Asphalt concrete mixes made with asphalt cement are prepared at an asphalt mixing plant. Here, aggregates are blended, heated, dried and mixed with asphalt cement to produce a hot mix asphalt (HMA). There are two basic types of plants used to manufacture asphalt concrete:

- Batch plants, which make asphalt in batches as needed
- Drum plants, which make asphalt continuously

These two types of asphalt plants derive their names from their particular mixing operation. In the batch-type mixing plant, hot aggregate and asphalt are withdrawn in desired amounts to make up one batch for mixing. After thoroughly mixing, the material is discharged in one batch. In the drum-type mixing plant, the aggregate is dried, heated and mixed with the asphaltic cement in the drum in a continuous operation. Either system can store the asphalt for several days in heated storage silos.

This chapter discusses these two types of asphalt plants, their operation and main components, special procedures to ensure mixture success, and typical plant problems.

**Learning Objectives:**

Upon completion of this chapter, you should be able to:

- Describe the operation of both batch-type and drum-type mixing plants
- Recall tips for successful operation of the various components
- Describe minimum and maximum mixing times
- Use the Ross Count Procedure to determine minimum mixing times
- Determine the percentage of moisture content in aggregate and asphalt concrete mixtures
- Identify likely solutions for common plant problems
### Batch Plant

The following terms will be used throughout this section:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Batch asphalt plant</strong></td>
<td>A manufacturing facility for producing hot asphalt mix that makes the product in batches, rather than continuously.</td>
</tr>
<tr>
<td><strong>Cold aggregate bins and feeders</strong></td>
<td>Containers that store aggregate and accurately feed required amounts of each size to comply with specifications and to maintain a balance of material in each of the hot bins.</td>
</tr>
<tr>
<td><strong>Cold elevator</strong></td>
<td>Conveyor belt that picks up the blended aggregate at the cold feed and feeds it to the dryer in a continuous flow.</td>
</tr>
<tr>
<td><strong>Dryer</strong></td>
<td>A revolving cylinder, usually from 1 to 3 meters in diameter and 6 to 12 meters long, in which aggregate is dried and heated.</td>
</tr>
<tr>
<td><strong>Emissions Control System</strong></td>
<td>A fan in the unit furnishing the draft that controls the gas and air flow for the dryer combustion system and dust collection.</td>
</tr>
<tr>
<td><strong>Screening unit (plant screens or screen deck)</strong></td>
<td>Screens located between the dryer and hot bins which separate the heated aggregate into the proper hot bin sizes.</td>
</tr>
<tr>
<td><strong>Hot bins</strong></td>
<td>Containers used to temporarily store heated and screened aggregate in the various size fractions required.</td>
</tr>
<tr>
<td><strong>Hot elevator</strong></td>
<td>Carries the hot, dried aggregate from the dryer and deposits it onto a screening unit (also called a screen deck or a plant screen).</td>
</tr>
<tr>
<td><strong>Carry-over</strong></td>
<td>The depositing of finer material in a bin that should contain the next larger size aggregate.</td>
</tr>
<tr>
<td><strong>Pugmill</strong></td>
<td>Chamber in which the batch is mixed and discharged into the truck or hauling unit.</td>
</tr>
<tr>
<td><strong>Mineral filler</strong></td>
<td>Finely divided mineral matter, such as rock dust, including limestone dust, slag dust, hydrated lime, hydraulic cement, or other suitable mineral matter.</td>
</tr>
<tr>
<td><strong>RAP</strong></td>
<td>Reclaimed asphalt pavement.</td>
</tr>
<tr>
<td><strong>Weigh box</strong></td>
<td>A weigh box or hopper in batch plants connected with scales, which weighs each aggregate fraction before dropping the aggregate into the pugmill.</td>
</tr>
<tr>
<td><strong>Dry mixing time</strong></td>
<td>The time between the release of the dry batch into the pugmill and the release of the asphalt into the pugmill.</td>
</tr>
<tr>
<td><strong>Wet mixing time</strong></td>
<td>The time between the release of the asphalt into the pugmill and the opening of the pugmill discharge gate.</td>
</tr>
</tbody>
</table>
The batch-type asphalt plant is a manufacturing facility for producing hot mix asphalt (HMA). A batch plant produces hot mix asphalt in 3 to 5 ton batches. Figure 5-1 is photo of a modern batch plant.

About 70% of all operational HMA plants in the U.S. are batch plants, while about 95% of all newly manufactured plants in the U.S. are drum plants (Roberts, et al., 1996).\(^1\)

Batch plants fall into three categories, depending on the degree of automation:

- **Manual**—Operators use air or hydraulic cylinders actuated by electric switches to operate supply bin gates, feeders, asphalt valves, the weigh box discharge gate, and the pugmill discharge gate.

- **Semi-automatic**—All operations are under automatic cycle control, including measuring and mixing, which frees the operator to coordinate other plant operations through remote control.

- **Automatic**—All principal components of the plant are automatically controlled by electrical circuits, which operate from preset batch weight data without manual assistance or monitoring, removing the human error factor from the batching operation. Input to controls is a computer program, batch plug, or preset dials containing design weights for each batch.

---

Batch Plant Operation and Components

An overview of the operation of a batch-type plant follows:

1. Coarse and fine aggregate is removed from storage, or stockpiles, in controlled amounts and passed through a dryer where it is heated and dried.

