Storing Fly Ash in a Concrete Dome
A Case Study

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ABSTRACT

This paper offers a case study for a 120’ (36.6m) diameter by 127’ (38.7m) tall fly ash SiloDome™ with aerated floor reclaim near a power plant on the eastern seaboard of the USA constructed in 2011-2012. It explains the reasons and benefits of choosing a dome with aerated floor reclaim. It explores the construction process and installation of the dome and reclaim system.

Insulated concrete bulk storage domes provide an economical way to store and reclaim fluidized product [1], [2]. By their very nature, domes are strong, durable and efficient. They hold up well in high winds and driving rain, earth movement events, avoid internal sweating, handle differential internal pressure and settlement and are quick to construct in good or adverse weather environments.

Aerated floors provide an economical solution for reclaim of material by fluidizing product through the introduction of air into targeted zones within the storage space. The unique design by DCL provides piping through the Aeration Pads allowing for easy installation, cost savings and protection from load movement within the dome. The SiloDome™ shrinks the footprint of the dome thereby decreasing the cost of the reclaim floor.

INTRODUCTION

Insulated concrete domes are a proven method for storing large amounts fly ash and act as a storage buffer between seasonal demands. [3] Building with concrete is economical, environmentally sustainable and durable [4]. Concrete domes offer better protection of products, more efficient use of land space and are rapidly constructed. Domes enclose and protect their contents better and more economically than any other type of structure. [5] Virtually air tight and superbly insulated, they are fire safe, do not corrode, nearly eliminate all interior condensation and tolerate differential ground settlement. The apex of a dome can support conveyors, head houses and other structures without adding significant costs to the building itself. Able to withstand hurricane-force winds, seismic events and other natural disasters, domes hold up better than most other types of structures.
Constructed worldwide, insulated concrete domes store dry bulk products in the power, cement, fertilizer and mining industries. They store products such as fly ash, wood pellets, limestone, fgd gypsum, cement, clinker, various fertilizers and ores.

The dual curvature of a dome adds strength and durability to resist hurricane and tornado-force winds and driving rain and debris. The interior is completely free span, so product doesn’t rest on any interior structural members. Product is stacked against the wall like a silo, but much more economically.

Sandwiched between the outer DomeSkin™ and the inner concrete and rebar is a 2” (5cm) layer of polyurethane foam. The foam protects the concrete from freeze-thaw cycles, extending the life of the concrete. Because the concrete is not exposed to extreme elements, the temperature fluctuations in a dome are minimal, hence virtually eliminating condensation.

Because the dome is one large monolithic building it tolerates substantial settlement as a complete structure. This characteristic reduces and in some cases eliminates the need for deep foundations, saving money.

When it was determined to build a new plant in Maryland, SEFA performed an analysis to determine the most cost effective storage solution for their application based on their need to store 30,000 tons (27,216 m. tonnes) of finished product required for seasonal storage. They investigated using multiple silos or one large insulated concrete dome. In the end it was determined the dome option was the preferred storage method.

There were several design considerations in the final geometry of the dome.
- First, the area of the new fly ash terminal and treatment plant was rather small, on a sliver of land in an odd trapezoidal shape.
- Second, the water table was very high.
- Third, the reclaim equipment cost of the fluidized floor.
The final design solved design considerations in an economical way. The footprint was a small SiloDome™, a 120’ (36.6m) diameter dome engineered and built by DOMTEC International. The decreased footprint of the dome allowed more room for the truck load out and the STAR™ benefaction process buildings and turn around. The small diameter reduced the amount of fluidized floor reclaim equipment need by eliminating a significant amount of floor square footage.

The smaller dome diameter increased the vertical wall height and also slightly increased the cost of dome construction; however, the increased cost of construction was more than offset by the savings in reduced equipment for the fluidized floor.

The tall SiloDome™ allowed for the sloped floor to discharge fly ash out the side of the dome, rather than to a subfloor reclaim tunnel under the center of the floor, thus avoiding ground water issues.

The final design was a dome 120’ (36.6m) diameter by 127’ (38.7m) tall with an aerated floor capable of withdrawing 96.5% of initial product reclaim.

DOME CONSTRUCTION

Upon arrival to the job site, DOMTEC began their construction process by placing all the rebar, crane and other equipment needed to construct the dome within the ring foundation.

Next, the DomeSkin™ air form was attached to the foundation and inflated. The DomeSkin™ is a commercial/industrial waterproof, tear resistant roofing membrane custom fabricated by expert air form manufacturers to each application and which acts as the outer most shell of the dome.

It contains UV inhibitors which extend the fabric’s lifespan. A PVDF topcoat resists staining from industrial environmental factors and stays cleaner, longer.

Following inflation all work is completed from inside the dome. This unique construction process eliminates nearly all weather delays from hot, cold or wet weather. First a layer of

Figure 2 Cross-section of SEFA dome

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polyurethane foam is applied to the inside surface of the DomeSkin™. The foam acts as a thermal barrier and provides initial rigidity to the dome. Next a rebar mat is attached to the layer of foam and then shotcreting begins. All shotcreting is done by DOMTEC’s expert technicians who average more than 20 years experience. Additional mats of rebar and shotcrete are attached and applied intermittently until the dome reaches its engineered thickness and depth gauges are covered.

