understanding of the historical reasoning for having separate rules for the handling, storage and processing of bulk materials/bulk solid materials and seeds is that it has been identified that seed cleaning, conveying, packaging, processing, handling, treatment and storage has a lower potential for dust emissions and nuisance effects beyond the boundary than those associated with similar activities conducted with bulk solid materials.

6.2 My interpretation and experience is that in general this is true (primarily for the reasons stated in para 4.4 above), and therefore the separate rules are appropriate. Consequently here is no need to limit the rate of handling or the amount of storage of these products to meet the permitted activity threshold, as the current rules have not resulted in adverse effects in the environment surrounding such facilities/activities.

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[1] Physical Propoerties of Five Grain Dust Types; C. B. Parnell, D.D. Jones. R. D. Rutherford, and K. J. Goforth. Environmental Health Perspectives, 1986

6.3 I consider the handling, processing and storage of grain and other stock feed to be most similar to 'seeds' than that of rock aggregates, cement, fertiliser, coal, flour and wood chips in terms of dust generation potential and potential off-site nuisance effects. Therefore the more applicable rule for controlling this activity/industry would be the currently proposed 7.39.

7. RECOMMENDATIONS

Based on the evidence above which draws a distinction between dust emission potential from grain, seed, and stock feed handling and processing as compared with other 'bulk solid material' handling and processing I recommend that the proposed pCARP rules/definition be amended as detailed in Daniel Murrays evidence. The definition of bulk solid material should be amended to specifically exclude grain, seed, and stock feed and the term 'seeds' in 7.39 be expanded to include grains and other stock feed.

8. CONCLUSION

8.1 To conclude, in my professional opinion there is a distinction between seed, grain, and stock feed, and other bulk solid materials included in proposed rules 7.37 and 7.38.

8.2 The historical compliance of the feed industry in Canterbury and other regions within New Zealand under permitted air discharge activity status is testimony to its generally low potential for nuisance dust emission and effective controls on identified emission sources.

8.3 My professional opinion is that the grain and stock feed industry is more similar to that of the seed industry in terms of potential for nuisance dust emissions and therefore would best be grouped in proposed rule 7.39 than those of 7.37 and 7.38.

8.4 The use of dust management plans for permitted activities which do discharge dust beyond their boundaries is an additional control to ensure industry is maintaining a no more than minor effect from their activities.

8.5 Finally I note that proposed Rule 7.3 in the pCARP restricts offensive and objectionable discharges of dust beyond the boundary of any industry or activity. Therefore there is a mechanism within the proposed plan to ensure these activities do not generate nuisance.

Donovan Van Kekem

18 September 2015

Exhibit A: USEPA AP42 section 9.9.1

9.9.1 Grain Elevators And Processes

9.9.1.1 Process Description[1-14]

Grain elevators are facilities at which grains are received, stored, and then distributed for direct use, process manufacturing, or export. They can be classified as either "country" or "terminal" elevators, with terminal elevators further categorized as inland or export types. Operations other than storage, such as cleaning, drying, and blending, often are performed at elevators. The principal grains and oilseeds handled include wheat, corn, oats, rice, soybeans, and sorghum.

Country elevators are generally smaller elevators that receive grain by truck directly from farms during the harvest season. These elevators sometimes clean or dry grain before it is transported to terminal elevators or processors. Terminal elevators dry, clean, blend, and store grain before shipment to other terminals or processors, or for export. These elevators may receive grain by truck, rail, or barge, and generally have greater grain handling and storage capacities than do country elevators. Export elevators are terminal elevators that load grain primarily onto ships for export.

Regardless of whether the elevator is a country or terminal, there are two basic types of elevator design: traditional and modern. Traditional grain elevators are typically designed so the majority of the grain handling equipment (e.g., conveyors, legs, scales, cleaners) are located inside a building or structure, normally referred to as a headhouse. The traditional elevator often employs belt conveyors with a movable tripper to transfer the grain to storage in concrete or steel silos. The belt and tripper combination is located above the silos in an enclosed structure called the gallery or bin deck. Grain is often transported from storage using belt conveyors located in an enclosed tunnel beneath the silos. Particulate emissions inside the elevator structure may be controlled using equipment such as cyclones, fabric filters, dust covers, or belt wipers; grain may be oil treated to reduce emissions. Controls are often used at unloading and loading areas and may include cyclones, fabric filters, baffles in unloading pits, choke unloading, and use of deadboxes or specially designed spouts for grain loading. The operations of traditional elevators are described in more detail in Section 2.2.1. Traditional elevator design is generally associated with facilities built prior to 1980.

Country and terminal elevators built in recent years have moved away from the design of the traditional elevators. The basic operations performed at the elevators are the same; only the elevator design has changed. Most modern elevators have eliminated the enclosed headhouse and gallery (bin decks). They employ a more open structural design, which includes locating some equipment such as legs, conveyors, cleaners, and scales, outside of an enclosed structure. In some cases, cleaners and screens may be located in separate buildings. The grain is moved from the unloading area using enclosed belt or drag conveyors and, if feasible, the movable tripper has been replaced with enclosed distributors or turn-heads for direct spouting into storage bins and tanks. The modern elevators are also more automated, make more use of computers, and are less labor-intensive. Some traditional elevators have also been partially retrofitted or redesigned to incorporate enclosed outside legs, conveyors, cleaners, and other equipment. Other techniques used to reduce emissions include deepening the trough of the open-belt conveyors and slowing the conveyor speed, and increasing the size of leg belt buckets and slowing leg velocity. At loading and unloading areas of modern elevators, the controls cited above for traditional elevators can also be used to reduce emissions.

The first step at a grain elevator is the unloading of the incoming truck, railcar, or barge. A truck or railcar discharges its grain into a hopper, from which the grain is conveyed to the main part of the elevator. Barges are unloaded by a bucket elevator (either a continuous barge unloader or marine leg) that is extended down into the barge hold. The main building at an elevator, where grain is elevated and distributed, is called the "headhouse". In the headhouse, grain is lifted on one of the elevator legs and, at older facilities, is typically discharged onto the gallery belt, which conveys the grain to the storage bins. A "tripper" diverts grain off the belt and into the desired bin. At more modern facilities, other modes of transfer include enclosed conveyors, direct spouting, augers, and screw conveyors. Grain is often cleaned, dried, and cooled for storage. Once in storage, grain may be transferred one or more times to different storage bins or may be emptied from a bin, treated or dried, and stored in the same or a different bin. The most common method for unloading ships is by leg, using either an in-house leg operated by the facility or a self-unloading system (leg and conveyors) designed into the vessel. Figure 9.9.1-1 presents the major process operations at a grain elevator.

A grain processing plant or mill receives grain from an elevator and performs various manufacturing steps that produce a finished food product. The grain receiving and handling operations at processing plants and mills are basically the same as at grain elevators. Examples of processing plants are flour mills, oat mills, rice mills, dry corn mills, and animal feed mills. The following subsections describe the processing of the principal grains. Additional information on grain processing may be found in AP-42 Section 9.9.2, Cereal Breakfast Food, and AP-42 Section 9.9.7, Corn Wet Milling.

9.9.1.1.1 Flour Milling[2,5] -

Most flour mills produce wheat flour, but durum wheat and rye are also processed in flour mills. The wheat flour milling process consists of 5 main steps: (1) grain reception, preliminary cleaning, and storage; (2) grain cleaning; (3) tempering or conditioning; (4) milling the grain into flour and its byproducts; and (5) storage and/or shipment of finished product. A simplified diagram of a typical flour mill is shown in Figure 9.9.1-2. Wheat arrives at a mill and, after preliminary cleaning, is conveyed to storage bins. As grain is needed for milling, it is withdrawn and conveyed to the mill area where it first enters a separator (a vibrating screen), then, an aspirator to remove dust and lighter impurities, and then passes over a magnetic separator to remove iron and steel particles. From the magnetic separator, the wheat enters a disc separator designed to catch individual grains of wheat and reject larger or smaller material and then to a stoner for removal of stones, sand, flints, and balls of caked earth or mud. The wheat then moves into a scourer which buffs each kernel and removes more dust and loose bran (hull or husk). Following the scouring step, the grain is sent to the tempering bins where water is added to raise the moisture of the wheat to make it easier to grind. When the grain reaches the proper moisture level, it is passed through an impact machine as a final cleaning step. The wheat flows into a grinding bin and then into the mill itself.

The grain kernels are broken open in a system of breaks by sets of corrugated rolls, each set taking feed from the preceding one. After each break, the grain is sifted. The sifting system is a combination of sieving operations (plansifters) and air aspiration (purifiers). The flour then passes through the smooth reducing rolls, which further reduce the flour-sized particles and facilitate the removal of the remaining bran and germ particles. Plansifters are used behind the reducing rolls to divide the stock into over-sized particles, which are sent back to the reducing rolls, and flour, which is removed from the milling system. Flour stock is transported from the milling system to bulk storage bins and subsequently packaged for shipment.