2. The aggregate then passes over a screening unit that separates the material into different size fractions and deposits them into bins for hot storage.

3. The aggregate and mineral, when used, are then withdrawn in controlled amounts, to make up one batch for mixing.

4. The entire combination of aggregate is dumped into a mixing chamber called a pugmill. Then the asphalt, which has also been weighed, is thoroughly mixed with the aggregate in the pugmill.

5. After mixing, the material is emptied from the pugmill in one batch.

Figure 5-2 depicts the basic components of a batch-type plant. Each of the major components is further detailed in this section.

Figure 5-2. Basic Components of a Batch Plant (Steve Muench, 2003)
Aggregate
Aggregate is an inert material such as sand, gravel, shell, slag, or broken stone, or combination of these materials. Aggregate is usually stored in stockpiles, but may be kept in silos or bunkers before being inserted into cold feed bins.

Cold Feed Bins
The cold aggregate feed is the first major operation in the batch-type asphalt concrete plant. The plant is equipped with multiple bins to handle different sizes of aggregates, as shown in Figure 5-3. Stockpiled aggregate is loaded into the cold feed bins for delivery to the aggregate dryer.

The cold feeder may be charged or fed by one or a combination of the following methods:

1. Open top bins with two, three, or four compartments, usually fed by a crane with a clamshell bucket or a front-end loader, as illustrated in Figure 5-4.

2. Tunnel under stockpiles separated by bulkheads. Materials are stockpiled over the tunnel by belt conveyor, truck, crane, or front-end loader.

3. Bunkers or large bins. These usually are fed by trucks, car unloaders, or bottom-dump freight cars. Each bin usually holds a separate aggregate size or gradation and has an adjustable gate that meters the aggregate onto the cold elevator. Some bins have extensions on the back sides to reduce the possibility of the loader operator overfilling the bins and materials overflowing from one bin to the other.

The cold aggregate feed is one of the critical control points in the production operation. While most of the problems in asphalt concrete production occur in the dryer, on the plant screen, in the bins, or in the pugmill, the causes can usually be traced back to the cold feed.
When charging the cold feed, care should be exercised to minimize segregation and degradation of the aggregate. This can be prevented by taking the same precautions outlined for proper stockpiling.

How the Feeders Work. Aggregate feeder units are located beneath the storage bins or stockpiles, or in positions that assure a uniform separation and flow of aggregate.

Feeder units have controls that can be set to produce a uniform flow of aggregate to the cold elevator. An example is shown in Figure 5-5. Generally belt and vibratory feeders are best for accurate metering of the fine aggregates. Coarse aggregates usually flow satisfactorily with any type of feeder.

For a uniform output from the asphalt concrete plant, input must be accurately measured. Figure 5-6 illustrates this operation.

Stop the feeder unit during lubrication, maintenance, or adjustment.
Adding Lime

When lime is to be used in asphalt concrete, it must be mixed by pugmill or other approved means to achieve a uniform lime coating on the aggregate prior to adding the asphalt cement to the mixture. The method of introducing and mixing the lime and aggregate is subject to approval by the Engineer prior to beginning production.

Cold Elevator

The cold elevator is a moving conveyor belt that transfers aggregate from the feed bins to the dryer. The degree to which the gates on the cold feed bin open, and the speed of the conveyor belt, control the amount of aggregate introduced into the plant.

Best Practice

The importance of feeding the exact amounts of each size aggregate into the dryer at the correct rate of flow cannot be overemphasized.

Dryer/Heater

One of the basic units in any asphalt concrete plant is the dryer. It is a necessary part of the hot-mix operation because it dries and heats aggregates coming from the cold feed supply, thus making them suitable for mixing with asphalt.

The dryer is a large rotating metal drum mounted at an angle and equipped with a gas- or oil-heating unit at the lower end. Hot gases from the burner pass from the lower end of the rotating drum out through the upper end.

Cold aggregate is fed from the cold elevator into the upper end of the dryer, as shown in Figure 5-7.

Inside the dryer the aggregate is picked up by steel angles or flights mounted on the inside of the unit. As the drum rotates, the aggregate is lifted up and dumped through hot gases. Because of the inclination, the aggregate also gradually works its way toward the lower end of the dryer.

The hot aggregate then discharges from the lower end onto a hot elevator that carries it to the screens and hot storage.

Figure 5-7. Aggregate Entering the Dryer
Drying is the most expensive operation in mix production. It is also the most frequently encountered bottleneck in the plant operation. The best dryer is the one that meets a desired performance level at the lowest investment and operating cost. Most dryers are designed for average aggregate moisture content. Very wet aggregate will reduce the dryer capacity and require corrective measures.

### Drying Aggregate

The aggregate shall be dried to a point at which the moisture content of the completed mixture does not exceed **1 percent** as determined from samples taken at the point of discharge from the mixing operation.

**Temperature Control and Indicating Devices.** Proper aggregate temperature is essential. The temperature of the aggregate, not the binder, controls the temperature of the hot mix asphalt. The layer of binder put on each particle of aggregate during mixing assumes the temperature of that aggregate almost instantaneously. Overheating of the aggregates can damage the asphalt by hardening the binder during mixing. Underheated aggregates are difficult to coat thoroughly with binder, and the resulting mix is difficult to place on the roadway.

Aggregate temperature is measured by either a thermometer or a thermocouple attached to an indicating pyrometer. Pyrometers react much faster to changes in temperatures and are usually preferred.

