# Appendix E
# DCR Control Measure Evaluation, Methodology, and Criteria

APPENDIX E

# Dry Cargo Residue Control Measures

## Approach

Reducing dry cargo residue (DCR) discharges through various control measures is not new to the Coast Guard or to Great Lakes carriers. DCR control measures preventing and capturing spillage are used on many Great Lakes ships to varying degrees. The ships in use have been built by several different manufacturers over the course of more than 60 years. Some have been retrofitted with newer technologies to reduce DCR, such as installing covers over unloading conveyors, but not all ships share the same degree of DCR controls. Control measures on a specific ship are based on ship age and the technological generation of the ship's loading and unloading equipment, shoreside loading mechanisms, cargo type, port origin and destination, and general ship operation and policies.

Studies have been conducted for the Coast Guard and Transport Canada that discuss DCR control methods in place and others that could be implemented to reduce ship-generated DCR that is discharged to the waters of the United States. These studies were reviewed to develop a database of control measures with a proven history in the shipping industry (U.S. Coast Guard, 2002, 2006; Reeves and Perry, 1995; Melville, 1993).

In addition to reviewing the literature, CH2M HILL visited several Great Lakes ships carrying dry cargo to collect DCR samples from decks and unloading tunnels, to view control measures, and to interview crew members about cargo-handling procedures and operations. One ship was boarded for a 4-day trip in April 2007 so that loading, unloading, and washing operations for taconite, coal, and limestone cargos could be witnessed. Officers, deck-hands, engineers, and tunnel operators were interviewed about cargo-handling operations and other aspects of DCR.

Other relevant control measures were identified from the literature review, boat tours, and crew interviews. Control measures used by other industries for wastewater and drinking water treatment, stormwater management, and industrial processes were identified and

evaluated for possible use to reduce DCR. These relevant control measures are included in the analysis.

This appendix documents DCR control measures that were considered for their potential to reduce DCR discharges to the Great Lakes. The control measures are categorized as structural or operational. They are further divided into deck controls, tunnel controls, and shoreside controls. Some control measures prevent DCR from spilling on the ship deck and in the cargo hold tunnel. Others are used to capture DCR after it has spilled.

In addition to describing the range of potential DCR control measures (some currently in use), this appendix evaluates their suitability and likely benefit. Based on the evaluation, DCR control measures were selected for inclusion in the Proposed Action with DCR Control Measures on Ships alternative and the Proposed Action with Shoreside DCR Control Measures alternative.

# Structural DCR Control Measures in Use

Structural DCR control measures are mechanical devices or structural modifications used to reduce the volume or frequency of DCR sweepings. The structural DCR control measures discussed below are practiced in some capacity in the shipping industry, either by ships to reduce deck or tunnel DCR discharge, or by shoreside facilities to reduce spillage on the ship deck. Structural DCR control measures for the three categories are discussed below.

## Structural DCR Control Measures Installed on Ships to Reduce Deck DCR

Deck DCR control measures are implemented on the ship to reduce the amount of DCR falling on the deck and to capture DCR that falls on the deck during loading or unloading of cargo. A significant amount of deck DCR is due to the conveyor system used during loading and unloading; thus these DCR control measures target deck DCR from conveyor systems:

- Enclosed conveyor
- Deck tarps
- Troughed (U-shaped) conveyor
- Conveyor skirts and conveyor belt transfer skirts
- Belt scrapers
- Water/mist for dust control
- Broom and shovel
- Conveyor capacity indicators
- Remote controls for conveyor

## Enclosed Conveyor

Enclosing the conveyor belt on self-unloading ships reduces the potential for DCR to spill from the conveyor to the deck. An enclosed conveyor can be a top-covered conveyor belt (Figure 1), or a fully enclosed conveyor. Enclosed conveyors can prevent wind and precipitation from causing DCR to spill on the deck. They also can capture material spilled from the conveyor belt, such as on the underside of the unloading boom along the return path of the belt. Enclosed conveyors have been used on many ships in the Great Lakes to reduce DCR. Enclosed conveyors can provide highly effective DCR control but require routine cleaning to ensure their effectiveness.