Generally, durum wheat processing comprises the same steps as those used for wheat flour milling. However, in the milling of durum, middlings rather than flour are the desired product. Consequently, the break system, in which middlings are formed, is emphasized over the part of the reduction system in which flour is formed. Grain receiving, cleaning, and storage are essentially

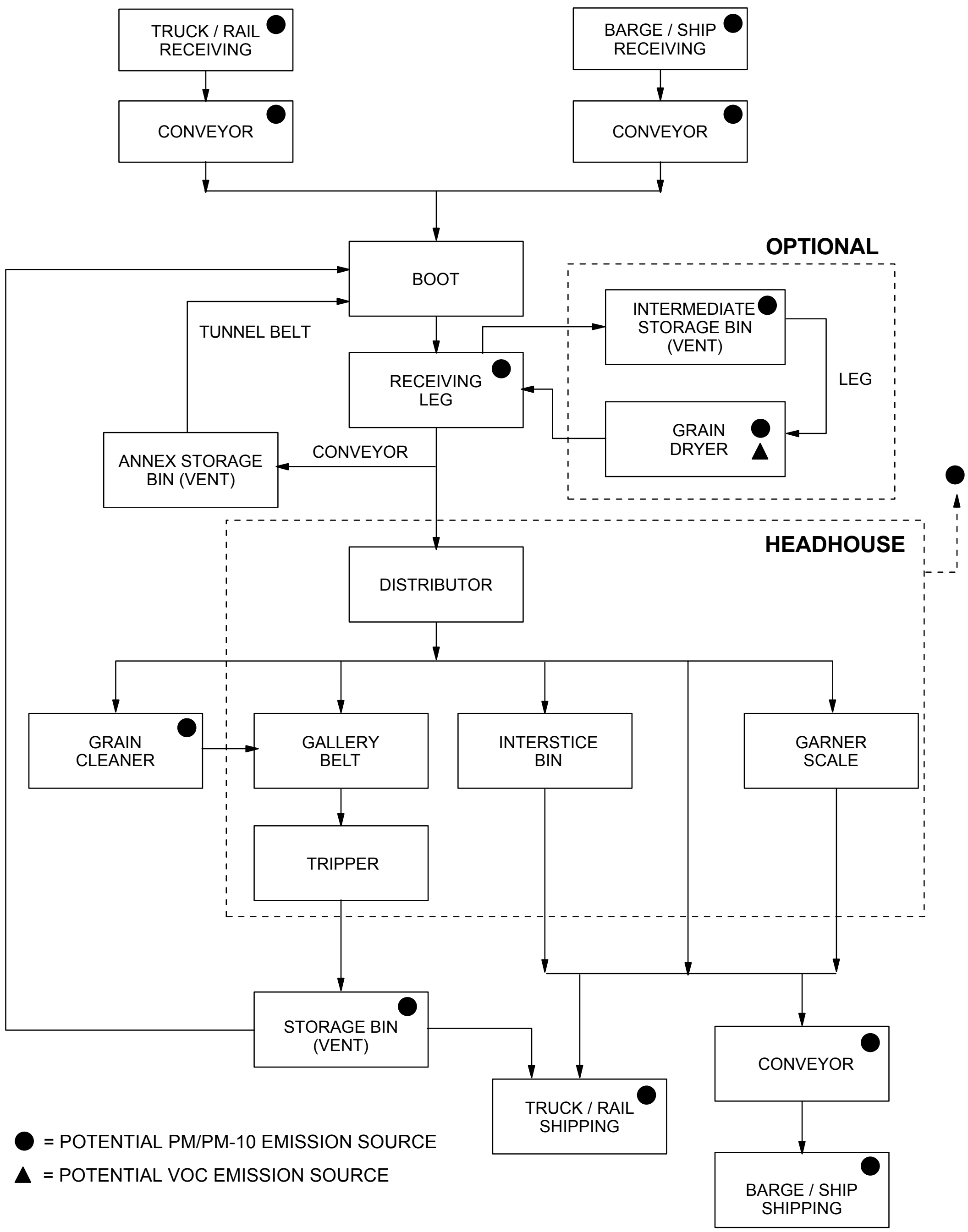

Figure 9.9.1-1. Major process operations at a grain elevator.

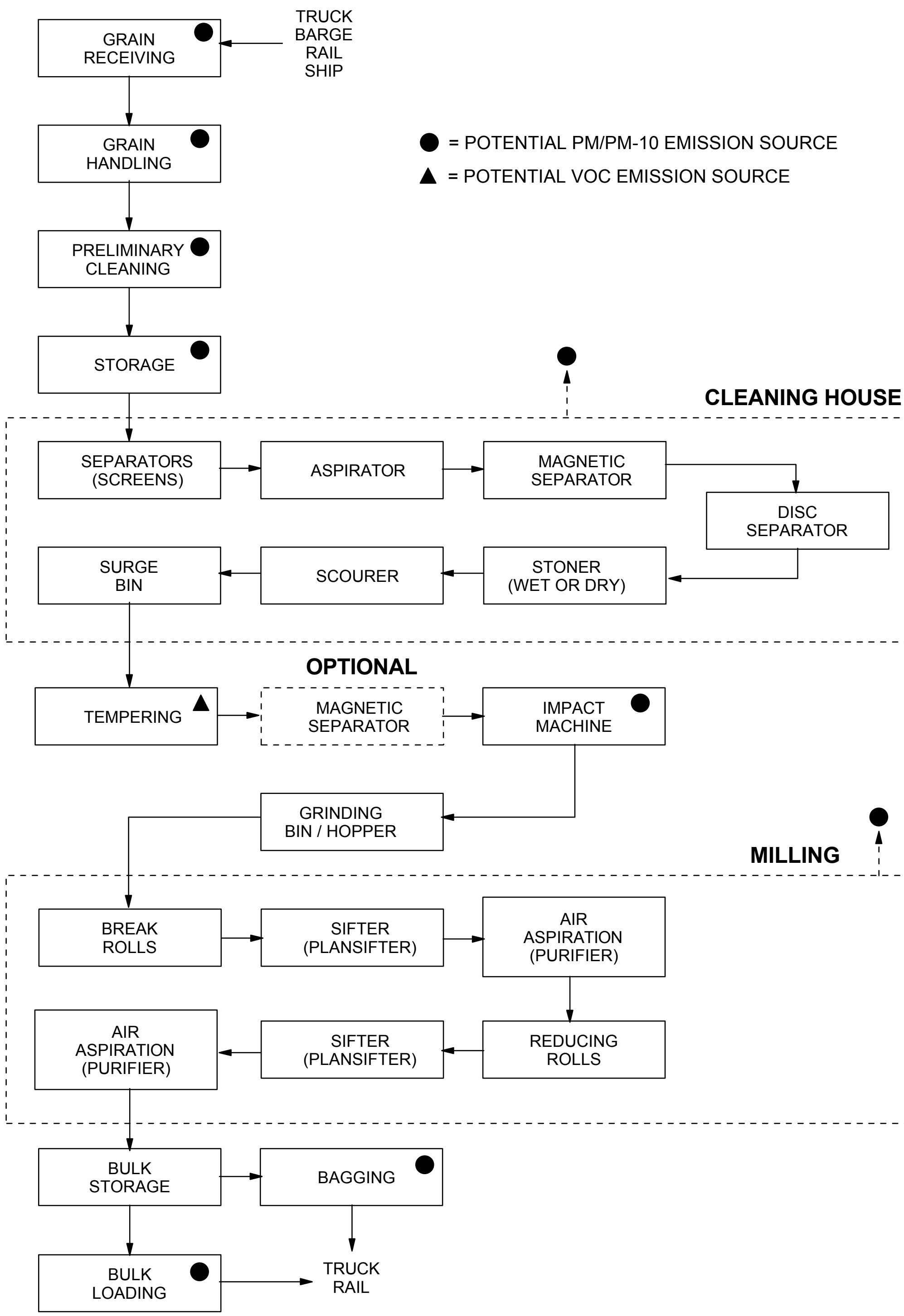

Figure 9.9.1-2. Simplified process flow diagram of a typical flour mill.

identical for durum and flour milling. The tempering step varies only slightly between the two processes. The tempering of durum uses the same equipment as wheat, but the holding times are shorter. Only the grain milling step differs significantly from the comparable flour milling step.

The break system in a durum mill generally has at least five sets of rolls for a gradual reduction of the stock to avoid producing large amounts of break flour. The rolls in the reduction system are used for sizing only, and not to produce flour. The sizing produces a uniform product for sale. The sifting system differs from that in a wheat flour mill in that it relies heavily on purifiers. In place of plansifters, conventional sieves are more common and are used to make rough separations ahead of the purifiers.

Rye milling and wheat flour milling are quite similar processes. The purpose of both processes is to make flour that is substantially free of bran and germ. The same basic machinery and process are employed. The flow through the cleaning and tempering portions of a rye mill is essentially the same as the flow through the wheat flour mill. However, because rye is more difficult to clean than wheat, this cleaning operation must be more carefully controlled.

In contrast to wheat milling, which is a process of gradual reduction with purification and classification, rye milling does not employ gradual reduction. Both the break and reduction roller mills in a rye mill are corrugated. Following grinding, the screening systems employ plansifters like those used in wheat flour mills. There is little evidence of purifier use in rye mills.

The wheat milling and rye milling processes are very similar because flour is the product of the break rolling system. In durum wheat flour milling, the intent is to produce as little flour as possible on the break rolls. As in wheat flour milling, the intent in rye milling is to make as much rye flour as possible on the break rolls. Consequently, there are more break rolls in proportion to reduction rolls in a rye mill than in a durum wheat flour mill.

9.9.1.1.2 Oat Milling[2,7] -

The milling process for oats consists of the following steps: (1) reception, preliminary cleaning, and storage; (2) cleaning; (3) drying and cooling; (4) grading and hulling; (5) cutting; (6) steaming; and (7) flaking. A simplified flow diagram of the oat milling process is shown in Figure 9.9.1-3. The receiving and storage operations are comparable to those described for grain elevators and for the wheat flour milling process. Preliminary cleaning removes coarse field trash, dust, loose chaff, and other light impurities before storage. After the oats are removed from storage, they flow to a milling separator combining coarse and fine screening with an efficient aspiration. In the next sequence of specialized cleaning operations, the oats are first routed to a disk separator for stick removal, and then are classified into three size categories. Each size category is subjected to a variety of processes (mechanical and gravitational separation, aspiration, and magnetic separation) to remove impurities. Large and short hulled oats are processed separately until the last stages of milling.

The next step in the oat processing system is drying and cooling. Oats are dried using pan dryers, radiator column dryers, or rotary steam tube dryers. Oats typically reach a temperature of 88° to 98°C (190° to 200°F) here, and the moisture content is reduced from 12 percent to 7 to 10 percent. After drying and cooling, the oats are ready for hulling; hulled oats are called groats. Some mills are now hulling oats with no drying or conditioning, then drying the groats separately to develop a toasted flavor. Hulling efficiency can be improved by prior grading or sizing of the oats. The free hulls are light enough that aspirators remove them quite effectively.