The pyrometer monitors the aggregate temperature as the material leaves the dryer, as suggested by its placement in Figure 5-8.

![Figure 5-8. Pyrometer Placement](image)

**TOOLS AND EQUIPMENT**

An aggregate temperature measuring device should be installed in the dryer discharge in full view of the burner operator. This device is one of the most important plant control accessories and should be a reliable and accurate instrument.

_Describes what tools, equipment and tests are required to complete the job safely and with the highest level of quality._
**Emissions Control System**

All batch and drum mix plants have a significant amount of fine aggregate and dust created from the drying process. In order to meet federal and state air quality codes, emission control equipment is necessary to capture particulate emissions that might otherwise be released into the atmosphere. In addition, some emission control devices permit the plant operator to collect and return these “fines” back into the mixture.

The emissions control system is also known as the dust collector. The collector eliminates or abates the dust nuisance that might result from exhaust air from the dryer. The dust collector is generally operated adjacent to and in conjunction with the dryer, and is necessary for efficient plant operation.

Provisions are usually made in the dust collecting system to return the collected dust back to the hot aggregate as it emerges from the dryer and is picked up by the hot elevator. If the collected dust is unsuitable for use in the asphalt concrete mixture, it may be removed from the collector and wasted.

The dust collector is comprised of the two main components listed below; each of these is described in more detail in the text that follows.

- The Primary (Multicone) Collector
- The Secondary Collector (Baghouse)

**The Primary (Multicone) Collector.** The primary collector, also known as the multicone collector, is located between the dryer and the secondary collector. Figure 5-9 shows the primary dust collector associated with a counter-flow drum plant. The primary collector uses a cyclone effect to collect larger dust particles and fine aggregate from the exhaust gases before they enter the more effective secondary collector.

It is typically available as a knockout box, cyclone, multiplecyclone, or multicone collector. In any case, the collector’s fan furnishes the draft that draws the flame and hot gases through the dryer. Dust particles from the dryer and other parts of the plant are also carried in the current of draft air, which enters the dust collector at the upper end and goes into vertical motion. The heavier dust particles in the air stream are separated by centrifugal force into the collector shell and fall to the bottom. The finer dust may remain in suspension and be carried out the exhaust stack with the air.
The **Secondary Collector (Baghouse)**: The exhaust gases that pass through the primary collector are pulled by the exhaust fan through cylindrical fabric filter bags in the baghouse. The baghouse removes the fine particulate matter from the dryer exhaust gases before the exhaust gases are released to the atmosphere. With the use of a baghouse, “fines” can be reclaimed and returned to the mixing unit.

Some plants may use a wet scrubber or wet wash system as a secondary collector to reduce the amount of fine dust being carried out the exhaust stack with the air. There are several types of wet systems, but they all usually consist of a short tower, with or without baffles. Exhaust from the dust collector enters the tower at the bottom and passes upward through a series of water sprays that remove the dust. Use of a wet wash system usually will increase fan requirements by 10 to 15% because of the pressure loss in the tower.

**Hot Elevator**

The hot elevator takes the heated, dried aggregate from the aggregate dryer and deposits it onto a screen deck (also called a screening unit) that is mounted over the plant bins inside of the batching tower. Figure 5-10 depicts a hot elevator.
**Batching Tower/Mixing Tower**

The tall item in Figure 5-11 is an example of a batching tower, which is sometimes referred to as the mixing tower.

The hot, dry aggregate enters the batching tower from the hot elevator. Inside the batching tower are the following components, each of which will be discussed in more detail:

- Screening deck and screening unit
- Hot aggregate holding bins, also known as hot bins
- Asphalt weigh hopper
- Weigh bucket
- Pugmill

The batching tower divides the hot aggregate into fractions, depending on their size, and prepares batches for loading onto trucks.

![Example of a Batching Tower](image)

**Figure 5-11. Example of a Batching Tower**
Screen Deck and Screening Unit. The screen deck and screening unit is one of the major components of the batching tower. Aggregate is discharged from the hot elevator over a series of vibrating screens in the batching tower. The screens in the screen deck separate the aggregate into various specified sizes. When the screening is complete, each size of aggregate resides in its own bin. Figure 5-12 illustrates how aggregate flows through a typical screen deck with four screens.

![Flow of Material through a Typical Screen Deck](image)

**Figure 5-12. Flow of Material through a Typical Screen Deck**

The screens are critical to the plant’s ability to produce mixtures that are uniform and to specification. To properly perform the screening function, the screening area must be large enough to handle the maximum feed.

**INSPECTION AND MEASUREMENTS**

<table>
<thead>
<tr>
<th>Screen capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>The capacity of the screens should be checked against the capacity of the dryer to ensure the size is appropriate. The technician also should observe the screens in operation to be sure they can handle the maximum feed.</td>
</tr>
</tbody>
</table>

*Describes inspection, Quality Assurance and/or Quality Control practices.*
If the effective screening area is reduced by plugged screen openings, or if more material is fed to the screens than they can handle, the usual result is “carry-over.” Carry-over is the depositing of finer material in a bin that should contain the next larger size aggregate. When carry-over fluctuates, lack of uniformity in the aggregate gradation will cause a corresponding lack of uniformity in the mixture. Carry-over increases the amount of fine aggregate in the total mix, and since fine aggregate has much more surface area per unit of weight requiring asphalt coating, this condition should be kept at a minimum. Excessive carry-over, or its fluctuations, will be apparent from the sieve-analysis made from the contents of the individual hot bins.