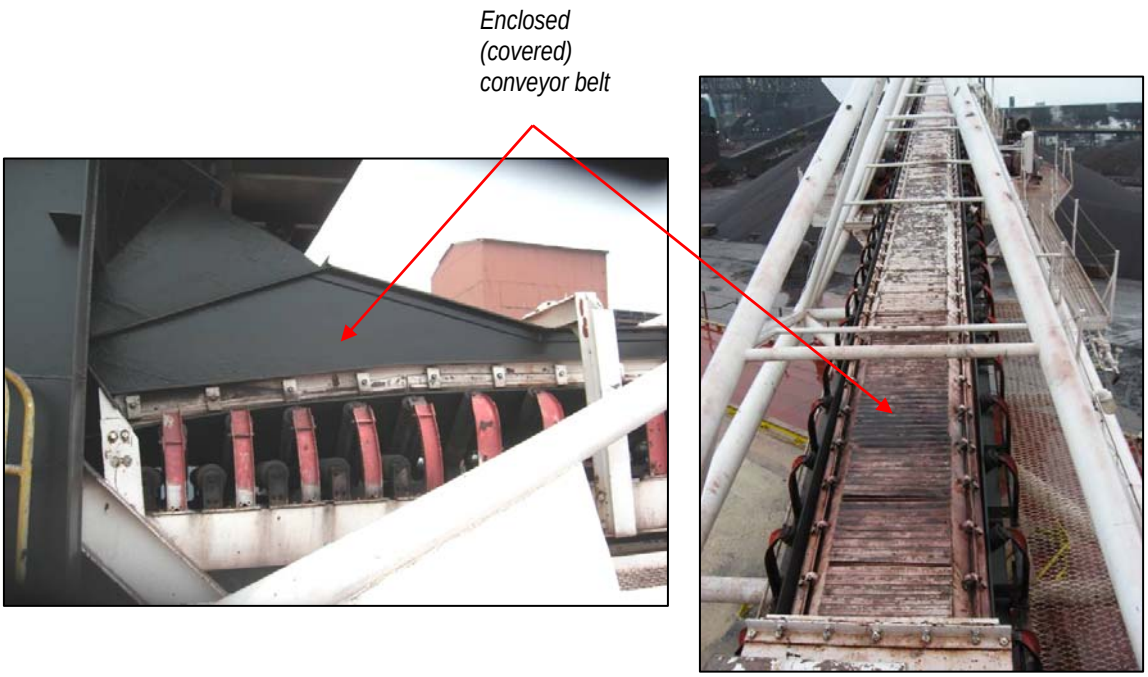


FIGURE 1
Examples of an Enclosed Conveyor Belt

## Deck Tarps

A tarp under a conveyor collects spilled cargo that falls on the deck. Tarps can be used during loading and unloading operations, especially when the conveyors are not enclosed or when the loading conveyor moves between hatch openings. Examples of using tarps on a ship during loading and unloading are shown in Figure 2. The figure on the left shows a tarp placed under a conveyor during unloading and the right figure illustrates how a tarp would

be placed during loading. Tarps have been successfully used on carriers in the Great Lakes and can provide highly effective DCR control, but they are less effective during windy conditions because they do not shield DCR from the wind.

FIGURE 2
Deck Tarps Used to Collect DCR Underneath a Conveyor Belt during Unloading (*left*) and Loading (*right*)

## Troughed (U-shaped) Conveyor

A troughed conveyor is a U-shaped conveyor that forces the cargo to the middle of the conveyor belt, reducing the potential for the cargo to fall off the side of the belt. Troughed conveyors can reduce DCR on the deck and in the tunnel. Figure 3 shows two examples of a troughed conveyor.

