BATCH PLANT DUST COLLECTION — AN ENGINEERED APPROACH TO DUST REDUCTION

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ABSTRACT

In an effort to continuously improve its processes, PPG Industries is interested in reducing dust in their glass batching operations. With this goal in mind. PPG Industries, Inc. and Middough Inc. collaborated to evaluate a batch plant's dust collection systems. The review consisted of an assessment of the existing conditions, the system's design intents, plant operations and maintenance standards. This paper will define the project approach used and the successes achieved in improving the plant systems.

CONTROL OF AIRBORNE CONCENTRATIONS

The three traditional approaches to controlling emissions and employee exposures are administrative controls, personal protective equipment and engineering controls. Administrative controls are a way of reducing the duration, frequency and severity of exposure. Examples would include job rotation and reducing the amount of time a person spends in an area. Personal protective equipment may be used to reduce employee exposure while other controls are being implemented or are not feasible or effective. Engineering controls and maintenance of those systems is another method for controlling airborne concentrations of dust and is the focus of this discussion.

PROJECT APPROACH

PPG has a number of glass facilities that utilize dry granular materials in large volumes. It was decided to evaluate the dust collection systems at these facilities to determine if engineering controls could be utilized to improve the ambient conditions by lowering the level of air particulates.

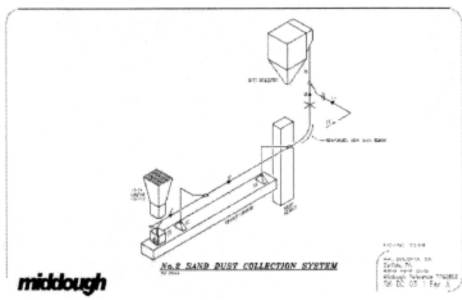
An initial site was identified that is representative in age, condition and production capacity to be evaluated. Once the site selection was completed, a project plan was formulated to monitor the progress.

The key milestones to the plan were:

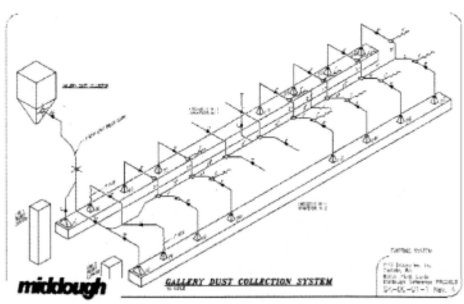
1. Gather and Review the Existing Documentation
2. Site Visit / System Evaluation
3. Interview Key Stakeholders
4. Measure the Existing Conditions
5. Recommend Changes
6. Measure the Improvements / Report the Results

1. Gather and Review the Existing Documentation:

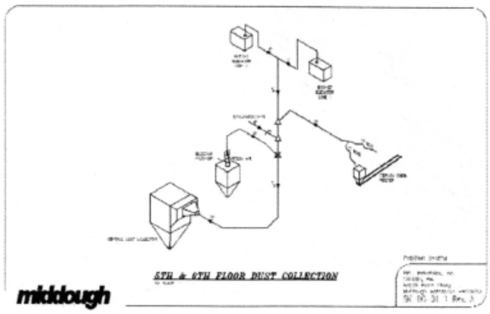
The selected site has two side-by-side glass float lines that operate 24 hours per day, 7 days per week, and an approximately 14-year rebuild cycle. The associated batch plant has six concrete stave silos located over two parallel batch collecting conveyors. An unloading shed with two rail sidings runs parallel to the silos. Stations for each raw material allow unloading by either bulk truck or railcar, with most deliveries by truck. Two silos are divided, so that there are eight unloading stations in all, four per siding. Each unloading station typically consists of an unloading hopper, vibratory feeder, bucket elevator, and transfer chute to the silo. Each station also has a dust collection system including a dust collector, blower, rotary discharge, and ductwork.