Generally, the final step in the large oat system is the separation of groats totally free of whole oats that have not had the hulls removed. These groats bypass the cutting operation and are directed to

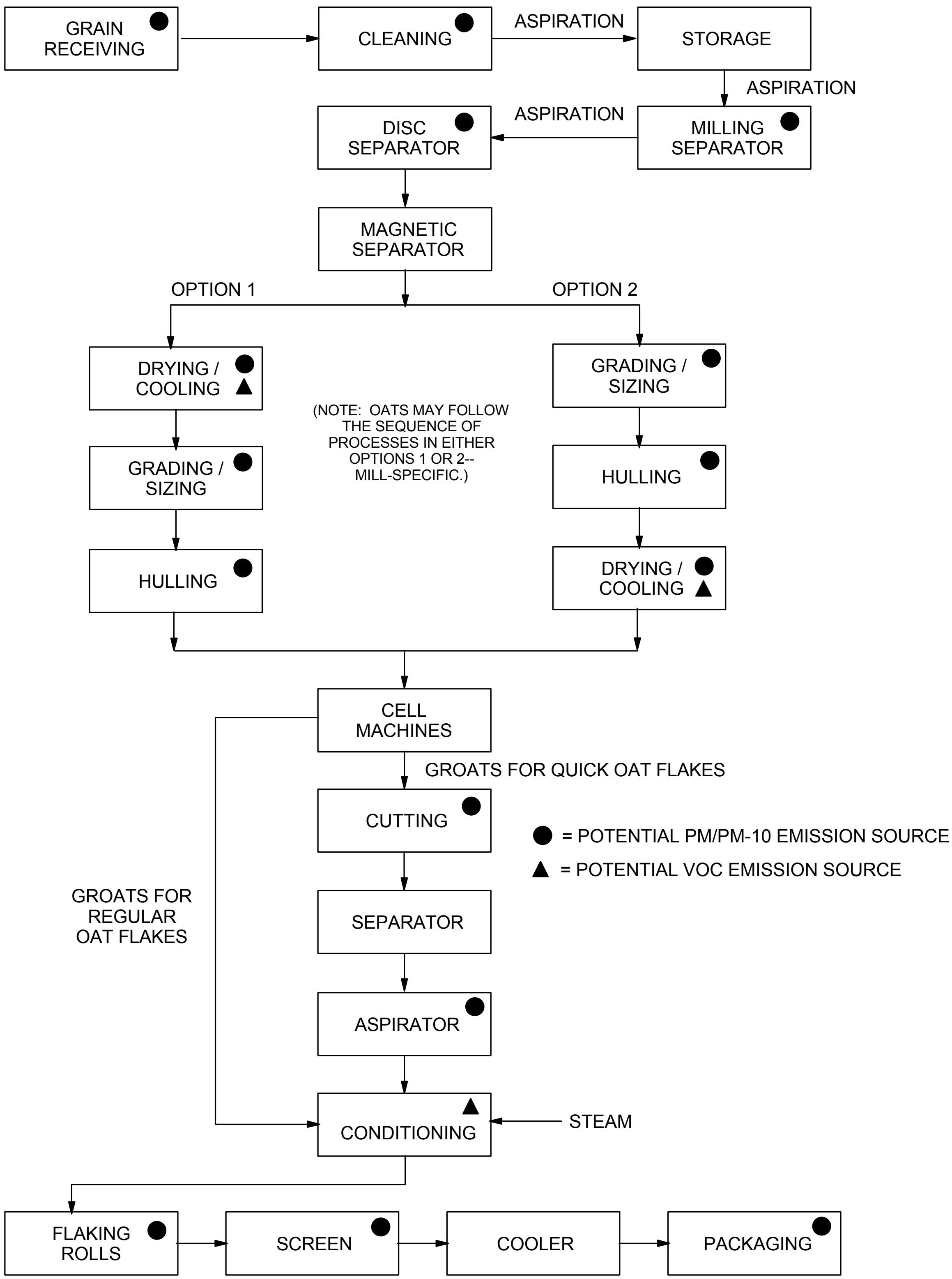

Figure 9.9.1-3. Flow diagram for oat processing operations.[8]

storage prior to flaking. The rejects are sent to the cutting plant. The cutting plant is designed to convert the groats into uniform pieces while producing a minimum of flour. The cut material is now ready for the flaking plant. First, the oats are conditioned by steaming to soften the groats thereby promoting flaking with a minimum of breakage. The steamed groats pass directly from the steamer into the flaking rolls. Shakers under the rolls remove fines and overcooked pieces are scalped off. The flakes generally pass through a dryer and cooler to quickly reduce moisture content and temperature which ensures acceptable shelf life. The cooled flakes are then conveyed to the packaging system.

9.9.1.1.3 Rice Milling[2,8-10]-

The first step in rice processing after harvest is drying using either fixed-bed or continuous-flow dryers to reduce the wet basis moisture content (MCwb) from 24 to 25 percent to 13 to 14 percent MCwb. Essentially all of the rice is dried either on the farm or at commercial drying facilities prior to shipping to the rice mill. After the rice is dried, it is stored and subsequently shipped to either conventional or parboil rice mills for further processing. There are three distinct stages in both mills: (1) rough rice receiving, cleaning, drying, and storage; (2) milling; and (3) milled rice and byproduct bagging, packaging, and shipping. A simplified flow diagram of the rice milling process is shown in Figure 9.9.1-4.

Grain is received primarily by truck and rail. The rough rice is precleaned using combinations of scalpers, screens, aspirators, and magnetic separators and then passed through a stoner, or gravity separator, to remove stones from the grain. The cleaned rice is transported to a disk huller where the rice is dehulled. The rice then passes through a sieve to remove bran and small brokens and to an aspirator to remove hulls. The unshelled rice grains (commonly called paddy) and brown rice are separated in a paddy separator. The unshelled paddy is then fed into another pair of shellers set closer together than the first set, and the process of shelling, aspiration, and separation is repeated.

From the paddy machines, the rice is conveyed to a sequence of milling machines called whitening cones, which scour off the outer bran coats and the germ from the rice kernels. Milling may be accomplished by a single pass through a mill or by consecutive passages through multiple whitening cones. The discharge from each stage is separated by a sieve. After the rice is milled, it passes through a polishing cone, which removes the inner bran layers and the proteinaceous aleurone layer. Because some of the kernels are broken during milling, a series of classifiers, known as trieurs, is used to separate the different size kernels. The rice may be sold at this point as polished, uncoated rice, or it may be conveyed to machines known as trumbels, in which the rice is coated with talc and glucose to give the surface a gloss. The rice is transferred to bulk storage prior to packing and shipping. For packing, the rice is transported to a packing machine where the product is weighed and placed in burlap sacks or other packaging containers.

In parboiling mills, the cleaned rough rice is steamed and dried prior to the milling operations. Pressure vessels are used for the steaming step, and steam tube dryers are used to dry the rice to 11 to 13 percent MCwb. Following the drying step, the rice is milled in conventional equipment to remove hull (bran), and germ.

9.9.1.1.4 Corn Dry Milling[2,12-13] -

Corn is dry milled by either a degerming or a nondegerming system. Because the degerming system is the principal system used in the United States, it will be the focus of the dry corn milling process description here. A simplified flow diagram of the corn dry milling process is shown in Figure 9.9.1-5. The degerming dry corn milling process is more accurately called the tempering degerminating (TD) system. The degerming system involves the following steps after receiving the grain: (1) dry cleaning, and if necessary, wet cleaning; (2) tempering; (3) separation of hull, germ, and

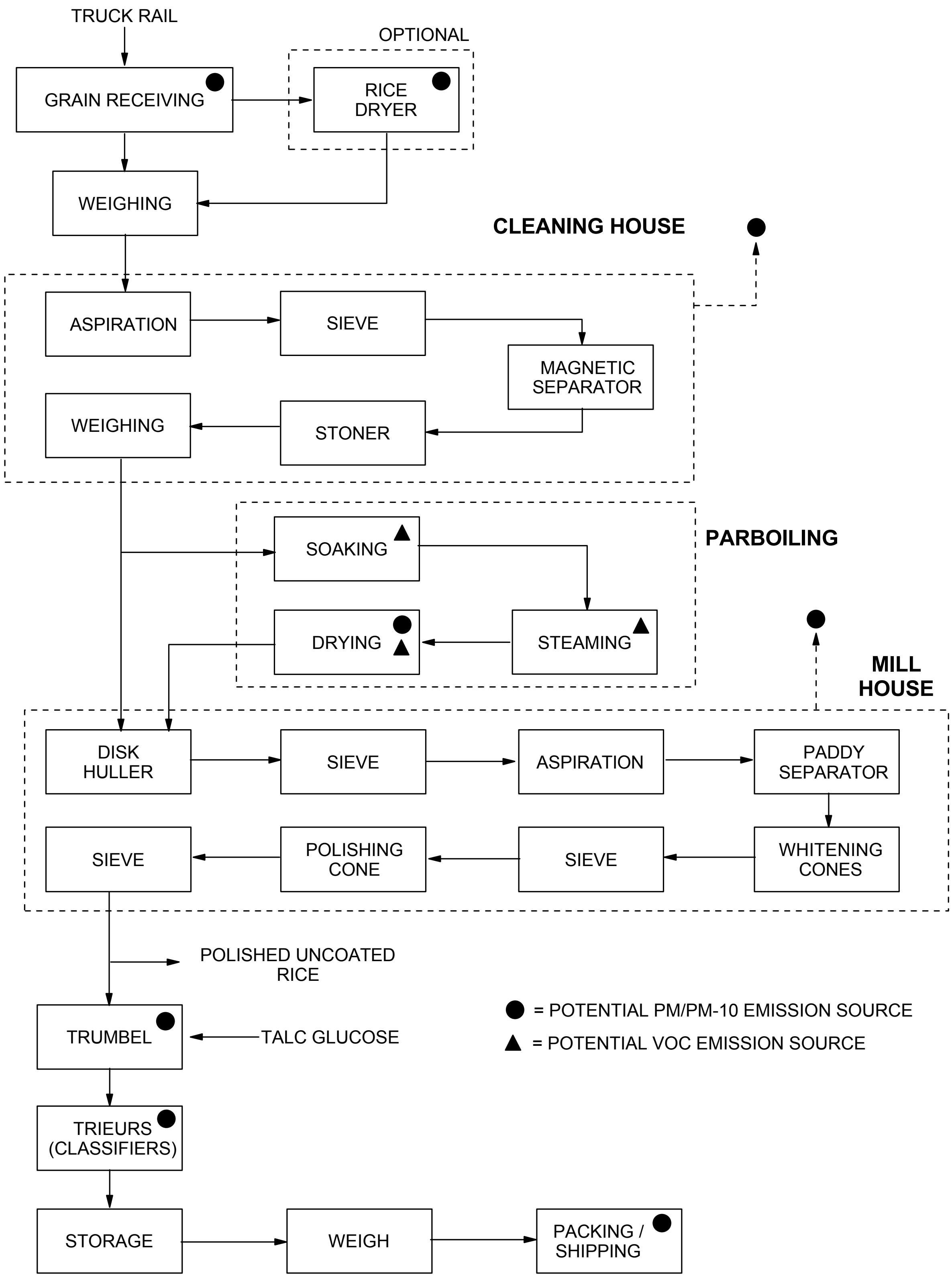

Figure 9.9.1-4. Flow diagram for conventional and parboil rice mills.

