1. Introduction

Concrete domes are currently storing large quantities of cement, fertilizer, flyash, gypsum and other bulk products at port terminals around the world. Even so, compared to other types of storages, domes are still just beginning to be discovered. This presentation will discuss why companies are choosing concrete domes and will also compare a few of the various reclaim systems presently being used in domes.

2. Where are Concrete Domes

A few ports where domes constructed by various dome builders are currently being used:

Europe: Las Palmas de Gran Canaria and Santa Cruz de Tenerife, Canary Islands (Spain), Odessa (Ukraine), Port of Gdynia (Poland), Tallin (Estonia), Riga (Latvia), Klaipèda (Lithuania)

Middle East: Aqaba (Jordan), Dammam (Saudi Arabia)

North America: Reserve, LA, Charleston, SC, Morehead City NC, Providence RI, Portland OR, Bristol (Philadelphia) PA, Stockton CA, Quebec City Quebec, Bath Ontario

Central / South America: Puerto Cabello (Venezuela), Puerto Ventanas (Chile), Manzanillo (Mexico)

Asia: Mokpo (Korea)

3. Why a Concrete Dome

Concrete domes are efficient and economical for storing bulk materials in large quantities (shipment size - such as 30,000 to 100,000 tonnes). Some of the main reasons companies select concrete domes include:

- Better protection of stored materials
• Efficient use of land and space
• Strength and durability
• Rapid construction
• Simplicity & Cost

**Better Storage:** Imagine a storage building that keeps products dry even through hurricanes or typhoons. In addition an insulated storage building which virtually eliminates condensation and dripping; a tightly constructed building that positively keeps out birds and rodents and prevents fugitive dust emissions. Such a building is a DOMTEC® insulated concrete dome.

A waterproof outer membrane keeps out rain and snow. Directly underneath the waterproof membrane is a 2 inch layer of sprayed-in-place polyurethane foam insulation, which minimizes interior temperature cycling and greatly reduces condensation. The result is that materials can be maintained in the same quality they were going into storage.

**Efficiency:** Large quantities of materials can be stored on relatively small spaces. For example, 90,000 tonnes of cement can be stored within a 60 m circle. Domes are efficiently filled by conveying to a single opening at the top. The dome’s compactness results in filling conveyors being shorter in length and simpler than would be needed to fill a silo or flat storage. Automated reclaim equipment is also simplified. In the case of reclaiming with front end loaders trips are fewer and shorter.

Domes can serve as mere pile covers, however they are most efficient functioning as material containers. Metal domes are often used only as pile covers, however they are usually not designed capable of withstanding the pressure of materials piled high against the walls. The disadvantage is that more land space is required. Concrete domes on the other hand function either as a pile cover, or they are designed to allow product to be piled high against the walls. In this way concrete domes perform more like silos, containing the material on a relatively small footprint. This results in a higher percentage of the stored material being reclaimed by gravity.

Not all concrete domes are the same either. Different dome builders use different construction methods. Even for domes constructed the same way, there may be significant differences in the quantity and quality of materials used, as well as the quality of workmanship.

**Strength and Durability:** Properly constructed concrete domes are strong enough for materials to be piled high against the walls. They also can support heavy conveyor loads. Concrete doesn’t burn. It doesn’t oxidize. It isn’t eaten by insects. Concrete domes are able to withstand hurricane force winds and even earthquakes much better than other structures.

**Rapid Construction (regardless of the weather):** Depending on the size, most domes are usually completed within 2 to 4 months after the foundation is completed. When other construction projects are stopped due to bad weather, dome construction continues, since most of the work is done inside an insulated form. The construction process is as follows:

1. A fabric form is attached to a ring beam foundation and inflated.
2. Polyurethane foam insulation is sprayed to the form’s inner surface.
3. Reinforcement bars are attached to the foam.
4. Concrete is sprayed to embed the reinforcing bars. *(figure 1)*

**Cost & Simplicity:** Concrete domes are cost competitive, especially in large capacities. They are constructed on relatively simple and inexpensive foundations. Pilings or other types of costly deep foundations are often avoided. Minimal foreign materials means that less hard currency is required.

**3. Reclaim Systems**

While domes are easy filled through a single opening, the question often asked is how the stored materials can be retrieved. The simplest method is with front end loaders, which is the approach utilized by many dome owners. Each concrete dome includes at least one drive in door way.