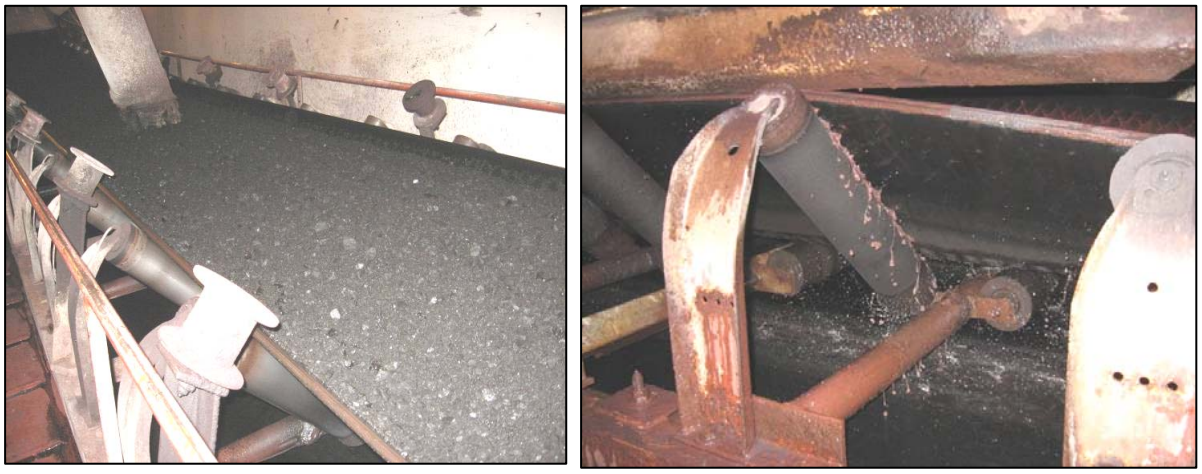

FIGURE 3
Examples of a Troughed (U-Shaped) Conveyor

## Conveyor Skirts

Conveyor skirts are used to keep the cargo on and toward the middle of the conveyor belt, thereby reducing the amount of cargo that spills over the edges. There are several kinds of skirts, depending on the desired level of protection. A continuous skirt protects the sides of the conveyor for entire length of the conveyor belt, whereas other skirts may be installed at critical locations more prone to spillage. Conveyor skirts may be added at conveyor belt transfer locations to provide protection from cargo falling off the conveyor while switching from one conveyor to another. They can be added at the gate openings in the tunnel to direct cargo toward the middle of the conveyor belt. Figure 4 shows a conveyor belt transfer skirt. Conveyor skirts can provide highly effective DCR control but require routine adjustment to ensure their proper operation and to prevent damage to the conveyor belts. Conveyor skirts are most effective at transfer locations and cargo hold gate openings, and therefore would be considered only for those locations.

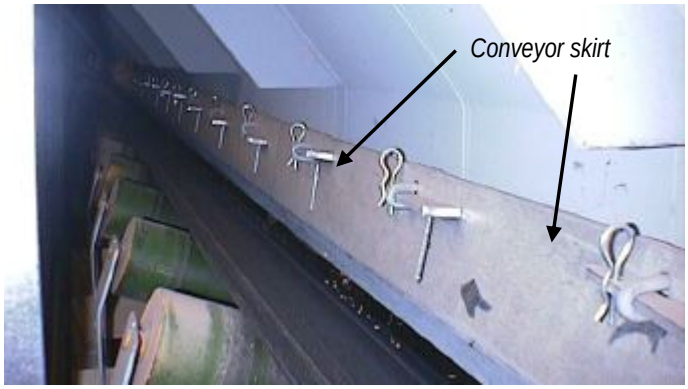


FIGURE 4
Example of Conveyor Skirt Installed to Minimize DCR Spillage
*Image courtesy of Kinder Company. Used with permission.*

## Belt Scraper

Scrapers rub against conveyor belts to dislodge cargo (typically cargo with high moisture content) that may stick to the top the belt. Scraping the belt allows more of the cargo to land in one location, instead of being carried over and falling off the conveyor as the belt continues along its return path. In some applications, scrapers are used in series to further limit spillage. Figure 5 shows two examples of belt scrapers.

## Water or Mist for Dust Control

Water or chemical misters that spray cargo during loading and unloading minimize the amount of dust generated and thus reduce the chance for dust to become airborne and to be deposited elsewhere. Some misting equipment atomizes the water with compressed air to minimize the amount of water or chemical surfactant added to the cargo. The reduction in cargo weight can allow more cargo to be loaded and reduce the potential for freezing.

Misters may be especially beneficial during windy conditions or for fine-grained cargo such as coal or limestone. Figure 6 is an example of a water mister system.