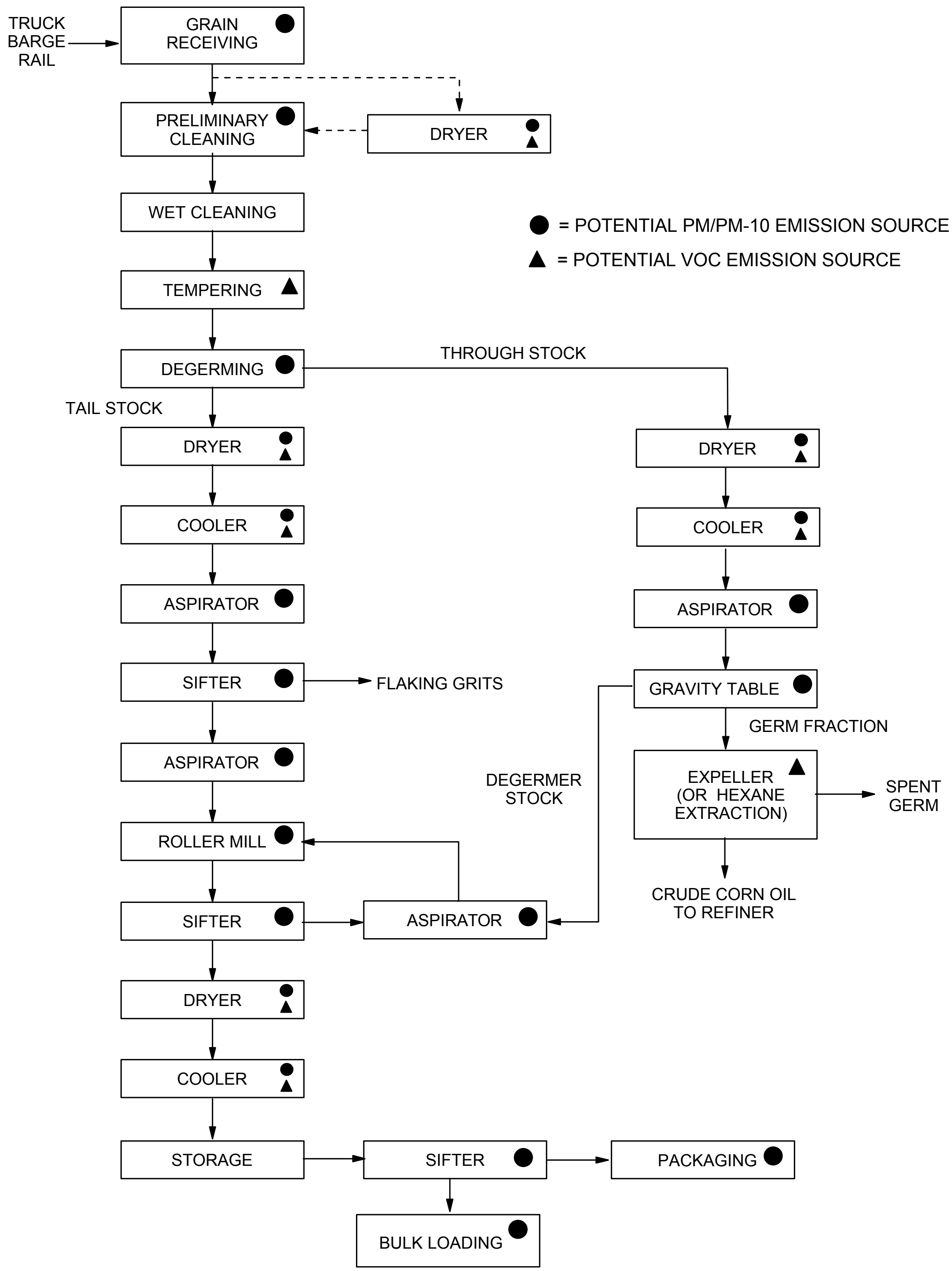

Figure 9.9.1-5. Simplified process flow diagram for a corn dry milling operation with degerming.

tip cap from the endosperm in the degerminator; (4) drying and cooling of degermer product; (5) multistep milling of degermer product through a series of roller mills, sifters, aspirators, and purifiers; (6) further drying of products, if necessary; (7) processing of germ fraction for recovery of crude corn oil; and (8) packaging and shipping of products.

Unloading and dry cleaning of corn is essentially the same as described for wheat. However, for corn, surface dirt and spores can best be removed by wet cleaning, which involves a washing-destoning unit followed by a mechanical dewatering unit. After cleaning, the corn is sent through the tempering or conditioning step, which raises the moisture content of the corn to 21 to 25 percent. After tempering, the corn is degermed, typically in a Beall degermer and corn huller. The Beall degermer is essentially an attrition device built in the form of a cone mill. The product exits in two streams, thru-stock and tail stock. Rotary steam-tube dryers are often used to dry the degermer product, because its moisture content must be in the 15 to 18 percent range for proper milling. After drying, the product is cooled to 32° to 37°C (90° to 100°F). After drying and cooling, the degermer stock is sifted or classified by particle size and is fed into the conventional milling system.

The milling section in a dry corn mill consists of sifting, classifying, milling, purifying, aspirating, and possibly, final drying operations. The feed to each pair of rolls consists of selected mill streams produced during the steps of sifting, aspirating, roller milling, and gravity table separating. For the production of specific products, various streams are withdrawn at appropriate points in the milling process. A number of process streams are often blended to produce a specific product. The finished products are stored temporarily in working bins, dried and cooled if necessary, and rebolted (sifted) before packaging or shipping in bulk.

Oil is recovered from the germ fraction either by mechanical screw presses or by a combination of screw presses and solvent extraction. A more detailed discussion of the corn oil extraction process is included in AP-42 Section 9.11.1, Vegetable Oil Processing.

9.9.1.1.5 Animal Feed Mills[2,5,14] -

The manufacture of feed begins with receiving of ingredients at the mill. A simplified flow diagram of the animal feed manufacturing process is shown in Figure 9.9.1-6. more than 200 ingredients may be used in feed manufacture, including grain, byproducts (e.g., meat meal, bone meal, beet and tomato pulp), and medicinals, vitamins, and minerals (used in very small portions). Grain is usually received at the mill by hopper bottom truck and/or rail cars, or in some cases, by barge. Most mills pass selected feed ingredients, primarily grains, through cleaning equipment prior to storage. Cleaning equipment includes scalpers to remove coarse materials before they reach the mixer. Separators, which perform a similar function, often consist of reciprocating sieves that separate grains of different sizes and textures. Magnets are installed ahead of the grinders and at other critical locations in the mill system to remove pieces of metal, bits of wire, and other foreign metallic matter, which could harm machinery and contaminate the finished feed. From the cleaning operation, the ingredients are directed to storage.

Upon removal from storage, the grain is transferred to the grinding area, where selected whole grains, primarily corn, are ground prior to mixing with other feed components. The hammermill is the most widely used grinding device. The pulverized material is forced out of the mill chamber when it is ground finely enough to pass through the perforations in the mill screen.

Mixing is the most important process in feed milling and is normally a batch process. Ingredients are weighed on bench or hopper scales before mixing. Mixers may be horizontal or vertical type, using either screws or paddles to move the ingredients. The material leaving the mixer is meal, or

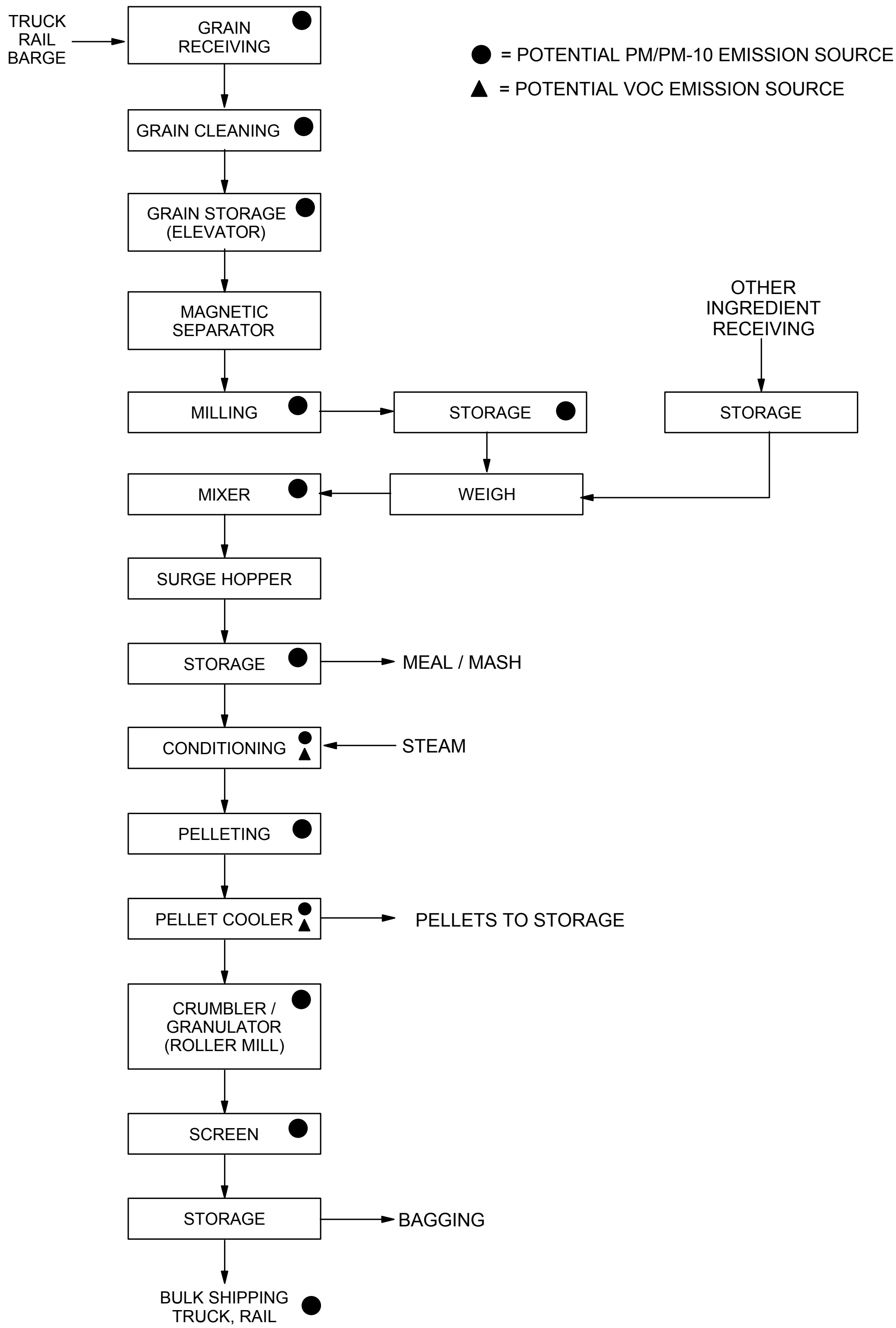

Figure 9.9.1-6. Typical animal feed milling process flow diagram.

mash, and may be marketed in this form. If pellets are to be made, the meal is conditioned with steam prior to being pelleted.