**INSPECTION AND MEASUREMENTS**

**Screen inspection**

The condition and cleanliness of the screens will, to a large extent, control their efficiency. Excessive wear of the screen wire causes enlarged openings resulting in oversize material in the bin. Daily visual inspection of the screens for cleanliness is recommended, preferably before the start of the day’s operations.

Describes inspection, Quality Assurance and/or Quality Control practices.

Hot Aggregate Holding Bins/Hot Bins. Hot bins are used to temporarily store heated and screened aggregate in the various size fractions required until the predetermined amount of aggregate size is accumulated for a batch. Figure 5-13 depicts a set of hot bins.

Hot bin partitions should be tight, free from holes, and of sufficient height to prevent intermingling of aggregates. Each bin should be large enough to prevent depletion of the material when the mixer is operating at full capacity.

Each bin should have an overflow pipe to prevent aggregate from backing up into the other bins. The overflow pipe also prevents overfilling to the point where the vibrating screen will ride on the aggregate. If this were to happen, it would result in a heavy carry-over and probably damage the screens.

**INSPECTION AND MEASUREMENTS**

**Inspecting overflow vents**

Inspect the overflow vents frequently to make sure that they are free flowing and thus preventing contamination by the intermingling of contents from adjacent bins.

Describes inspection, Quality Assurance and/or Quality Control practices.
The correctly proportioned aggregate from each hot bin is discharged into the weigh hopper. Material is withdrawn from the hot bins in predetermined proportions and at a specified rate. A balanced flow of aggregate is being achieved if the level of aggregate in hot storage has little variation during plant operation.

**Aggregate Weigh Hopper.** Aggregates are released from the hot bins into the weigh hopper, generally beginning with the largest size aggregate and progressing down to the finest size, with the mineral filler (if used) sandwiched between the larger aggregates.

The amount from each bin is determined by the batch size and the proportions or percentages required to be blended. The weigh hopper is suspended from a scale beam and the amounts of aggregate weighed cumulatively.

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**AWARENESS/IMPORTANT**

Before withdrawing material to be weighed, there should always be sufficient materials in the hot bins for a complete batch. If a bin is near depletion or is running over, chances are that an adjustment in the cold feed is required.

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**Weigh Bucket.** Asphalt may be weighed in a special bucket, or it may be measured by a meter for each batch. When weighed into a batch, asphalt is pumped into a bucket of known weight and weighed on a scale. When metering devices are used, a volumetric measurement is made. The volume of asphalt changes with temperature. Some asphalt meters have built-in temperature-compensating devices that correct the flow of asphalt when changes in temperature occur. *Note:* The volume of asphalt pumped between two-meter readings may be weighed as one means of calibrating the meter.

**Pugmill.** The aggregate and asphalt cement are blended together in the pugmill. Blending is done in batches, giving the “batch plant” its name. Pugmills typically have a capacity of 2 to 5 tons per batch. A twin pugmill-type mixer is commonly used in all modern asphalt concrete plants. In a batch plant this unit is mounted directly beneath the weigh box and asphalt bucket, and high enough so that it may discharge the mixture into the truck or other hauling unit. Figure 5-14 depicts mixing paddles within the pugmill.

![Figure 5-14. Pugmill Mixing Paddles](image-url)
When aggregates are drawn from the hot bins, some dry mixing takes place as the materials are deposited in the weigh hopper, as well as in the pugmill. The wet mixing time begins with the start of the flow of asphalt from the bucket or meter, as illustrated in Figure 5-15.

**Figure 5-15. Steps in Typical Batch Plant Mixing Cycle**

Asphalt film on the aggregate is hardened by exposure to air and heat. The Engineer may require a dry mixing time of up to 15 seconds. However, the wet mixing cycle shall not be less than 20 seconds. (See the Ross Count Procedure, p. 5-26 for details on how to establish pugmill mixing times.) Upon completion of the mixing time, the bottom of the pugmill mixer opens up and discharges the contents into a truck or other hauling equipment.

**AWARENESS/IMPORTANT**

The mixing time should be no longer than necessary to get a uniform distribution of aggregate sizes and a uniform coating of asphalt on all aggregate particles.

Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.
Asphalt Storage Tanks
Asphalt is stored in tanks such as those shown in Figure 5-16 while awaiting delivery into the pugmill, where it is mixed with the aggregate (as the second step in Figure 5-15 illustrated).

Asphalt storage at the plant should be equal to one day’s output, and storage tanks should be calibrated so the amount of material remaining in the tank can be determined at any time.

Since asphalt must be fluid enough for movement through the delivery and return lines, it must be heated. Heating may be done by the circulation of steam or hot oil through coils in the tank, or it may be done electrically.

Asphalt cement in the tanks is kept heated between 150 °C (300 °F) to 180 °C (350 °F), depending on the grade and type of asphalt.

### INSPECTION AND MEASUREMENTS

<table>
<thead>
<tr>
<th>Describes inspection, Quality Assurance and/or Quality Control practices.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inspecting the hot oil level</strong></td>
</tr>
<tr>
<td>If the asphalt temperature is maintained by circulating hot oil, the hot oil level in the reservoir of the heating unit should be inspected frequently. If the level falls, a check should be made for leakage of the hot oil into the stored asphalt.</td>
</tr>
</tbody>
</table>

**Truck Loading and Plant Scales**
Trucks can be loaded directly from the pugmill after mixing has been completed. Weigh scales are located in the truck loading area to ensure trucks are loaded with the correct amount of mix.