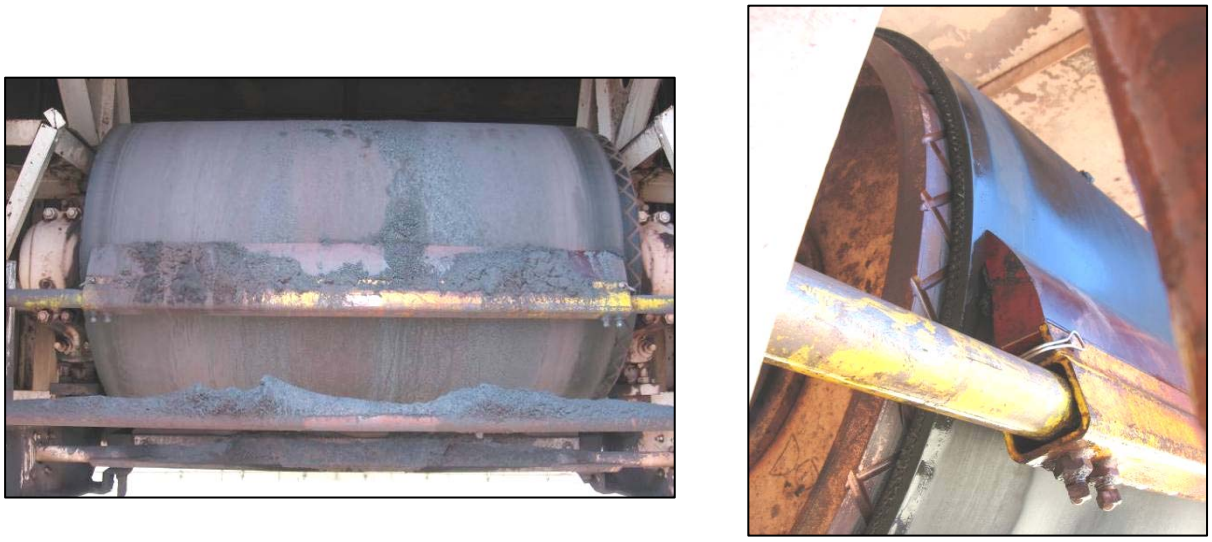

FIGURE 5
Examples of Belt Scrapers

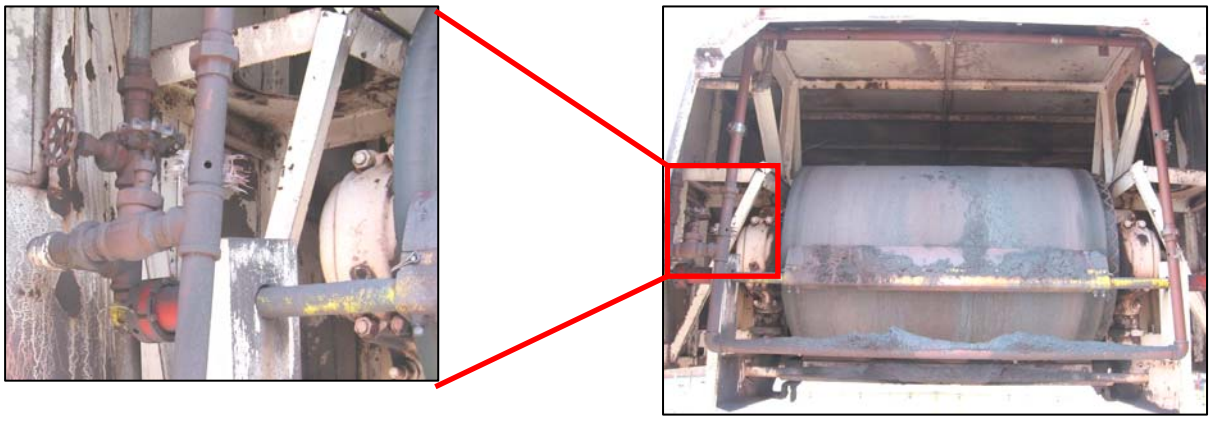

FIGURE 6
Example of a Water Mister System

### Broom and Shovel

The ship's crew may use brooms and shovels to return spilled DCR to the cargo hold if a large enough quantity of cargo is spilled. For smaller amounts, DCR typically is discharged overboard. Broom-and-shovel use could be expanded to increase the collection of DCR. An example of what the broom and shovel may pick up is shown in Figure 7.

FIGURE 7
Example of DCR Collected with a Broom and Shovel

### Conveyance Capacity Indicators

Conveyance capacity indicators include belt scales and a lighting system along the conveyor belt that allow crew and operators to monitor the capacity of the conveyor belt. The indicators signal when conveyor belts are overloaded so that operators can manually adjust the flow of cargo to match the conveyor belt capacity. This allows the crew to maximize the capacity of the conveyor belts and minimize spillage.

### Remote Controls of Conveyors

Some ships have programmable logic controls that allow the deck crew to control the loading conveyors. The controls may also be able to control the loading and unloading conveyors to minimize spillage.