Many clients would prefer to not use front end loaders, and several manufacturers offer various types of automated systems. Many people assume that all reclaim systems work equally well in any dome. This simply is not the case. The dome and reclaim system are integrally related, and the type of reclaim system selected almost always significantly impacts the shape, size and cost of the dome.

In this presentation we will discuss a few reclaim systems all of which are actual working installations. The author acknowledges that there may be other systems not mentioned which would also work in domes. Our discussion will be *only* in *broad*, general terms. Since each project is unique precise cost data is purposely avoided. For specific information including pricing we recommend that you contact the equipment manufacturers.

Dome reclaim systems fall into two general categories, mechanical and pneumatic; even though many systems include both pneumatic and mechanical components. **DOMTEC®** is often asked which is better, pneumatic or mechanical. The answer depends on many things which often are project specific. Sometimes either type of system could work and the choice simply depends on the client’s preference. In order to select the best system for a particular application the client need to evaluate the following:

- Site constraints (available land area as well as any height limitations)
- Geotechnical conditions (including soil bearing capacity and the depth to the water table)
- The length of time product is to remain in storage
- The importance of 100% reclaim
- The importance of *first in, first out*
- Initial capital cost (including *all* costs associated with installation of the system)
- Operating costs (including the cost of electrical energy)
- Maintenance costs

By determining the relative importance of each of the above issues, and how they apply to a specific project, the most logical type of reclaim system will often become evident. The enclosed table (table 1) can help clients evaluate between different types of equipment in selecting the reclaim system that will be right for a particular project.

Most clients seem to prefer the capability for fully automated 100% reclaim. Indeed if it is important to regularly empty the storage completely several times each year, then such a system is probably warranted. On the other hand if what is really important is to simply have a certain total capacity, but the storage will seldom or never be emptied completely, then money can be saved by purchasing a system capable of reclaiming only a portion of the dome’s capacity, and front end loaders can be employed to accomplish the occasional complete clean out.

If a client purchases a system capable of withdrawing only part of the stored material, when in fact they really need or expect complete automated withdrawal, then they are sure to be frustrated. Unfortunately, this occasionally may occur, sometimes when a client is lured by a system’s lower price while not fully understanding the system’s limitations, or if the system’s capabilities have been over represented.

When it comes to a system’s capital cost, the complete cost of the dome plus the reclaim system, including special civils works and all other associated components necessary to make the system functional need to be considered. It is a mistake to compare only the cost of equipment, as there may be additional costs associated with the system’s installation which can be as costly or more so than the equipment itself. For example there are systems which require a larger or taller dome to achieve the same capacity as with other types of systems, and other systems require more extensive civils work, such as specially sloped floors. All the costs associated with such extra work must be included in any cost comparison of systems.

### 3.1. Mechanical Systems

One of the main advantages of mechanical reclaim systems is their ability to handle a wide variety of products, including some that are difficult to handle. Various mechanical systems have been installed in domes by companies such as Cambelt International, Starvrc, Decker Industries, Mid-West Conveyor, BRP (offered through BMH), and others. Mechanical systems differ significantly in their design, construction, performance and cost.

To date the most popular of all systems for concrete domes (pneumatic or mechanical) has been Cambelt’s open screw reclaimed. (figure 2) It has been installed in nearly 30 domes around the world and has proven effective reclaiming...
cement, fly ash, clinker, borax, synthetic gypsum, metal concentrates and other products. Cambelt’s system is designed for virtually 100% reclaim and continuous heavy duty use. Cambelt systems have been installed in domes larger than 60 m diameter. They can reclaim at rates up to 1500 tph and handle particles up to 150 mm (6 inches).

Starvrac is another manufacturer offering open screw type extractors (figure 3). Starvrac has installed over 4,000 machines in more than 250 different products. Most of these machines are working inside relatively small diameter silos, however, a few have been installed in domes. These include several machines in sugar storage domes up to 60 meters in diameter. Starvrac machines work on the bottom of the storage pile withdrawing material on a first in-first out basis. Starvrac extractors work best with materials that have a particle size of 60 mm (2.5 inches) or smaller. A single Starvrac machine’s reclaim capacity is usually limited to about 500 tph, however multiple machines can be installed in the same dome when higher reclaim rates are required.