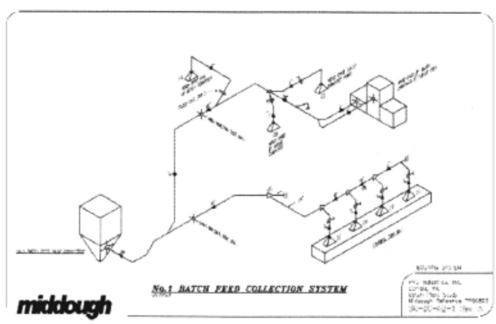
Each silo (or silo section) has two discharge/weigh systems, one over each batch conveyor. Each of these sixteen systems consists of a vibratory feeder, weigh hopper, and a second vibratory feeder that unloads the weighed ingredients onto the batch collecting conveyor. As an exception to this, the two Salt Cake systems use a double feed and weigh concept to improve measuring accuracies. The Gallery Dust Collector is located in the east end of the Unloading Shed. It serves the unloading and weighing of raw materials from all silos onto either collecting conveyor.



There is a Mix Tower at the east end of the silo row that houses two mix systems. Each collecting conveyor dumps to a bucket elevator, which in turn takes batch components up to a totalizer hopper to stage and check-weigh the batch into the mixer. A manual bag-fed volumetric feeder is set up to add minor ingredients to the totalizer hopper for specific recipes. The 5th & 6th Floor Dust Collector also serves to control dust from additional sources in the batch tower.



There are two transfer belt conveyors that take batch from the mixers to the tank feed hoppers in the main building by way of an overhead enclosed bridge. Normally Batch Line No.1 feeds Tank No.1. and Batch Line No.2 feeds Tank No.2, but a diverter valve in the unloading chute under each mixer allows batch to be fed to the alternate belt conveyor and tank. Tank No.1 Feed End Dust Collector serves the belt transfer / unload operation in the bridge, and the tank feed operation. Tank No. 2 Feed End Dust Collector serves the same function for Tank No. 2.



The plant provided data including tables for each dust collection system with rough schematics. expected flows, measured flows, and a drawing set (plans & elevations) for the batch plant.

While these drawings provided a good background of the process, there was very little documentation for the original design of the dust collection systems. The data available did not establish the original design operating point for any of the dust collection systems such as flow rates, static pressure across the blower and duct velocity. It was assumed that the collectors and blowers were installed with the original plant, and their nameplates generally have been lost and are no longer available. Some target operating criteria has been developed by the plant for the purpose of monitoring system performance, but the missing data made the evaluation more challenging.

2. Site Visit / System Evaluation:

The process operations appeared to be reasonable for the plant requirements. The batch plant is typical for this type of operation. Capacity appears to be well matched for operations, and the original equipment selection appears to be logical and functional. The material transport systems were basically industry standard and reasonable for the system size. In general, all points of material transfer had dust collection pick up points.

The original sizing of the batch dust collection systems could be improved in terms of the bag cloth area. This may not have been a problem initially, but as new bags became slightly impinged, flows dropped below conveying velocities, and the systems all became difficult to maintain.

A review of the dust collection equipment (the blowers and the dust collectors) resulted in a decision that the existing equipment, even at thirty plus years old, was in reasonably good condition. Therefore, an effort was made to retain the existing equipment. It was determined that the original design of all twelve (12) of the batch dust collection systems provided ample air flow volume, but minimal dust conveying line velocities. This situation caused chronic maintenance and operational issues and compromised the plant's effort to maintain proper housecleaning. Therefore, the focus of the engineering solution was aimed at the duct system, since the dust collection equipment was determined to be reasonable for the application.

3. Interview Key Stakeholders:

Key personnel in management, engineering, and operations were interviewed to gain a working perspective of concerns with operation and maintenance of the systems. The discussions were centered around the adequacy of the existing process and dust collection equipment, especially in regards to dust management.