## Structural DCR Control Measures Installed on Ships to Reduce Tunnel DCR

Tunnel DCR control measures are implemented in the tunnel or cargo holds of the ship to prevent DCR from falling into the tunnel and to capture DCR that falls during unloading of cargo. Control measures discussed previously that can be used to reduce tunnel and deck DCR are the following:

- Troughed (U-shaped) conveyor
- Conveyor skirts
- Belt scraper
- Water/mister for dust control
- Brooms and shovels

- Conveyor capacity indicators

Control measures specific to preventing and capturing DCR in the ship tunnel include the following:

- Cargo hold vibrator
- Watertight gate seal
- Cargo hold lining
- Fire hose

### Cargo Hold Vibrator

When cargo releases from the cargo hold in large clumps during unloading, the conveyor can become overloaded, resulting in spillage in the tunnel. A pneumatic or hydraulic vibrator that mounts on the underside of a cargo hold vibrates against the hold to loosen wet or damp material that may stick to it. The vibration helps to release a steady flow of cargo. If not used properly or used with very moist cargo, the vibrators can compact the material in the hold and make unloading more difficult. Figure 8 is an example of a vibrating mechanism that is installed on the underside of a cargo hold.

FIGURE 8
Example of a Cargo Hold Vibrator

### Watertight Gate Seal

The bottom of the cargo hold contains a gate that controls the flow from the hold to the conveyor belt during unloading. If the opening is not watertight, it can leak water and cargo slurry when the conveyor is started or run without cargo. Leakage from the cargo hold onto an empty conveyor can spill in the tunnel, because the conveyors are not designed to transport liquids. However, watertight gate seals, which are used in the Great Lakes, can reduce the amount of cargo that leaks out of the cargo hold during loading and unloading.

Watertight gate seals are used in the Great Lakes shipping fleet. The seal can be an inflatable bladder that seals a gate and cargo hold opening when the gate is closed. Figure 9 shows a simulation of a cargo hold opening with a gate seal.

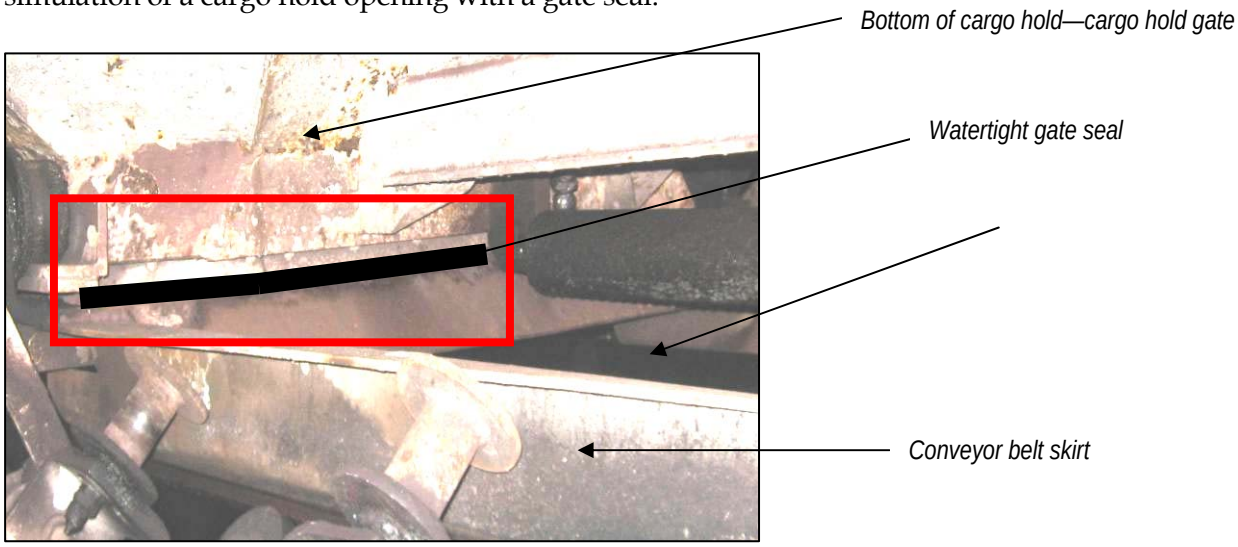


FIGURE 9
Example of a Cargo Hold with Watertight Gate Seal

## Cargo Hold Lining

The cargo holds of a ship may be coated with Teflon®, Tivar® (an ultra-high-molecular-weight plastic), or similar material to create a surface that minimizes the potential for cargo to stick to the side of the cargo hold. The coating promotes uniform unloading from the cargo hold and reduces spillage in the tunnel. Teflon has been used for hauling gypsum, but it can be damaged when loading taconite or limestone and is expensive. Loading limestone or taconite cargo in a lined cargo hold would require the material that is being loaded to be placed very close to the hold bottom initially and not down the sides of the hold, so that the free-falling material does not damage the lining. Tivar is a stronger and less expensive alternative.