Scales used in the weighing of materials paid for on a tonnage basis shall be approved and sealed in accordance with the requirements of the policies of the Bureau of Weights and Measures of the Department of Agriculture and Consumer Services, or other approved agencies, at least once every six months and anytime they are moved.

Hopper and truck scales shall be serviced and tested by a scale service representative at least once every six months. Hopper scales shall be checked with a minimum 500 pounds of test weights. Truck scales shall be checked with a minimum of 20,000 pounds of test weights (see Section 109.01).
## INSPECTION AND MEASUREMENTS

### Truck bed

The bed of the haul truck should be clean and free of all deleterious materials before mix is placed in it. The bed should be reasonably smooth and free from any holes. Trucks must also be equipped with a tarpaulin to prevent contamination of material during transportation to the job site and to prevent some heat loss.

*Describes inspection, Quality Assurance and/or Quality Control practices.*

### Filler/Additive Silo (Hopper)

Some plants may have one or more silos for storing mineral filler, fine particles from the baghouse, or special additives that are added to the mix. Some asphalt concrete plants often have a separate feeding system for the addition of mineral filler to the mix. The mineral filler is supplied in paper sacks or in bulk.

The filler is placed into a ground-mounted feeder and conveyed into a surge hopper, where it is added to the aggregate as it leaves the hot bins. Mineral filler is added as an unheated material.

### AWARENESS/IMPORTANT

When filler is used, the hopper must be emptied at the end of the day and kept dry to prevent caking of the filler.

*Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.*

### RAP Bin

Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement. These materials may be added into mixes.

There are several methods of batch plant recycling. RAP is typically added to heated aggregates. This is most commonly done by introducing RAP from a separate bin and feeding it into the pugmill or weigh hopper via conveyor belt or chutes.

### Storage Silos

Batch plants do not require a silo, but often have them to increase plant production. Drum mix plants must have silos since they produce asphalt continuously.
Control Center (Control House)

The Control Center controls plant operations from one central location. Figure 5-17 provides an example of the kinds of equipment and controls common to these operations centers.

Figure 5-17. Control Center
Drum Plant

The following terms will be used throughout this section:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum-type asphalt plant</td>
<td>A manufacturing facility for producing HMA. It manufactures HMA continuously, rather than in batches.</td>
</tr>
<tr>
<td>Surge silos</td>
<td>Silos that are usually insulated, but unheated and are designed to hold hot mix for short periods of time (up to several hours) between truck arrivals.</td>
</tr>
<tr>
<td>Storage silos</td>
<td>Silos that are well insulated, heated, near air tight, and are designed to hold hot mix for long periods of time (up to one week).</td>
</tr>
</tbody>
</table>

A drum-type mix plant is a manufacturing facility for producing hot mix asphalt (HMA). It manufactures HMA continuously, rather than in batches. A modern drum mix plant is shown in Figure 5-18.

Figure 5-18. Modern Drum Mix Plant
Drum Plant Operation and Components

Drum mixing is a relatively simple process of producing asphalt mixtures. The mixing drum looks like the familiar dryer. The difference is that the aggregate is not only dried and heated within the drum, but it is also mixed with the asphalt cement in the drum. The drum mix plant also requires the use of a surge silo for mix loadout. Drum mixers can produce a true hot mix, or a low temperature mix.

Drum plants share many of the components with the batch plant, including:

- **Cold feed bins**—To accurately meter the different aggregates used in the mix to the drying drum
- **Asphalt cement storage**—Aboveground tanks for asphalt cement storage that must meet stringent regulatory guidelines
- **Dryer drum/mixer**—To dry out and heat aggregates by tumbling them through hot air
- **Emission control systems**—To trap and remove fine sand and dust particles and return them to the mix
- **RAP bins**—Bins containing removed and/or processed pavement materials containing asphalt and aggregates
- **Hot mix conveyor**—For moving the hot mix asphalt to the storage silos
- **Truck loading area**—Where trucks are loaded with asphalt for jobs
- **Control center**—For controlling plant operations

In addition, operation of the drum plant depends on components shown in Figure 5-19.

Figure 5-19. Major Components of a Basic Drum Plant
**Cold Feed Bins**

As with the batch plant, production in the drum plant starts with the cold feed bins. The plant is equipped with multiple bins to handle different sizes of new aggregates. A bulkhead or divider is used between each bin to prevent overflow of one aggregate into an adjacent bin, as Figure 5-20 illustrates. Contamination of different size aggregates can significantly alter the gradation of the mix being produced.

At this point of production, good quality control over the aggregates is especially critical.

![Figure 5-20. Cold Feed Bins with Dividers](image)

**AWARENESS/IMPORTANT**

The aggregates in each stockpile should be consistent as to gradation. Stockpiles must be separated properly to prevent contamination of one aggregate by one of another gradation.

Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

The drum mix process depends upon cold feed control for proportioning and gradation of aggregates. Ingredients must be added in required proportion. The proportioning is even more important to the drum-type plants than to batch-type plants. Some cold feed bins are equipped with a gate to control the size of the discharge opening. This will set the amount of the material used from that bin.