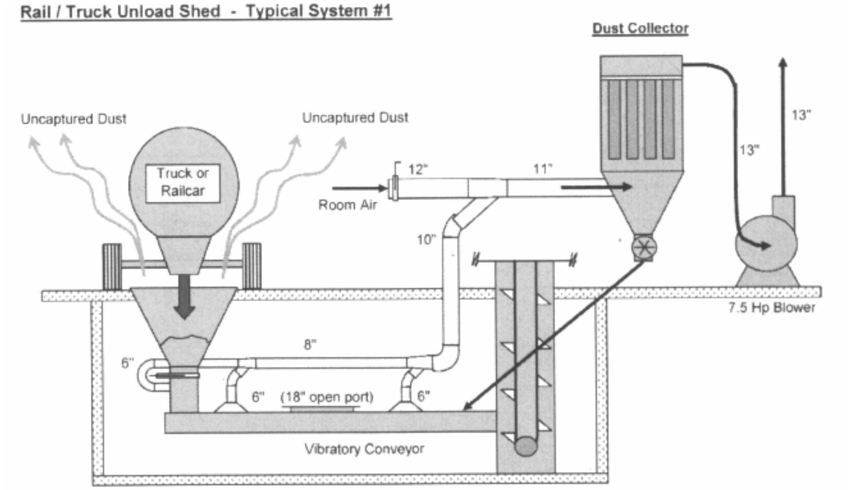
There was a general consensus that all of the dust collection systems are hard to maintain and are prone to plugging. It is difficult to keep the bags from fouling in some of the systems as well. There were no major issues raised regarding the process equipment.

4. Measure the Existing Conditions:

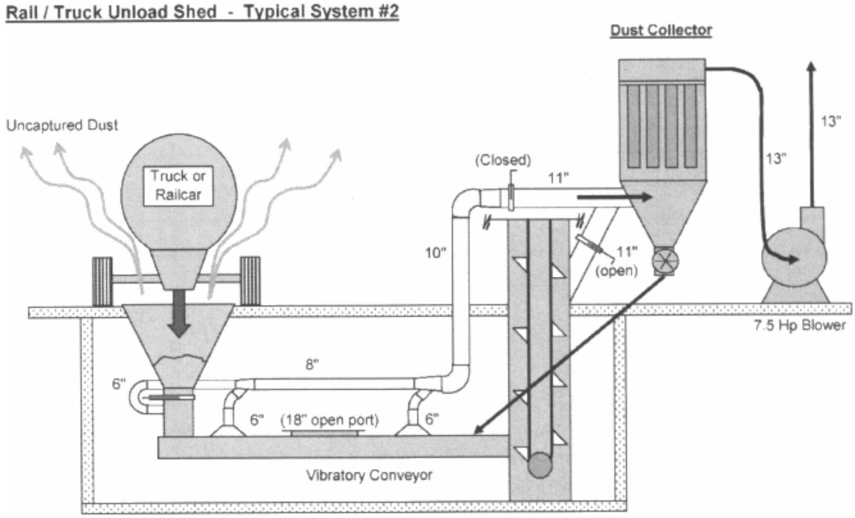
The remainder of this paper concentrates on the analysis of three of the Truck / Railcar Unloading Shed Dust Collection Systems. While some of the other batch dust collection systems have a larger distribution network, their problems, analysis, and potential solutions are very similar. The eight truck/railcar Unload Dust Collection systems were all installed with the original plant. They are basically identical with the exception that some of the ductwork has been individually modified for various reasons. They each utilize a reverse pulse jet dust collector with 236 ft^2 of polyester fabric bags. All have pick-ups at both the feed and discharge ends of the vibratory conveyor, and a dust recycle chute from the collector hopper back to the conveyor. The soda ash and aragonite pick-ups were by-passed with a short pick-up straight to the bucket elevator due to chronic plugging, but these new legs plug occasionally. Ducts were added to both of the sand systems to draw in room air, and to provide a common crossover.

EXISTING SYSTEMS:

Rail / Truck Unload Shed - Typical System #1



Rail / Truck Unload Shed - Typical System #2



The following tables show a summary of the plant flow measurements:

Table I. Rail / Truck Unloading Shed - Measured Dust Collector Flow Rates

Plant Data taken in January 2007

Raw Material	Flow Rate (cfm)	Main Header Size	Velocity (fpm)	Air to Cloth Ratio
#1 Sand (low Iron)	864	11"	1,370	3.7
#2 Sand	873	11"	1,390	3.7
Soda Ash	plugged	11"	0	0.0
Average Flow	579		920	2.5