The SEFA project was completed on time, without any over runs in cost as has been the case with every project DOMTEC has engaged.

AERATED FLOORS

DCL’s scope of supply for the project was to provide an aerated floor reclaim capable of withdrawing 96.5% of initial product reclaim. Included in this scope were the following components; air pads, PD blowers, pneumatic valves, piping and programming. The dome consists of 120’ (36.6m) diameter floor with an 8 degree primary slope and 10 degree dihedral sides feeding a 14” (.36m) side discharge allowing 500 ton (454 m. tonnes) per hour discharge rate. In order to provide a 96.5% product reclaim DCL calculated the air pad floor coverage would need to be 33%. In order to achieve the 33%, 3,800 square feet (353 square meters) of air pad surface was necessary.

DCL’s unique dome floor design utilizes air pads in multiple zones that are typically no larger than 200 square feet (18.6 square meters). The dome floor required 19 zones. The reason the zones were limited to 200 square feet (18.6 square meters) is in the event of media failure the zone can be shut down and still allow material to be reclaimed without interruption. The use of 1” (2.5cm) bar grating the entire length of the air pad supports the media. This assures a robust design capable of withstanding the head pressure of product with a 100’ (30.5m) high dome ceiling.

The smaller zones also allow for smaller and more energy efficient positive displacement blowers. This project required two primary PD blowers and one redundant PD blower. The redundant blower is used when additional air is required or in the event
that a primary blower is being serviced. Each blower is sized with a 40hp motor capable of 1000 CFM (28.3 cubic meters/min.) at 11psi (75.8kPa). One primary PD blower provides air to the discharge zone only. The second primary PD blower provides air to the other 18 zones in a pulse sequence operated via butterfly valves and a computer interface which can be manually overridden if the need arises. Three various program recipes were developed for zone aeration. One program was designed for a full or nearly full dome, another for half full and one for nearly empty.

Piping of the air pads starts at the main header located around the outside of the dome. This main header is connected directly to the PD blowers. The main air header feeds each zone using an electrically operated butterfly valve. The zone piping is routed from the main header through a sealed sleeve in the dome wall. The incoming pipe is then connected to an 8" (.2m) vertical expansion joint before being routed to the zone. The purpose of the expansion joint is to allow for floor settlement.

All piping is installed above the floor using straight piping and clamps. In addition DCL used another unique design by manufacturing air pads with piping run through the air chamber. By doing this during manufacturing huge savings were realized in the costs of field pipe fitters. According to the install contractor the saving exceeded USD$70,000. DCL’s unique and robust designs provide customers reliable reclaim assuring continuous operation in their facility.

ABOUT DOMTEC INTERNATIONAL:

Founded in 1995 after more than 10 years in the insulated concrete dome industry, DOMTEC (pronounced dōm-tēk) International was built on the values of leadership, craftsmanship and quality control. Beginning truly as an international contractor,
DOMTEC was awarded a prime contract to build a USD$5 million, 40,000 metric tonne (44,000 tons) fly ash dome in Germany. Included in the contract was an automated reclaim system, sub-grade tunnel, stair tower, bridge and head house.

Their quality control procedures and quality assurance program are best in the industry. Their shotcrete and foam technicians average over twenty years of experience. They have built their business on making and keeping promises and helping owners and engineers avert risk. In roughly 20 years in business they have completed every project on time.

Now a global leader in bulk storage solutions in the cement, agricultural & fertilizer, power and mining industries, they have successfully completed dome projects the world over storing products such as coal, fgd gypsum, fly ash, metals, ores, potash, fertilizers, grains, peanuts, salt and sugar.

ABOUT SEFA:

The SEFA Group, founded in 1976 and formerly Southeastern Fly Ash Company, is a transportation and marketing company dedicated to the idea that the optimum amount of fly ash should be used in each yard of concrete placed. In order to fulfill its mission of maximizing the “beneficial utilization of coal combustion products in an environmentally friendly way,” SEFA partners with utility companies who product fly ash as a power generating by-product and the construction firms who utilize fly ash in their concrete.

SEFA has nine plants currently operating in the mid-South and mid-Atlantic states.

ABOUT DCL

Since 1981, DCL, Inc. has been the leader in manufacturing dry bulk loading equipment.

A privately held company, they were founded with one simple goal: to design and build the most efficient and cost-effective solutions for dry bulk loading – in any industry sector.

They’ve met that goal, as a manufacturer: in some industries, DCL is recognized as the standard against which other loading systems are measured. They’ve met it as a designer, engineer and integrator – offering complete one-stop source to develop build and install bulk loading solutions. They’ve met it as an innovator, with ongoing research and development that has led to ground-breaking new ways to work. But their more important role has been as innovator through their Research & Development. And they’ve met it as a corporate citizen, by remaining firmly committed to the success and economic growth of their community and state. With more than 60 employees and a 40,000-square-foot manufacturing facility serving customers worldwide, they take seriously their role as one of northwestern lower Michigan’s business leaders.
REFERENCES