Another mechanical concept utilized in several domes is the rotary plow. These systems are offered by companies including Decker Industries (figure 4), Mid-West Conveyor, and Aumund (Louise). The basic design consists of a traveling rotating feeder installed above a belt conveyor. The feeder moves back and forth across the dome’s diameter pulling material on to the belt conveyor as it goes. The systems are not designed to reclaim all the stored material, however they reliably reclaim whatever material that comes in contact with them. If the dome only occasionally needs to be cleaned out completely, this type of system could save the client money. This type of system would not be appropriate if complete automated withdrawal is what is really needed.

For products other than cement and flyash several companies such as Krupp, Koch, Aumund, MVT, FLS and others have built circular reclaimer systems for many years, even before concrete domes became popular. There are a variety of designs to choose from, including some which are made specifically for blending materials. Many of these systems also include a circular stacker which allows for stacking operations to occur simultaneously during the reclaim process. These systems usually reclaim on a first in-first out basis, and are capable of reclaiming at very high rates. They also can handle a wide range of particle sizes. A few of these types of systems have been installed in concrete domes, however, since many of the designs include an outside
perimeter rail which cannot be buried in product, they are installed under large diameter dome covers.

The Aumund Mole has proven effective and reliable for reclaiming clinker from round storage buildings. Recently Aumund has introduced a less costly version of their proven Mole machine.

For any mechanical system it is important that critical system components such as electric motors, gearboxes, etc. are located where they can be accessed and serviced, even when the dome is full. Provision for repair should be anticipated. Equipment problems don’t always result in complete cessation of reclaiming operations. Manufacturers usually offer technical assistance, including those who can troubleshoot and sometimes even repair a problem via modem. Often systems can continue reclaiming while planning for a convenient opportunity to effect a needed repair.

3.2 Pneumatic Systems

Pneumatic reclaim systems work only for products which can be fluidized such as cement, flyash and alumina, etc. Various types of pneumatic reclaim systems have been installed in domes. The first were installed over 20 years ago. These domes were equipped with Fuller fluidized floors (figure 5), all of which continue operating to this day, although over time their effectiveness has decreased somewhat. Fuller has since added several more designs of fluidized floors to its repertoire.

The general concept of pneumatic systems is to slope the dome’s floor (typically between 6° and 10°), and then install open top aeration units (such as Airslides) on or within the sloped floor. Air blown up through a porous media causes the cement or flyash to fluidize and flow down hill to a pneumatic pump or other conveyor. Since the material is reclaimed from the bottom of the pile, it is generally reclaimed on a first in-first out basis.

Several manufacturers including Van Aalst (figure 6), Ibau, Fuller, BMH, Modco, DCL, Alesa and others offer a variety of pneumatic reclaim systems which can differ significantly in their general lay out, complexity, performance and cost. The effectiveness of these systems seems to be directly related to the percentage of the floor that is covered with fluidizing media. In general, a high percentage of coverage will result
in high performance, while covering only a low percentage of the floor area will result in low performance.

The main advantage of pneumatic reclaim systems is that they have very few moving parts, thus maintenance costs are expected to be low. Also in most systems, in order to minimize the initial capital investment and reduce operating costs, the dome’s floor area is divided up into zones and the fluidizing air is cycled through the various zones by means of piping and valves. This approach minimizes the quantity and cost of blower equipment as well as the operating costs.

*Set pack* is probably the biggest challenge for fluidized floor systems when dealing with cement or flyash. When left in storage for long periods of time cement and flyash will pack and set up often to the point that it will no longer fluidize properly. If a client’s operations will include storing cement or flyash for extended periods of time, then they should select a fluidized floor system which provides for the entire floor area to be covered with fluidizing media, and is capable of completely cleaning out sections of the floor on a regular rotating basis. Otherwise a contingency plan and method should be developed for getting in to manually clean out the dome in the event the material set packs to the point that it will not fluidize. For applications which require storage for very long periods of time perhaps a mechanical system would be more suitable.

### 4. Conclusion

Concrete domes are becoming more widely used for storing bulk materials. *DOMTEC®* insulated concrete domes provide superb protection to their stored materials. They are economical and efficient, especially for large capacities (shipment size - 30,000 to 100,000 tonnes).

Prospective buyers should be aware that the storage dome and automated reclaim system are integrally related, and not all reclaim systems work equally well for any size and shape of dome. In order to select the correct storage dome and reclaim system which will perform as expected, clients should become familiar with the various types of domes and dome suppliers, as well as the various reclaim systems available.

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