Plant Data taken in June 2007

Raw Material	Flow Rate (cfm)	Main Header Size	Velocity (fpm)	Air to Cloth Ratio
#1 Sand (low Iron)	1,900	11"	3,020	8.1
#2 Sand	1,530	11"	2,430	6.5
Soda Ash	1,680	11"	2,670	7.1
Average Flow	1,700		2,700	7.2

Target Plant Data after Modifications

Raw Material	Flow Rate (cfm)	Main Header Size	Velocity (fpm)	Air to Cloth Ratio
#1 Sand (low Iron)	1,420	8"	4,070	6.0
#2 Sand	1,420	8"	4,070	6.0
Soda Ash	1,420	8"	4,070	6.0
Average Flow	1,420		4,070	6.0

5. Recommended Changes:

Dust system line velocities should always be greater than the saltation velocity for the particular dust being handled. This will vary for any given material based on particle size density (PSD), moisture and particle shape. The new design criteria minimum line velocity for free flowing non-hazardous powders is set at 3,500 feet per minute.

Reverse pulse jet dust collectors can operate across a range of flows, but differential pressure across the fabric increases as flow rate increases. At some point, airflow becomes too great for the bags to effectively clean. This maximum airflow depends on collector design, pulse air pressure and material characteristics. The new design criteria for the maximum air to cloth ratio is set at 6 to 1. This assumes the powder load is light (dust collection, not a product collector) and that the dust collector is of a reasonably good design with adequate interstitial area. The air to cloth ratio uses air flow and the cloth area (sum of all bags), so the net value is actually the face velocity of air across the fabric in feet per minute. The velocities in the Unloading Shed Dust Collection Systems are too low to provide adequate dust collection.

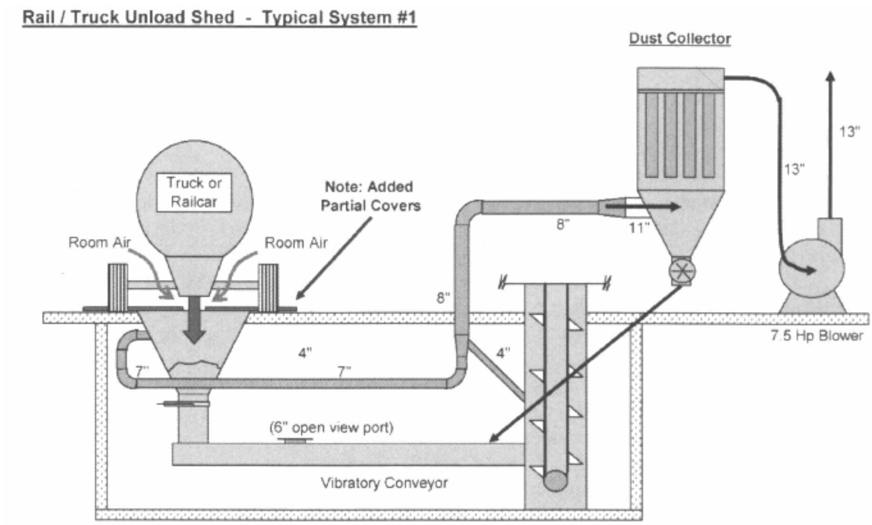
Specifically, if any of these systems were started clean and fresh after a complete overhaul (new bags, clean ducts, repairs), duct velocity would initially be adequate for conveying, but the dust collector would not be capable of adequately cleaning itself. The dust that was dislodged by the pulsing action would immediately be re-entrained and carried back to the bag surface. As powder builds up on the bags, velocity would gradually drop to an equilibrium value where the bags clean, but at a resulting duct velocity that is too low to properly convey powder, so the ducts continue to plug. Soda ash and aragonite are additionally troublesome as the settled hygroscopic powder in the ducts and on the bags would readily absorb moisture, become tacky, and attract yet more powder out of the air stream.