## Fire Hose

Using a water mist to dislodge cargo from the sides of the hold can promote uniform unloading and minimize spillage in the cargo hold. Great Lakes ships employ this practice, but overuse may create additional tunnel spillage if the unloading conveyor is overloaded with water. Figure 10 is an example of a cargo ship worker using a fire hose during unloading.

## Structural DCR Control Measures Installed Shoreside

Shoreside DCR control measures also prevent DCR from spilling on the ship deck during loading operations. Several shoreside DCR control measures are similar to those used on the ship to reduce deck DCR during unloading operations:

- Enclosed conveyor
- Deck tarps
- Troughed (U-shaped) conveyor
- Conveyor skirts
- Belt scrapers
- Water/mist for dust control
- Conveyor capacity indicators
- Deck remote control of conveyors

FIGURE 10
Example of a Fire Hose Used to Achieve Uniform Cargo Unloading

Control measures for preventing and capturing DCR that are specific to shoreside loading facilities include the following:

- Plowfeeder
- Loading chute, including telescoping loading chute
- Chemical surfactants
- Suctioned/pumped cargo, slurry transport, and pneumatic or screw conveyors

### Plowfeeder

A plowfeeder (Figure 11) can be attached to the end of the conveyor belt and loading arm. It directs cargo from the end of the conveyor belt into the cargo hold instead of allowing the cargo to fall from the end of the belt. This allows for a more controlled stream of cargo and less spillage on the deck.

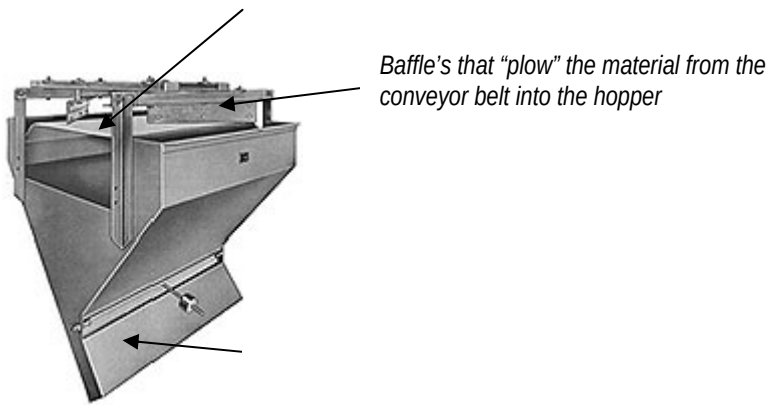


FIGURE 11
Plowfeeder
*Image courtesy of Deister Concentrator, LLC. Used with permission.*

## Loading Chute

Current operating practice at many loading facilities is to have a conveyor belt discharge directly into the cargo hold of the ship. The stream of cargo discharging from the conveyor falls by gravity in a wide flow stream into the hold. Installing a loading chute would enclose cargo from the conveyor belt and direct it into the cargo hold, reducing the potential for spillage on the deck. Loading chutes are used for loading grain and in conveyor systems outside of the shipping industry. They can include internal baffling to further control the conveyor discharge. Figure 12 is enhanced to show how a loading chute could be used at a shoreside facility during loading.

Telescoping loading (trimming) chutes are a type of loading chute installed in a shoreside cargo loading system to minimize the amount of cargo that spills on the deck of the ship. The chute, which may be articulated, moves in and out, directing cargo into specific areas in the cargo hold. It can be positioned below the top of the hold to minimize spillage on the deck surface. Figure 13 shows a telescoping chute at a coal-loading operation with the discharge point positioned below the ship deck. Telescoping loading chutes may include a gate that closes while the ship or loading conveyor repositions over each cargo hold, minimizing spillage between the cargo holds.