Pelleting is a process in which the conditioned meal is forced through dies. Pellets are usually 3.2 to 19 mm (1/8 to 3/4 in.) in diameter. After pelleting, pellets are dried and cooled in pellet coolers. If pellets are to be reduced in size, they are passed through a crumbler, or granulator. This machine is a roller mill with corrugated rolls. Crumbles must be screened to remove fines and oversized materials. The product is sent to storage bins and then bagged or shipped in bulk.

In modern feed mills, transport equipment is connected with closed spouting and turnheads, covered drag and screw conveyors, and tightly sealed transitions between adjoining equipment to reduce internal dust loss and consequent housekeeping costs. Also many older facilities have upgraded to these closed systems.

9.9.1.1.6 Malted Barley Production[36-37] -

Barley is shipped by railcar or truck to malting facilities. A screw conveyor or bucket elevator typically transports barley to storage silos or to the cleaning and sizing operations. The barley is cleaned and separated by size (using screens) and is then transferred to a malthouse where it is rinsed in steeping tanks (steeped) and is allowed to germinate. Following steeping and germination, “green” malt is dried, typically in an indirect-, natural gas-fired malt kiln. Malt kilns typically include multiple levels, called beds or layers. For a two-level kiln, green malt, with a moisture content of about 45 percent, enters the upper deck of the kiln and is dried, over a 24-hour period, to between 15 and 20 percent. The barley is then transferred to the lower deck of the kiln, where it is dried to about 4 percent over a second 24-hour period. Some facilities burn sulfur in a sulfur stove and exhaust the stove into the kiln at selected times during the kiln cycle. The sulfur dioxide serves as a fungicide, bactericide, and preservative. Malted barley is then transferred by screw conveyor to a storage elevator until it is shipped.

9.9.1.2 Emissions And Controls[2,5,14-39]

The main pollutant of concern in grain storage, handling, and processing facilities is particulate matter (PM). Organic emissions (e.g., hexane) from certain operations at corn oil extraction facilities may also be significant. These organic emissions (and related emissions from soybean and other oilseed processing) are discussed in AP-42 Section 9.11.1. Also, direct fired grain drying operations and product dryers in grain processing plants may emit small quantities of VOC’s and other combustion products; no data are currently available to quantify the emission of these pollutants. The following sections focus primarily on PM sources at grain elevators and grain milling/processing facilities.

9.9.1.2.1 Grain Elevators -

Except for barge and ship unloading and loading activities, the same basic operations take place at country elevators as at terminal elevators, only on a smaller scale and with a slower rate of grain movement. Emission factors for various grain elevator operations are presented later in this subsection. Because PM emissions at both types of elevators are similar, they will be discussed together in this subsection.

In trying to characterize emissions and evaluate control alternatives, potential PM emission sources can be classified into three groups. The first group includes external emission sources (grain receiving and grain shipping), which are characterized by direct release of PM from the operations to the atmosphere. These operations are typically conducted outside elevator enclosures or within partial enclosures, and emissions are quickly dispersed by wind currents around the elevator. The second group of sources are process emission sources that may or may not be vented to the atmosphere and include grain cleaning and headhouse and internal handling operations (e.g., garner and scale bins, elevator legs, and transfer points such as the distributor and gallery and tunnel belts). These operations are typically located inside the elevator structure. Dust may be released directly from these operations to the internal elevator environment, or aspiration systems may be used to collect dust generated from these operations to improve internal housekeeping. If aspiration systems are used, dust is typically collected in a cyclone or fabric filter before the air stream is discharged to the atmosphere. Dust emitted to the internal environment may settle on internal elevator surfaces, but some of the finer particles may be emitted to the environment through doors and windows. For operations not equipped with aspiration systems, the quantity of PM emitted to the atmosphere depends on the tightness of the enclosures around the operation and internal elevator housekeeping practices. The third group of sources includes those processes that emit PM to the atmosphere in a well-defined exhaust stream (grain drying and storage bin vents). Each of these operations is discussed in the paragraphs below.

The amount of dust emitted during the various grain-handling operations may depend upon the type of grain being handled, the quality or grade of the grain, the moisture content of the grain, the speed of the belt conveyors used to transport the grain, and the extent and efficiency of dust containment systems (i.e., hoods, sheds, etc.) in use at an elevator. Part of the dust liberated during the handling of grain at elevators gets into the grain during the harvesting operation. However, most of these factors have not been studied in sufficient detail to permit the delineation of their relative importance to dust generation rates.

Grain dust emitted from grain elevator handling operations comprises about 70 percent organic material. The dust may include particles of grain kernels, small amounts of spores of smuts and molds, insect debris, pollens, and field dust. Data recently collected on worker exposure to grain dust indicate that the characteristics of the dust released from processing operations to the internal elevator environment vary widely.[15] Because these dusts have a high organic content and a substantial suspendible fraction, concentrations above the minimum explosive concentration (MEC) pose an explosion hazard. Housekeeping practices instituted by the industry have reduced exploding hazards so this situation is rarely encountered in work areas.

Recent research on dust emissions from grain handling operations indicate that the fraction of dust particles equal to or less than 10 micrometers (µm) in aerodynamic diameter (PM-10) averages approximately 25 percent of total PM, and the fraction of dust particles less than 2.5 µm in aerodynamic diameter (PM-2.5) averages about 17 percent of PM-10.

Elevators in the United States receive grain by truck, railroad hopper car, and barge. The two principal factors that contribute to dust generation during bulk unloading are wind currents and dust generated when a falling stream of grain strikes the receiving pit. Falling or moving streams of grain initiate a column of air moving in the same direction. Grain unloading is an intermittent source of dust occurring only when a truck or car is unloaded. For country elevators it is a significant source during the harvest season and declines sharply or is nonexistent during other parts of the year. At terminal elevators, however, unloading is a year-round operation.

Trucks, except for the hopper (gondola) type, are generally unloaded by the use of some type of truck dumping platform. Hopper trucks discharge through the bottom of the trailer. Elevators are often designed with the truck unloading dump located in a drive-through tunnel. These drive-through areas are sometimes equipped with a roll-down door on one end, although, more commonly they are open at both ends so that the trucks can enter and leave as rapidly as possible. The drive-through access can act as a "wind-tunnel" in that the air may blow through the unloading area at speeds greater than the wind in the open areas away from the elevator. However, the orientation of the facility to the prevailing wind direction can moderate this effect. Many facilities have installed either roll-down or bi-fold doors to eliminate this effect. The use of these doors can greatly reduce the "wind tunnel" effect and enhance the ability to contain and capture the dust.

The unloading pit at a grain elevator usually consists of a heavy grate approximately 3.05 m x 3.05 m (10 ft x 10 ft) through which the grain passes as it falls into the receiving pit. This pit will often be partially filled with grain as the truck unloads because the conveyor beneath the pit does not carry off the grain as fast as it enters. The dust-laden air emitted by the truck unloading operation results from displacement of air out of the pit plus the aspiration of air caused by the falling stream of grain. The dust itself is composed of field dirt and grain particles. Unloading grain from hopper trucks with choke flow-practices can provide a substantial reduction in dust emissions.

Similarly, a hopper railcar can be unloaded with minimal dust generation if the material is allowed to form a cone around the receiving grate (i.e., choke feed to the receiving pit). This situation will occur when either the receiving pit or the conveying system serving the pit is undersized in comparison to the rate at which material can be unloaded from the hopper car. In such cases, dust is generated primarily during the initial stage of unloading, prior to establishment of the choked-feed conditions. Dust generated by wind currents can be minimized by the use of a shed enclosed on two sides with a manual or motorized door on one end or a shroud around the hopper discharge.

In most cases, barges are unloaded by means of a retractable bucket type elevator that is lowered into the hold of the barge. There is some generation of dust in the hold as the grain is removed and also at the top of the leg where the grain is discharged onto the transfer belt. This latter source is more appropriately designated a transfer point.

The loadout of grain from elevators into railcar, truck, barge, or ship is another important source of PM emissions and is difficult to control. Gravity is usually used to load grain from bins above the loading station or from the scale in the headhouse. The main causes of dust emissions when loading bulk grain by gravity into trucks or railcars is the wind blowing through the loading sheds and dust generated when the falling stream of grain strikes the truck or railcar hopper. The grain leaving the loading spout is often traveling at relatively high velocity, and dead boxes, aspiration, socks, or other means are often used to reduce dust emissions. Dust emitted during loading of barges and ships is comparable to levels generated during loading of trucks or railcars. The openings for the holds in ocean-going vessels may also be covered with tarps if needed to meet air quality standards.