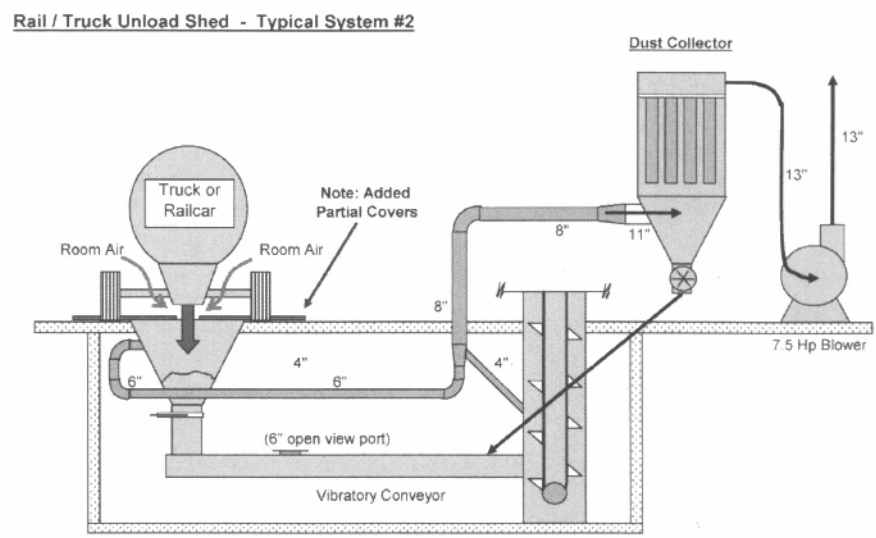
The goal of most dust collection systems is simply to create a slightly negative pressure at all points inside the dust-bearing equipment of a process or conveying system so that any entrained dust cannot escape at potential leak points or design openings in that equipment. Too little suction results in dust leaks, so many designers often provide extra capacity. Too much suction can create a bigger problem, however. In addition to the waste of capital in an oversized dust system, excessive suction can induce airflows inside the process that can result in product entrainment and product loss at transfer points. In some cases, fine minors or micro ingredients can be selectively 'vacuum cleaned' right out of a system, resulting in inaccurate batch formulations in addition to excessive collection of powders as waste material.

The design criteria was to provide a flow equal to 5 times the sum of the volume of displacement air from solids transfer and the expected or measured leak rate of the system seals, plus 150 fpm inflow at any openings to the system (such as bag dump stations or open inspection hatches). Each of the truck unload systems require approximately 150 cfm for material displacement below the dump hopper, 50 cfm for leaks, and another 30 cfm for the open face area of an open 6" round inspection port in the vibrating conveyor. Each system as originally installed provides several times this requirement, even at low velocity.

Since the powder unloading from the truck or railcar effectively forms a seal leg in the dump hopper, another 150 cfm is required for displacement and 450 cfm for the open face area to account for the new partial covers provided to reduce the open grating area to less than 3 ft^2.

RECOMMENDED SYSTEMS:





Our analysis of these systems determined the existing collector / blower combinations provide more than adequate flow for all re-sized pick-up points after adjusting to a 6.0 air to cloth ratio operating point. Most of this capacity will now be directed to 2 new pick-ups at the top of the unloading hopper, while a single 4" pick-up on the bucket elevator will provide adequate suction to all equipment downstream of the dump hopper seal leg. The main header to each collector was also reduced from 11" to 8" to establish conveying velocity. Flow rate and velocity at each pick-up and trunk is balanced as follows:

Table II. Rail / Truck Unload Shed
Target branch flows after balancing

Target Branch Flows - Unloading Systems

Duct / Pick-up	Flow Rate (cfm)	Velocity (fpm)
6" from hopper	750	3,820
4" from hopper	350	4,010
6" trunk	1100	5,600
4" from elevator	350	4,010
8" trunk (total flow)	1450	4,150
13" to blower (clean)	1450	1,700

It was recommended that Gore-Tex be specified as the bag material for the two hygroscopic powders, aragonite and soda ash. This PTFE membrane-lined filter fabric provides a relatively inexpensive additional safeguard against caking of material on the bags

6. Measure the Improvements / Report the Results:

Flow and pressure drop data will be taken on all three systems 1 week, 1 month, and 3 months after the systems are back on line. We expect to see consistent performance that will demonstrate that the modified systems are truly low maintenance as compared to the original installation.

Unload shed area measurements will also be measured to demonstrate the environment improvements.