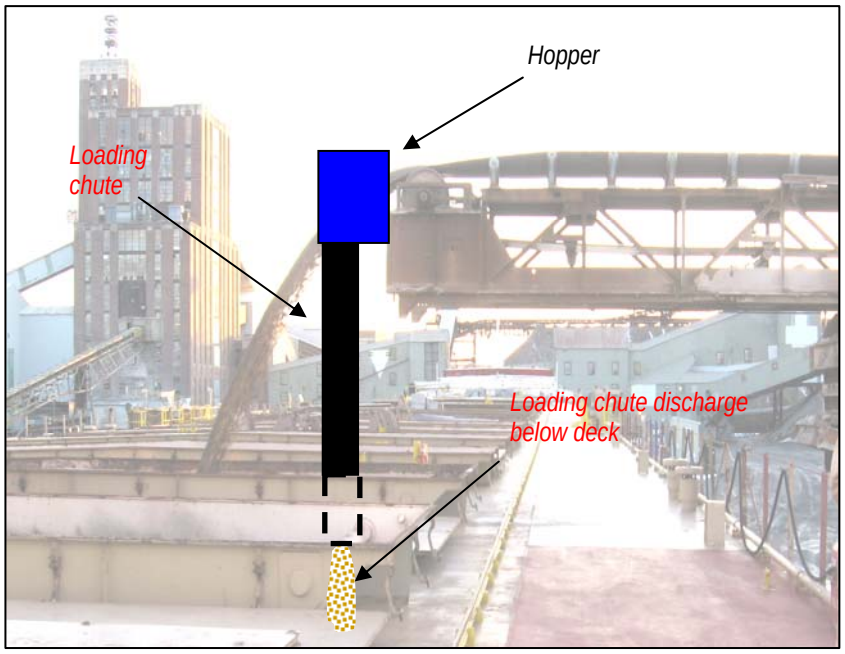


FIGURE 12
Loading Chute on the End of a Conveyor Belt

## Chemical Surfactants

A chemical surfactant may be added to the cargo at the shoreside facility to reduce DCR on the ship deck. The purpose is similar to that of a water spray: to bind fine particles and limit dust and windblown DCR. At least one Great Lakes coal port uses chemical surfactants to reduce DCR when coal is delivered to the shoreside facility by rail.

FIGURE 13
Example of a Telescoping Loading Chute

## Suctioned/Pumped Cargo, Slurry Transport, and Pneumatic or Screw Conveyors

Alternative measures for transporting cargo from the shoreside facility to the ship include suctioning or pumping the cargo, transporting the cargo as a slurry, or using pneumatic or screw conveyors. These techniques are used at some Great Lakes ports but typically for small or light particles, such as grain or

cement. They could be used more extensively to reduce DCR from the shoreside facility because they completely contain the cargo and do not expose it to weather conditions, such as wind, that disperse DCR or cause it to spill. Application of this technology may be used for taconite or coal. However, significant engineering modifications and increased operational maintenance may be required.

# Operational DCR Control Measures in Use

The operational DCR control measures discussed below are practiced in some capacity in the shipping industry—by ships to reduce deck or tunnel DCR discharge or by shoreside facilities to reduce spillage into the water or on the ship deck.

## Operational DCR Control Measures Practiced by Ships to Reduce Deck DCR

Operational DCR control measures are procedural methods or policies used to reduce DCR sweepings. They are implemented during cargo loading and unloading to minimize or prevent DCR from falling on the deck of the ship or into the water. The control measures described below do not necessarily require a ship to be retrofitted to be implemented; rather, they are procedural components of a ship's operation. Because loading and unloading operations can vary among ships, cargo types, and workers, operational control measures vary in effectiveness and degree of implementation.

The following operational control measures are used to reduce the likelihood of DCR falling on the deck:

- Starting/stopping cargo-loading conveyor when shifting between cargo holds
- Suspending loading/unloading during high winds
- Radio communication
- Crew and operator training
- Reducing vertical angle of conveyor boom

### Start/Stop Loading Conveyor

While the ship is being loaded, the conveyor or the ship may move to reposition the conveyor over each hatch. Stopping conveyors and then restarting them after they are repositioned over the hold reduces spillage on the ship deck. This practice is highly effective

at reducing deck DCR and can occur without causing additional wear on the loading conveyor system if the conveyor is emptied of cargo prior to being stopped.

### Suspend Loading/Unloading During High Winds

This practice delays loading and unloading cargo during high-wind conditions to minimize the amount of dust and small particles that becomes airborne and deposited on the ship deck. It can reduce DCR, but it can also delay ships from leaving port. During long periods of high winds, those delays and resulting backups at shoreside facilities could be significant.