Grain dryers present a difficult problem for air pollution control because of the large volumes of air exhausted from the dryer, the large cross-sectional area of the exhaust, the low specific gravity of the emitted dust, and the high moisture content of the exhaust stream. The rate of emission of PM from grain dryers is primarily dependent upon the type of grain, the dustiness of the grain, and the dryer configuration (rack or column type). The particles emitted from the dryers, although relatively large, may be very light and difficult to collect. However, during corn drying, the characteristic "bees wing" is emitted along with normal grain dust. "Bees wing," a light flaky material that breaks off from the corn kernel during drying and handling, is a troublesome PM emission. Essentially, all bees wing emissions are more than 50 µm in diameter, and the mass mean diameter is probably in the region of 150 µm. In addition to the bees wings, the dust discharged from grain dryers consists of hulls, cracked grain, weed seeds, and field dust. Effluent from a corn dryer may consist of 25 percent bees wing, which has a specific gravity of about 0.70 to 1.2. Approximately 95 percent of the grain dust is larger than 50 µm.[2]

Cross-flow column dryers have a lower emission rate than rack dryers because some of the dust is trapped by the column of grain. In some cases, an enclosure may be built around the dryer that can act as a relatively effective settling chamber because of its moist environment. New grain dryers being sold today do not require the use of enclosures. In rack dryers drying corn, the emission rate for larger PM can be higher because the turning motion of the grain liberates more bees wings from the kernel, and the design facilitates dust escape. Some rack dryers are exhausted only from one or two points and are thus better suited for control device installation. The EPA's New Source Performance Standards (NSPS) for grain elevators established visible emission limits for grain dryers by requiring 0 percent opacity for emissions from column dryers and rack dryers. The NSPS zero opacity standard does not apply to column dryers with column plate perforations less than or equal to 2.4 mm in diameter (0.094 in.) or to rack dryers with a screen filter that has openings that are less than or equal to 50 mesh.

Equipment used to clean grain varies from simple screening devices to aspiration-type cleaners. Both types of systems potentially generate substantial quantities of PM depending on the design and extent of enclosure.

Both country and terminal elevators are usually equipped with garner and scale bins for weighing of grain. A country elevator may have only one garner bin and scale bin. However, a terminal elevator has multiple scale and garner bin systems, each with a capacity ranging from 42.3 to 88.1 m^3 (1,200 to 2,500 bu) to process 1,233 to 2,643 m^3/hr (35,000 to 75,000 bu/hr). Dust may be emitted from both the scale and garner bin whenever grain is admitted. The incoming stream of grain displaces air from the bin, and the displaced air entrains dust. The potential for emissions depends on the design of the system. For example, some facilities employ a relief duct that connects the two pieces of equipment to provide a path for displaced air. Also, in some cases, the bins are completely open at the top while some systems are completely enclosed.

The leg may be aspirated to remove dust created by the motion of the buckets and the grain flow. A variety of techniques are used to aspirate elevator legs. For example, some are aspirated at both the top and bottom; others are fitted with ducting from the top to the bottom in order to equalize the pressure, sometimes including a small blower to serve this purpose. The collected dust is discharged to a cyclone or filter. Leg vents may emit small amounts of dust under some operating conditions. However, these vents are often capped or sealed to prevent dust emissions. The sealing or capping of the vent is designed to act as an explosion relief vent after a certain internal pressure is reached to prevent damage to the equipment.

When grain is handled, the kernels scrape and strike against each other and the conveying medium. This action tends to rub off small particles of chaff and to fragment some kernels. Dust is continuously generated, and the grain is never absolutely clean. Belt conveyors have less rubbing friction than either screw or drag conveyors, and therefore, generate less dust. Dust emissions usually occur at belt transfer points as materials fall onto or away from a belt. Belt speed has a strong effect on dust generation at transfer points. Examples of transfer points are the discharge from one belt conveyor or the discharge from a bin onto a tunnel belt.

Storage bin vents, which are small screen-covered openings located at the top of the storage bins, are used to vent air from the bins as the grain enters. The grain flow into a bin induces a flow of air with the grain, and the grain also displaces air out of the bin. The air pressure that would be created by these mechanisms is relieved through the vents. The flow of grain into the bin generates dust that may be carried out with the flow of air through the bin vents. The quantity of dust released through the vents increases as the level of the grain in the bin increases. Bin vents are common to both country and terminal elevators, although the quantity of dust emitted is a function of the grain handling rate, which is considerably higher in terminal elevators.

The three general types of measures that are available to reduce emissions from grain handling and processing operations are process modifications designed to prevent or inhibit emissions, capture/collection systems, and oil suppression systems that inhibit release of dust from the grain streams. The following paragraphs describe the general approaches to process controls, capture systems, and oil suppression. The characteristics of the collection systems most frequently applied to grain handling and processing plants (cyclones and fabric filters) are then described, and common operation and maintenance problems found in the industry are discussed.

Because emissions from grain handling operations are generated as a consequence of mechanical energy imparted to the dust by the operations themselves and local air currents in the vicinity of the operations, an obvious control strategy is to modify the process or facility to limit the effects of those factors that generate emissions. The primary preventive measures that facilities have used are construction and sealing practices that limit the effect of air currents and minimizing grain free fall distances and grain velocities during handling and transfer. Some construction and sealing practices that minimize emissions are enclosing the receiving area to the degree practicable, preferably with doors at both ends of a receiving shed; specifying dust-tight cleaning and processing equipment; using lip-type shaft seals at bearings on conveyor and other equipment housings; using flanged inlets and outlets on all spouting, transitions, and miscellaneous hoppers; and fully enclosing and sealing all areas in contact with products handled.

A substantial reduction in emissions from receiving, shipping, handling, and transfer areas can be achieved by reducing grain free fall distances and grain velocities. Choke unloading reduces free fall distance during hopper car unloading. The same principle can be used to control emissions from grain transfer onto conveyor belts and from loadout operations. An example of a mechanism that is used to reduce grain velocities is a “dead box” spout, which is used in grain loadout (shipping) operations. The dead box spout slows down the flow of grain and stops the grain in an enclosed area. The dead box is mounted on a telescoping spout to keep it close to the grain pile during operation. In principle, the grain free falls down the spout to an enclosed impact dead box, with grain velocity going to zero. It then falls onto the grain pile. Typically, the entrained air and dust liberated at the dead box is aspirated back up the spout to a dust collector. Finally, several different types of devices are available that, when added to the end of the spout, slow the grain flow and compress the grain discharge stream. These systems entrap the dust in the grain stream, thereby providing a theoretical reduction in PM emissions. There are few, if any, test data from actual ship or barge loading operations to substantiate this theoretical reduction in emissions.

While the preventive measures described above can minimize emissions, most facilities also require ventilation, or capture/collection, systems to reduce emissions to acceptable levels. In fact, air aspiration (ventilation) is a part of the dead box system described above. Almost all grain handling and processing facilities, except relatively small grain elevators, use capture/collection on the receiving pits, cleaning operations, and elevator legs. Generally, milling and pelletizing operations at processing plants are ventilated, and some facilities use hooding systems on all handling and transfer operations.

Grain elevators that rely primarily on aspiration typically duct many of the individual dust sources to a common dust collector system, particularly for dust sources in the headhouse. Thus, aspiration systems serving elevator legs, transfer points, bin vents, etc., may all be ducted to one collector in one elevator and to two or more individual systems in another. Because of the myriad possibilities for ducting, it is nearly impossible to characterize a “typical” grain elevator from the standpoint of delineating the exact number and types of air pollution sources and the control configurations for those sources.

The control devices typically used in the grain handling and processing industry are cyclones (or mechanical collectors) and fabric filters. Cyclones are generally used only on country elevators and small processing plants located in sparsely populated areas. Terminal elevators and processing plants located in densely populated areas, as well as some country elevators and small processing plants, normally use fabric filters for control. Both of these systems can achieve acceptable levels of control for many grain handling and processing sources. Although cyclone collectors can achieve acceptable performance in some scenarios, and fabric filters are highly efficient, both devices are subject to failure if they are not properly operated and maintained. Also, malfunction of the ventilation system can lead to increased emissions at the source.

The emission control methods described above rely on either process modifications to reduce dust generation or capture collection systems to control dust emissions after they are generated. An alternative control measure that has developed over the last 10 years is dust suppression by oil application. The driving forces for developing most such dust suppression systems have been grain elevator explosion control as well as emission control. Consequently, few data have been published on the amount of emission reduction achieved by such systems. Recent studies, however, have indicated that a PM reduction of approximately 60 to 80 percent may be achievable (see References 57 and 61 in Section 4 of the Background Report).

Generally, these oil application dust suppression systems use either white mineral oil, soybean oil, or some other vegetable oil. Currently the Food and Drug Administration restricts application rates of mineral oil to 0.02 percent by weight. Laboratory testing and industry experience have shown that oil additives applied at a rate of 60 to 200 parts per million by weight of grain, or 0.5 to 1.7 gallons of oil per thousand bushels of grain can provide effective dust control.[39] The effectiveness of the oil suppression system depends to some extent on how well the oil is dispersed within the grain stream after it is applied. Several options are available for applying oil additives.

1. As a top dressing before grain enters the bucket elevator or at other grain transfer points.
2. From below the grain stream at a grain transfer point using one or more spray nozzles.
3. In the boot of the bucket elevator leg.
4. At the discharge point from a receiving pit onto a belt or other type conveyor.
5. In a screw conveyor.

9.9.1.2.2 Grain Processing Plants -

Several grain milling operations, such as receiving, conveying, cleaning, and drying, are similar to those at grain elevators. In addition, applications of various types of grinding operations to the grain, grain products, or byproducts are further sources of emissions. The hammermill is the most widely used grinding device at feed mills. Some product is recovered from the hammermill with a cyclone collector or baghouse. Mills, similar to elevators, use a combination of cyclones and fabric filters to conserve product and to control emissions. Several types of dryers are used in mills, including the traditional rack or column dryers, fluidized bed dryers (soybean processing), and flash-fired or direct-fired dryers (corn milling). These newer dryer types might have lower emissions, but data are insufficient at this time to quantify the difference. The grain precleaning often performed before drying also likely serves to reduce emissions.

Because of the operational similarities, emission control methods used in grain milling and processing plants are similar to those in grain elevators. Cyclones or fabric filters are often used to control emissions from the grain handling operations (e. g., unloading, legs, cleaners, etc.) and also from other processing operations. Fabric filters are used extensively in flour mills. However, certain operations within milling operations are not amenable to the use of these devices and alternatives are needed. Wet scrubbers, for example, are applied where the effluent gas stream has a high moisture content. A few operations have been found to be difficult to control by any method. Various emission control systems have been applied to operations within the grain milling and processing industry.[2]

Grain processing facilities also have the potential to emit gaseous pollutants. Natural gas-fired dryers and boilers are potential sources of combustion byproducts and VOC. The production of various modified starches has the potential for emissions of hydrochloric acid or ethylene oxide. However, no data are available to confirm or quantify the presence of these potential emissions. Neither are there any data available concerning the control of these potential emissions.