Total and proportional control with variable speed belt feeders permits adjustments of individual feeder output to desired proportions, as Figure 5-21 illustrates. The speed of the belt can be used to control the amount of material to be used. The speed setting for each individual belt feeder is adjusted independently to allow the proper amount of aggregate to be pulled from each individual bin.
Cold Feed Conveyor and Weigh Bridge

From the cold feed, the aggregate moves up an incline conveyor over the weigh bridge, which continually weighs the aggregate passing over the belt and indicates the flow of material over the scale at any given instant. A computer calculates the tons of aggregate transported to the dryer by the accumulated weight over the load cell, as illustrated in Figure 5-22.

The weight reading is the foundation of the aggregate/asphalt blending system. The asphalt metering and delivery system must be interlocked with the aggregate weigh system to assure that the precise asphalt content is achieved and maintained in the mix. The tonnage rate of aggregate going into the drum mixer, as measured by the weigh bridge, is regarded as the base figure of the total mix formula.
Since the base reading reflects the mass of both the aggregate and moisture, the weight of the moisture must be subtracted to arrive at a true aggregate rate reading. Actual moisture content is determined by periodic moisture extraction test. (How to determine moisture content is detailed on p. 5-28.)

**AWARENESS/IMPORTANT**

The base figure of the total mix formula reflects total mass of both aggregate and moisture.

Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

**Drum Mixer**

From this point, the aggregates go into the drum mixer, an example of which is shown in Figure 5-23. The hottest gases and flame exist at the charging end of the drum mixer. Thus, the asphalt is protected from the harmful effects of oxidation and direct contact with the burner flame by the evaporating moisture on the aggregate.

![Figure 5-23. Drum Mixer](image)
Asphalt Concrete Plants

While the drum mix process features a smooth continuous flow of material, inside the drum mixer certain events occur in phases within fairly well delineated zones of the drum mixer. One of the principle differences between the conventional batch method of mix production and drum mixing is how the aggregate is coated. Heating and mixing of the aggregates and asphalt cement is done in four phases, as described in the table that follows.

<table>
<thead>
<tr>
<th>Heating/Mixing Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>The aggregate has entered the drum mixer. In the early heating phase, surface and free moisture begin to leave the aggregate as temperature rises.</td>
</tr>
<tr>
<td>Phase II</td>
<td>Most of the heat rise occurs in phase II as aggregate temperatures reach approximately 170 to 180 °F (77 to 82 °C). The majority of the moisture is driven off in this phase and the rate of increase in mixing temperature levels off.</td>
</tr>
<tr>
<td>Phase III</td>
<td>As mix temperature reaches between 180 and 200 °F (82 and 93 °C) asphalt is introduced to the mix. Moisture driven off now causes the asphalt to foam. This foaming action causes the surface area of the asphalt to be greatly enlarged, thus entrapping dust as well as larger particles and coating the aggregate rapidly. Thus, aggregate coating in a drum mixer is not a function of asphalt being forcibly mixed, but rather of the aggregate particles being engulfed by the foaming, rapidly spreading asphalt.</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Most of the moisture has been removed. The aggregate has been coated, and mix temperatures will continue to rise until desired temperature is reached.</td>
</tr>
</tbody>
</table>

*Hot Elevator*

After the mix temperature has been achieved, the mix is discharged into a hot incline elevator that carries the mix to either a surge silo or storage tank, where it is held at a constant temperature.

*Storage Silos*

The main purpose of the storage silo is to hold the mix temporarily until the next transport vehicle is available. There are two types of silos: surge and storage.

- **Surge silos** are usually insulated, but unheated and are designed to hold hot mix for short periods of time (up to several hours) between truck arrivals. Figure 5-24 depicts a surge silo.
- **Storage silos** are well insulated, heated, near air tight, and are designed to hold hot mix for long periods of time (up to one week).

*AWARENESS/IMPORTANT*

Coarse graded mixtures should not be stored for long periods of time because the asphalt cement will tend to flow off the aggregate (drain down) and collect at the bottom.

Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.
SAFETY WARNING

Care should be taken during the transport of hot mix asphalt from the drum mixer to the silo and from the silo to trucks to ensure the safety of personnel.

Describes a condition where personal safety may be at risk. This is used to alert personnel to operating procedures & practices which, if not observed, may result in personal injury.
Special Procedures

This section presents two important procedures used in asphalt plants: the Ross Count Procedure (particle coating) for batch plant mixing, and the procedure for determining aggregate moisture for drum mix operations.

The Ross Count Procedure for Establishing Batch Mixing Times

In establishing pugmill mixing times in a batch plant by the Ross Count Procedure, it is necessary first to become familiar with two definitions involved:

- **Dry Mixing Time**—The time between the release of the dry batch into the pugmill and the release of the asphalt into the pugmill.
- **Wet Mixing Time**—The time between the release of the asphalt into the pugmill and the opening of the discharge gate.

See the table below for more detail on mixing times.

The purpose of establishing a mixing time in this manner is to permit the operation of the asphalt concrete plant with the least mixing time cycle that is consistent with the production of a mix in which:

- The coarse particles are completely coated
- The gradation requirements are being met
- Other factors are satisfied.