Table 9.9.1-1 presents emission factors for filterable PM and PM-10 emissions from grain elevators. Table 9.9.1-2 presents emission factors for filterable PM; PM-10; inorganic, organic and total condensible PM emissions from grain processing facilities.

The most recent source test data for grain elevators either does not differentiate between country and inland terminal elevators or does not show any significant difference in emission factors between these two types of elevators. There are no current emission source test data for export terminal elevators. Because there is no significant difference in emission factors between different types of elevators, the emission factors presented in Table 9.9.1-1 are for grain elevators, without any distinction between elevator types.

In Tables 9.9.1-1 and 9.9.1-2, a number of potential emission sources are presented for each type of facility. The number and type of processes that occur within a specific elevator or grain processing plant will vary considerably from one facility to another. The total emissions from a specific facility will be dependent upon the different types of processes and the number of times a process or operation occurs within each facility. Not all processes occur at every facility; therefore, the specific emission sources and number of sources must be determined for each individual facility. It is not appropriate to sum emission factors for all sources and assume that total factor for all facilities.

9.9.1.3 Example Use of Emission Factor Table

The emission factors in Table 9.9.1-1 predict emissions from different operations at grain handling facilities. Except where specifically noted in the tables, the factors predict uncontrolled emissions.

The following guidance (with illustrative examples) is provided to users to promote greater consistency in the application of the data in Table 9.9.1-1.

(1) The emission factors for grain receiving and grain shipping (e.g., rail, truck, barge and/or ship) should be applied to the total amount of grain received and/or shipped by that mode of transportation.

Example: Facility reports shipping 1 million tons of grain by vessel. The calculated uncontrolled PM-10 emissions are:

1,000,000 tons x 0.012 lbs/ton = 12,000 lbs or 6 tons of PM-10

Example: Facility reports receiving 2 million tons of grain using a continuous barge unloader (e.g., Heyl-Patterson or Link Belt). The calculated uncontrolled PM-10 emissions are:

2,000,000 tons x 0.0073 lbs/ton = 14,600 lbs or 7.3 tons of PM-10

(2) Truck receiving can represent a unique situation at grain handling facilities. The preponderance of grain facilities receive grain by both straight and hopper bottom trucks. When actual truck counts/receipts by type of truck are not known, the emission factor for trucks should represent a weighted-average or a conservative percentage of the distribution of straight and hopper bottom trucks normally handled at the facility, or at a similar facility. The use of hopper bottom trucks to haul grain is steadily increasing over time. In some cases, industry reports that receipts of grain by hopper bottom trucks can often exceed 75 percent and in some cases represent nearly 100 percent of truck receipts. Thus, exclusive reliance on the emission factor for straight trucks would normally result in emission estimates that are strongly biased high.

Example: Facility reports receiving 42,000 tons of grain by truck with 75% being hopper bottom trucks and 25% straight trucks. The weighted average PM-10 emission factor for this facility is:

0.75 x 0.0078 lbs/ton = 0.006 lbs/ton
0.25 x 0.059 lbs/ton = 0.015 lbs/ton
Weighted average = 0.021 lbs/ton

Using this factor, the calculated uncontrolled PM-10 emissions from the truck dump can be calculated:

0.021 lbs/ton x 42,000 tons = 882 lbs or 0.44 tons of PM-10

Where actual truck counts/recipts by type of truck are known, then the above calculations can be made directly.

(3) The emission factors for headhouse and internal handling, and bin vents should be applied to the total amount of grain that is handled by these facilities. The headhouse and internal handling emission factor represents dust emissions from bin and basement conveyors, internal cleaners not vented to the atmosphere, scales, garners, legs and distributors.

Example: The facility reports that it handles 50,000 tons of grain. The calculated uncontrolled PM-10 emissions from these operations are:

50,000 tons x 0.034 lbs/ton = 1,700 lbs or 0.85 tons of PM-10

(4) The emission factor for internal vibrating cleaners is based on emissions from a control device and should be applied only in cases when the emissions are vented to the atmosphere. In cases where the internal cleaner is controlled with a fabric filter, calculated emissions will be biased high and the difference between the control efficiencies of both types of control devices should be accounted for when arriving at the final estimate. In cases where emissions from an internal cleaner are not controlled with a fabric filter or cyclone control device, the headhouse and internal operations emission factor accounts for any internal emissions from equipment within the structure that might escape to the atmosphere.

Example: The facility reports that it cleaned 5,000 tons of grain. The cleaner is aspirated using a cyclone collector and the emissions are vented to the atmosphere. The calculated controlled PM-10 emissions are:

5,000 tons x 0.019 lbs/ton = 94 lbs or .05 tons of PM-10

(5) The emission factors for column and rack dryers should be applied to the amount of grain dried by the facility. As rack dryers are normally equipped with self-cleaning rotary screens, it would be appropriate to apply the controlled emission factor for the rack dryer to the total amount of grain dried at the facility.

Example: The facility reports drying 10,000 tons of grain using a column dryer. The calculated uncontrolled PM-10 emissions are:

10,000 tons x 0.055 lbs/ton = 550 lbs or 0.28 tons of PM-10

Example: The facility reports drying 10,000 tons of grain using a rack dryer that is equipped with a self-cleaning rotary screen. The calculated controlled PM-10 emissions are:

10,000 x 0.12 lbs/ton = 1,200 lbs or 0.60 tons of PM-10

Example of the application of the emission factors in Table 9.9.1-1 to different types of grain handling operations:

Example 1 (uncontrolled emissions): A country elevator that receives 50,000 tons of grain by truck (80% by hopper and 20% by straight truck) and ships 8,000 tons by truck and 40,000 tons by rail (2,000 tons remain in storage). The facility also dried 10,000 tons of grain using a column dryer and cleaned 40,000 tons with an internal vibrating cleaner controlled by a cyclone cleaner vented to the atmosphere. The 48,000 tons shipped had to be re-elevated for loadout. The grain cleaned also was re-elevated as the grain was dried. Therefore, the grain handled is the grain received, plus that shipped, plus that cleaned, plus that dried. Calculated uncontrolled PM-10 emissions from the facility would be:

<u>Receiving</u>:

(0.8 x 0.0078 + 0.2 x 0.059) x 50,000 tons = 900 lbs or 0.45 tons of PM-10

<u>Shipping</u>:

0.029 x 8,000 tons + 0.0022 x 40,000 tons = 320 lbs or 0.16 tons of PM-10

<u>Handling/Internal Operations</u>:

0.034 x (50,000 + 48,000 + 40,000 + 10,000) tons = 5,000 lbs or 2.5 tons of PM-10

<u>Cleaning</u>:

0.019 x 40,000 tons = 760 lbs or 0.38 tons of PM-10

<u>Drying</u>:

0.055 x 10,000 tons = 550 lbs or 0.28 tons of PM-10

Total uncontrolled emissions of PM-10 from the facility would then be the sum of the above emissions or 7,500 lbs or 3.8 tons. To estimate total particulate (PM) emissions, multiply the PM-10 emissions for the facility by 4 so that, for this example, PM emissions would equal approximately 30,000 lbs or 15.2 tons.

Example 2 (controlled emissions): A system (conveying, cleaning, receiving, etc.) is aspirated to a baghouse filter. The facility reports handling 50,000 tons and that the design capacity of the aspiration system is 18,000 cubic feet per minute (cfm). A Method 5 emission test on a comparable system revealed a filter exhaust loading of 0.005 grains per actual cubic foot (gr/acf) of exhaust air and the typical handling rate of the system in question is 350 tons/hour.

The controlled emissions from the system would be calculated as follows:

0.005 gr/acf x 1 lb/7,000 grains x 18,000 acf/min x 60 min/hr x (50,000 tons/year)/(350 tons/hour)
= 110 lbs or 0.055 tons of PM.

9.9.1.4 Updates Since the Fifth Edition

The background document (Reference 1) for this section was released in May 1998 with the AP-42 section appearing as part of Supplement D in June 1998. Revisions to Section 9.9.1 since that date are summarized below:

April 2003 -- Emission factors for barge and ship loading/unloading incorporated into Table 9.9.1. Table 9.9.1 expanded to include PM-2.5 emission factors and ratings. Particle size data from Reference 40 used to scale PM-10 emission factors to other particle size ranges. Changes documented in Reference 41. Bin vent emission factor restored from earlier version of Table 9.9.1-1. Additional text revisions for clarification and to reflect current practice in the industry.

Table 9.9.1-1. PARTICULATE EMISSION FACTORS FOR GRAIN ELEVATORS[a]

Emission Source	Type of Control	Filterable[b]					
		PM	EMISSION FACTOR RATING	PM-10[c]	EMISSION FACTOR RATING	PM-2.5[d]	EMISSION FACTOR RATING
Grain receiving (SCC 3-02-005-05)							
Straight truck (SCC 3-02-005-51)	None	0.18[e]	E	0.059[f]	E	0.010[g]	E
Hopper truck (SCC 3-02-005-52)	None	0.035[e]	E	0.0078[f]	E	0.0013[g]	E
Railcar (SCC 3-02-005-53)	None	0.032[f]	E	0.0078[f]	E	0.0013[g]	E
Barge (SCC 3-02-005-54)							
Continuous barge unloader (SCC 3-02-005-56)	None	0.029[h]	E	0.0073[j]	E	0.0019[j]	E
Marine leg (SCC 3-02-005-57)	None	0.15[h]	E	0.038[j]	E	0.0050[j]	E
Ships (SCC 3-02-005-55)	None	0.15[k]	E	0.038[k]	E	0.0050[k]	E
Grain cleaning (SCC 3-02-005-03)							
Internal vibrating (SCC 3-02-005-37)	Cyclone	0.075[m]	E	0.019[n]	E	0.0032[g]	E
Grain drying (SCC 3-02-005-04)							
Column dryer (SCC 3-02-005-27)	None	0.22[p]	E	0.055[n]	E	0.0094[g]	E
Rack dryer (SCC 3-02-005-28)	None	3.0[p]	E	0.75[n]	E	0.13[g]	E
	Self-cleaning screens (<50 mesh)	0.47[p]	E	0.12[n]	E	0.020[g]	E
Headhouse and grain handling (SCC 3-02-005-30) (legs, conveyors, belts, distributor, scale, enclosed cleaners, etc.)	None	0.061[f]	E	0.034[f]	E	0.0058[g]	E
Storage bin (vent) (SCC 3-02-005-40)	None	0.025[q]	E	0.0063[n,q]	E	0.0011[g,q]	E

Table 9.9.1-1 (cont.).