### Mixing Times

| Wet Mixing Time | The wet mixing time may vary from plant to plant, from mix to mix, and with the condition of the mixing equipment. This procedure for establishing mixing times permits more economical mixing operations to the benefit of the Department of Transportation and the Contractor. The wet mixing cycle shall not be less than 20 seconds. |
| Dry Mixing Time | A dry mixing time of up to 15 seconds may be required by the Engineer to accomplish the degree of aggregate distribution necessary to obtain complete and uniform coating of the aggregate with bitumen. The lowest mixing time possible, that will still produce a mix that meets all Department requirements, should be used (See VDOT Road and Bridge Specifications). |
How to Conduct the Ross Count Procedure

Following is an outlined procedure for determining minimum mixing time by the Ross Count Procedure (see AASHTO T 195). To start the determination of the mixing time, the plant should operate on a 30-second wet mixing cycle. If the asphalt introduction requires more than 30 seconds, use this time.

STEP 1. Take a sample at the plant site from three alternate truckloads.

STEP 2. Sieve the sample immediately, while it is still hot, through a 3/8 in (9.5 mm) sieve, or through No. 4 sieve (4.75 mm) for Surface Mixes (SM).

STEP 3. Take a sample large enough to yield between 200 and 500 coarse particles on the 3/8 in (9.5 mm), or No. 4 (4.75 mm) sieve.

AWARENESS/IMPORTANT

Do not overload the sieves during the sampling step. If necessary, sieve the sample in two or three operations. The individual sieving operations should not require more than 20 seconds of manual shaking.

STEP 4. Very carefully examine each particle. If even a tiny speck of uncoated stone is noted, classify the particle as “partially coated.” If completely coated, classify the particle as “completely coated.”

STEP 5. Compute the Ross Count as below:

\[
\text{Ross Count} = \frac{\text{Number of Completely Coated Particles}}{\text{Total Number of Particles}} \times 100
\]

STEP 6. Use the decision table that follows to determine what to do with the results:

<table>
<thead>
<tr>
<th>IF</th>
<th>AND/OR</th>
<th>THEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF the average of the three (3) samples is greater than 95%...</td>
<td>...AND no one (1) sample is less than 92%...</td>
<td>...THEN a lower mix time can be tried. Lower time by five (5) seconds.</td>
</tr>
<tr>
<td>IF the average of the three (3) samples is less than 95%...</td>
<td>...OR any one sample (1) is less than 92%...</td>
<td>...THEN increase the mix time by five (5) seconds.</td>
</tr>
</tbody>
</table>
Aggregate Moisture Determination for Drum Mix Operation

Since aggregate in a drum mix operation is weighed before drying, moisture content of the aggregate must be determined. The weighing of aggregate and the metering of asphalt cement are interlocked electronically in drum mix operations. To ensure proper metering of asphalt cement, adjustments for aggregate moisture must be made. The moisture content of the aggregate should be determined, and proper allowance made for the water content, prior to mixing.

**AWARENESS/IMPORTANT**

Perform moisture determination prior to start of mixing and thereafter as changes occur in the condition of the aggregate.

How to Determine the Moisture Content of Aggregate

To establish the moisture content of aggregate being used, it is first necessary to secure a representative sample of the aggregate.

When sampling, it is easier to obtain a representative sample from the production stream (i.e., from the conveyor belt), than from storage bins or stockpiles. When taking the sample from the conveyor belt, remove it from the entire cross-section of the belt. The size of the sample taken is determined by the maximum size aggregate.

The steps for this procedure are outlined as follows:

**STEP 1.** Obtain a representative sample of the material from the production line (conveyor belt).

**STEP 2.** Reduce the sample to a size that can be handled by the weighing device by either a sample splitter or the quartering method.

**STEP 3.** Weigh the aggregate sample and record the weight (wet weight).

**STEP 4.** Dry the aggregate sample thoroughly. The sample or samples should be dried to constant weight on a hot plate or in an oven at a temperature of 230 °F (110 °C).

**STEP 5.** Accurately weigh the dried sample and record the weight (dry weight). In weighing and handling the sample, extreme care must be taken to avoid any loss of the material, as this will affect the accuracy of the results.

**STEP 6.** Determine moisture content. The percent moisture is determined by the following formula:

\[
\text{Moisture Content} = \frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100
\]
Example:

Wet Weight of Sample = 1225 g
Dry Weight of Sample = 1175 g

Moisture Content = \( \frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100 \)

Moisture Content = \( \frac{1225 - 1175}{1175} \times 100 = 4.3\% \)

How to Determine the Moisture Content of Asphalt Concrete Mixtures

The moisture content of an asphalt concrete mixture can also be determined. The procedure is similar to the aggregate moisture determination procedure. The steps are outlined as follows.

**STEP 1.** Place the mixture in the pan.

**STEP 2.** Weigh the pan and mixture together. Then record the wet weight.

**STEP 3.** Place the pan and mixture in the oven (set at compaction temperature) for approximately 30 minutes.

**STEP 4.** Take a sample from the oven and weigh it, then record this weight.

**STEP 5.** Place the sample back in oven for approximately 15 minutes.

**STEP 6.** Take another sample from oven and weigh it, then record this dry weight. (Repeat steps 5 and 6 until the sample reaches a constant weight.)

**STEP 7.** After a constant weight has been established, determine the percent of moisture using the following formula:

\[
\text{Moisture Content} = \frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100
\]

**AWARENESS/IMPORTANT**

NOTE: This test may be performed on aggregate blends also. The moisture content of an asphalt mixture should not exceed 1%.
## Types of Trouble at the Plant and Probable Causes

<table>
<thead>
<tr>
<th>Type of Trouble at the Plant</th>
<th>Extraction Fails to Check With Set-Up</th>
<th>Variation in Batch Color</th>
<th>Brown, Dead Appearing Mix</th>
<th>Rich, Glistening Mix Appearance</th>
<th>Mix Gradation Fails to Check Set-Up</th>
<th>Lifeless, Greasy Appearing Mix</th>
<th>Mix Temperature Too High</th>
<th>Smoking Batches</th>
<th>Overweight or Underweight Loads</th>
<th>Portion of Batches Unmixed</th>
<th>Variations in Batch Gradation</th>
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<tbody>
<tr>
<td>Faulty Extractions</td>
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<td>Type of Trouble at the Plant, continued</td>
<td>Extraction Fails to Check With Set-Up</td>
<td>Variation in Batch Color</td>
<td>Brown, Dead Appearing Mix</td>
<td>Rich, Glistening Mix Appearance</td>
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<td>Lifeless, Greasy Appearing Mix</td>
<td>Mix Temperature Too High</td>
<td>Smoking Batches</td>
<td>Steaming Batches</td>
<td>Overweight or Underweight Loads</td>
<td>Portion of Batches Unmixed</td>
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</tbody>
</table>
Chapter Five Knowledge Check

1. The overflow chutes on a batch plant are used to:
   A. Transfer material from one bin to another
   B. Prevent contamination by intermingling from adjacent bins
   C. Collect aggregate samples for gradation
   D. Decrease production

2. The asphalt material shall be delivered into the mixer in a thin, uniform sheet or multiple streams for the full width of the mixer.
   A. True
   B. False

3. Increasing the dryer time will remove more moisture than increasing the heat.
   A. True
   B. False

4. The asphalt content for batch weight calculations is obtained from the:
   A. Design range
   B. Job mix formula
   C. Acceptance range
   D. None of the above

5. During the drying operation, wet aggregate will reduce the dryer’s capacity.
   A. True
   B. False

6. In the drum mix plant, moisture content of aggregate must be determined before drying.
   A. True
   B. False

7. The maximum amount of moisture allowed in the completed mixture is:
   A. 10%
   B. 1%
   C. 2%
   D. 5%
8. What conditions affect screening efficiency?

9. What are some of the methods of controlling carry-over?

10. What is meant by proportioning of aggregates and asphalt?

11. What conditions will best insure a uniform flow of the proper aggregate sizes from the cold feed?

12. Why is proper cold feeding essential?

13. When hydrated lime is used in asphalt concrete as an anti-stripping additive, it shall be added at what rate?

14. What problems arise from overheating aggregate?

15. What problems arise from underheating aggregate?

16. What could cause leakage of aggregate into the weigh hopper after the desired amount has been withdrawn?

17. How often and by whom should hopper and truck scales be serviced and tested?

18. How often and by whom shall the scales used in the weighing of materials paid for on a tonnage basis be approved and sealed?

19. When using a metering device instead of a weigh bucket for proportioning asphalt to the mixer, what is one important thing that should be remembered?
20. What is the maximum dry mixing time for aggregates released into the pugmill?

21. What is the minimum wet mixing time allowed?

22. Who determines the mixing time? Who approves the mixing time?

23. Asphalt storage at the plant should be equal to at least:
   A. One-half of one day’s output
   B. One day’s output
   C. Two day’s output
   D. Three day’s output
Problem No. 1: Establishing the Wet Mixing Time

**Given:** The plant is operating on a 22-second wet mixing cycle. Two previous determinations yielded results of 94.3% and 95.1% completely coated particles. The third determination has shown that of the 230 particles there are 6 that are not completely coated.

**Find:**

1. The Ross Count for the third determination.
2. Does this meet the VDOT requirements for the wet mixing time?
3. What steps are taken if after conducting a Ross Count, the results do not meet VDOT requirements?

Problem No. 2: Establishing the Wet Mixing Time

**Given:** The plant is operating on a 21-second wet mixing cycle. Two previous determinations yielded results of 95.3% and 92.5% completely coated particles. The third determination has shown that of the 216 particles there are 14 that are not completely coated.

**Find:**

1. The Ross Count for the third determination.
2. Does this meet the VDOT requirements for the wet mixing time?
3. What steps are taken if after conducting a Ross Count, the results do not meet VDOT requirements?
Problem No. 3: Determining Aggregate Moisture

Determine the percent moisture in an aggregate sample that had a wet weight of 1335 grams and, after drying, a dry weight of 1290 grams. (Answer to nearest tenth of one percent.)

Problem No. 4: Determining Aggregate Moisture

Determine the percent moisture (to nearest tenth of one percent) in an aggregate sample that had a wet weight of 1275 grams and, after drying, a dry weight of 1235 grams.
Problem No. 5: Determining Moisture of an Asphalt Mixture

Given the following information, determine the percent moisture in the BM-25.0 asphalt concrete sample below.

Does this meet the VDOT Specifications?

Weight of Moist Sample = 2254 g
Weight of Dry Sample = 2232 g

Problem No. 6: Determining Moisture of an Asphalt Mixture

Given the following information, determine the percent moisture in the BM-25.0 asphalt concrete sample below.

Does this meet the VDOT Specifications?

Weight of Moist Sample = 2376 g
Weight of Dry Sample = 2342 g
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