Emission Source	Type of Control	Filterable[b]					
		PM	EMISSION FACTOR RATING	PM-10[c]	EMISSION FACTOR RATING	PM-2.5[d]	EMISSION FACTOR RATING
Grain shipping (SCC 3-02-005-06)							
Truck (unspecified) (SCC 3-02-005-60)	None	0.086[e]	E	0.029[f]	E	0.0049[g]	E
Railcar (SCC 3-02-005-63)	None	0.027[f]	E	0.0022[f]	E	0.00037[g]	E
Barge (SCC 3-02-005-64)	None	0.016[h]	E	0.0040[j]	E	0.00055[j]	E
Ship (SCC 3-02-005-65*)	None	0.048[h]	E	0.012[j]	E	0.0022[j]	E

[a] Specific sources of emission factors are cited in Reference 1, Table 4-16 and supporting tables, except as indicated in the following footnotes. Factors are in units of lb/ton of grain handled or processed. Lb/ton divided by 2 gives kg/Mg. SCC = Source Classification Code. ND = no data available. Example uses of emission factors in this table are provided in Section 9.9.1.3.

[b] Weight of total filterable PM, regardless of size, per unit weight of grain throughput.

[c] Weight of PM $\leq$ 10 micrometers (µm) in aerodynamic diameter per unit weight of grain throughput.

[d] Weight of PM $\leq$ 2.5µm in aerodynamic diameter per unit weight of grain throughput.

[e] Mean of two values from References 18 and 19.

[f] Reference 19.

[g] Emission factor for PM-10 scaled to PM-2.5 using the mean ratio of 17 percent from Reference 40.

[h] PM-10 emission factor scaled to total particulate using the ratio of 25 percent presented in Reference 1.

[j] Reference 40.

[k] Unloading a vessel with a marine leg is analogous to use of a marine leg in barge unloading.

[m] Mean of six A- and C-rated data points from References 20, 21, 22, 23, and 24.

[n] PM-10 emission factor estimated by taking 25 percent of the filterable PM emission factor.

[p] Mean of two D-rated data points from Reference 2.

[q] Based on average of wheat and sorghum PM emission factors reported in Reference 42. PM emission factors based on data at the inlet of an aspirated capture/collection system. Due to natural removal processes, uncontrolled emissions may be overestimated compared to those emissions that occur without such a system.

Table 9.9.1-2. PARTICULATE EMISSION FACTORS FOR GRAIN PROCESSING FACILITIES[a]

Type of Facility/ Emission Source	Type of Control	Filterable[b]				Condensible PM[c]			
		PM	EMISSION FACTOR RATING	PM-10[d]	EMISSION FACTOR RATING	Inorganic	Organic	Total	EMISSION FACTOR RATING
Animal feed mills									
Grain receiving (SCC 3-02-008-02)	None	0.017[e]	E	0.0025[e]	E				
Grain cleaning (SCC 3-02-008-07)	Cyclone	(f)		(f)					
Storage	None	ND		ND					
Grain milling (SCC 3-02-008-15)									
Hammermill (SCC 3-02-008-17)	Cyclone	0.067[h]	E	(g)					
	Baghouse	0.012[j]	E	(y)					
Flaker (SCC 3-02-008-18)	Cyclone	0.15[k]	E	(g)					
Grain cracker (SCC 3-02-008-19)	Cyclone	0.024[k]	E	(g)					
Mixer	None	ND		ND					
Conditioning	None	ND		ND					
Pelletizing									
Pellet cooler[m] (SCC 3-02-008-16)	Cyclone	0.36[n]	E	(g)		--	--	0.059[p]	E
	High efficiency cyclone[r]	0.15[q]	E	(g)					
Feed shipping (SCC 3-02-008-03)	None	0.0033[e]	E	0.0008[e]	E				
Wheat flour mills									
Grain receiving (SCC 3-02-007-31)	None	(f)		(f)					
Grain handling (SCC 3-02-007-32) (legs, belts, etc.)	None	(f)		(f)					

Table 9.9.1-2 (cont.).

Type of Facility/ Emission Source	Type of Control	Filterable[b]				Condensible PM[c]			
		PM	EMISSION FACTOR RATING	PM-10[d]	EMISSION FACTOR RATING	Inorganic	Organic	Total	EMISSION FACTOR RATING
Cleaning house separators (SCC 3-02-007-33)	Cyclone	0.012[s]	E	(g)					
Wheat milling (SCC 3-02-007-34) (roller mill)	None	70[s]	E	(g)					
Bulk loading		ND		ND					
<u>Corn dry mills</u>									
Grain receiving (SCC 3-02-007-41)	None	(f)		(f)					
Grain drying (SCC 3-02-007-42)	None	(f)		(f)					
Grain handling (SCC 3-02-007-43) (legs, belts, etc.)	None	(f)		(f)					
Grain cleaning (SCC 3-02-007-44)	None	(f)		(f)					
Degermer/milling (SCC 3-02-007-45)		ND		ND					
Bulk loading		ND		ND					
<u>Rice Mills</u>									
Grain receiving (SCC 3-02-007-71)	None	ND		ND					
Precleaning/handling (SCC 3-02-007-72)		ND		ND					
Rice drying (SCC 3-02-007-73)	None	0.063[t]	E	(g)					
Cleaning house (SCC 3-02-007-74)		ND		ND					

Table 9.9.1-2 (cont.).

Type of Facility/ Emission Source	Type of Control	Filterable[b] PM	EMISSION FACTOR RATING	PM-10[d]	EMISSION FACTOR RATING	Condensible PM[c] Inorganic	Organic	Total	EMISSION FACTOR RATING
Parboiling	None	ND		ND					
Mill house (SCC 3-02-007-76)	Fabric filter	0.27[u]	E	(y)					
Paddy cleaner (SCC 3-02-007-75)	Fabric filter	0.0031[u]	E	(y)					
Aspirator (SCC 3-02-007-77)	Fabric filter	0.0030[u]	E	(y)					
Bran handling (SCC 3-02-007-78)	Fabric filter	0.017[u]	E	(y)					
Trumbel	None	ND		ND					
Trieurs	None	ND		ND					
Packaging/Shipping		ND		ND					
<u>Durum Mills</u>									
Grain receiving (SCC 3-02-007-11)		(f)		(f)					
Grain precleaning/ handling (SCC 3-02-007-12)		ND		ND					
Cleaning house (SCC 3-02-007-13)		ND		ND					
Durum milling (SCC 3-02-007-14)		ND		ND					
Bulk loading		ND		ND					

Table 9.9.1-2 (cont.).

Type of Facility/ Emission Source	Type of Control	Filterable[b]				Condensible PM[c]			
		PM	EMISSION FACTOR RATING	PM-10[d]	EMISSION FACTOR RATING	Inorganic	Organic	Total	EMISSION FACTOR RATING
<u>Rye Mills</u>									
Grain receiving (SCC 3-02-007-21)		(f)		(f)					
Grain precleaning/ handling (SCC 3-02-007-22)		(f)		(f)					
Cleaning house (SCC 3-02-007-23)		ND		ND					
Rye milling (SCC 3-02-007-24)		ND		ND					
Bulk loading		ND		ND					
<u>Oat Mills</u> (SCC 3-02-007-60)									
Grain receiving		(f)		(f)					
Grain cleaning		(f)		(f)					
Separators		ND		ND					
Drying/cooling		ND		ND					
Grading/sizing		ND		ND					
Hulling		ND		ND					
Cutting		ND		ND					
Steaming/conditioning		ND		ND					
Flaking		ND		ND					
Screening		ND		ND					
Packaging		ND		ND					

Table 9.9.1-2 (cont.).

Type of Facility/ Emission Source	Type of Control	Filterable[b] PM	Filterable[b] EMISSION FACTOR RATING	Filterable[b] PM-10[d]	Filterable[b] EMISSION FACTOR RATING	Condensible PM[c] Inorganic	Condensible PM[c] Organic	Condensible PM[c] Total	Condensible PM[c] EMISSION FACTOR RATING
Barley Malting									
Grain receiving (SCC 3-02-007-08)	Fabric filter	0.016[v]	E	(y)					
Gas-fired malt kiln (SCC 3-02-007-09)	None	0.19[w]	E	0.17[x] (PM-2.5 =0.075)	E	0.075[x]	0.013[x]	0.088[x]	E

[a] Specific sources of emission factors are cited in Reference 1, Table 4-17 and supporting tables. Factors are in unit of lb/ton of grain handled or processed. Lb/ton divided by 2 gives kg/Mg. SCC = Source Classification Code. ND = no data available.
[b] Weight of total filterable PM, regardless of size, per unit weight of grain throughput.
[c] Condensible PM is material collected in the impinger portion of a PM sampling train.
[d] Weight of PM $\leq$ 10µm in aerodynamic diameter per unit weight of grain throughput.
[e] Reference 38. Feed shipping emission factor based on data for loading of bulk feed (not pellets).
[f] See emission factors for grain elevators, Table 9.9.1-1.
[g] PM-10 test data are not available. PM-10 emission factors can be estimated by taking 50 percent of the filterable PM emission factor.
[h] Mean of two values from References 26 and 27.
[j] Mean of two B-rated values from References 28, 29, and 30.
[k] Reference 31.
[m] Includes column and pan dryers.
[n] Mean of 11 A-, B-, and C-rated values from References 26, 27, 31, and 32.
[p] Mean of three B- and C-rated values from References 26 and 32.
[q] Mean of two B-rated values from References 29, 30, and 31.
[r] Equivalent to triple cycle or modern high efficiency cyclone.
[s] Reference 2.
[t] Mean of five D-rated values from Reference 34.
[u] Reference 35.
[v] Reference 36.
[w] Mean of two values from References 36 and 37. Value converted from bushels to tons using a conversion factor of 50 bu/ton.
[x] Reference 37.
[y] PM-10 test data are not available. PM-10 emission factors can be estimated by taking 100 percent of the filterable PM emission factor.

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