### Radio Communication

Some loading operations do not allow the conveyor operator to see the entire cargo hold. Great Lakes ships with direct radio communication between the deck crew and the shoreside facility are better able to control loading and unloading, minimizing DCR spillage on the ship deck.

### Crew and Operator Training

Training the loading and unloading operator and ship crew can help to reduce the amount of DCR spilled on the deck. Training can be a reminder of procedures already in effect, or crews can be trained in the use of new policies and procedures.

### Reduce Vertical Angle of Conveyor Boom

The unloading conveyor boom can be raised vertically to allow offloading cargo to be transported to shoreside stockpiles of varying heights. When the unloading boom is raised at a steep angle, the cargo can fall backwards against the flow of cargo, which can result in DCR spillage from the side of the unloading conveyor boom. Limiting the vertical angle of the conveyor boom lessens the potential for cargo to spill.

## Operational DCR Control Measures Practiced by Ships to Reduce Tunnel DCR

Operational DCR control measures implemented during loading and unloading of cargo also minimize (or prevent) DCR from falling onto the floor of the tunnel of the ship. Operational control measures in addition to crew and operator training include the following:

- Limiting cargo hatch removal during poor weather
- Careful gate operation

### Limiting Hatch Removal during Poor Weather

Some ship operations remove all cargo hatch covers at one time when loading cargo. Under poor weather conditions, this allows precipitation to enter the cargo holds and possibly spill into the tunnel. Although some loading operations require multiple open hatches, by limiting the number of open cargo hatch covers during poor weather, ship operators can reduce the amount of rain and snow in the cargo holds.

### Careful Gate Operation

Cargo holds are emptied by opening a gate at the bottom of each hold and allowing cargo to fall through the opening to a conveyor belt below, in the tunnel. If the gates are operated improperly, too much cargo may fall and spill over onto the tunnel floor. Proper and careful operation of the gates minimizes the amount of DCR spilled in the tunnel.

## Operational DCR Control Measures Practiced Shoreside

Operational DCR control measures implemented at shoreside facilities to reduce DCR are similar to those implemented on ships to reduce deck DCR. Operational control measures in use shoreside include the following:

- Starting/stopping loading conveyor when shifting between cargo holds
- Suspending loading/unloading in high winds
- Radio communication
- Crew/operator training
- Reducing vertical angle of conveyor

# Structural DCR Control Measures Not Currently in Use

Structural DCR control measures in use at industrial or municipal facilities or in other applications have the potential to further reduce deck and tunnel DCR discharge from ships and to reduce spillage from shoreside facilities onto the ship deck. Structural control measures that were considered potentially applicable in the Great Lakes shipping industry are described below.

## Potential Ship Installed Structural DCR Control Measures to Reduce Deck DCR

Structural DCR control measures to minimize (or prevent) DCR from falling on to the deck of the ship during loading and unloading of cargo include the following:

- Mechanical sweeper
- Small sweeper/vacuum
- Coaming and deck sump with storage
- Folded or circular conveyor

### Mechanical Sweeper

A mechanical sweeper could be used to collect DCR that has fallen on the ship deck after loading or unloading. Several manufacturers produce sweepers that might have shipboard use, but ship safety requirements and equipment permanently stored on the deck surface may limit the area where sweepers could be used. For example, some cargo ships have rails along the cargo hatches that run the length of the ship. The rails are elevated about 4 to 6 inches above the deck and, depending on the available space, could prevent the mechanical sweeper from accessing the area between the rails. Environmental conditions such as moisture and ship motion further limit the potential usefulness of a mechanical sweeper on the ship deck.

### Small Sweeper or Vacuum

An industrial grade sweeper or a vacuum of the type more commonly used to collect sawdust, yard debris (pine cones, leaves), or other industrial or residential materials could access more areas of the ship deck than a traditional mechanical sweeper and therefore could collect more DCR spillage. The small sweeper might be safer because it is manually pushed, whereas the mechanical sweeper is driven.

### Coamings and Deck Sump with Storage

Coamings—vertical surfaces on the ship deck—could be installed to collect water and swept material in a deck sump. The deck sump could include a pump that would transfer swept material, which could total more than 10,000 gallons, to a storage tank. This control measure would require shoreside support to receive the discharge from the deck sump or yet another measure to remove the solids from the sump water.

### Folded or Circular Conveyor

A folded or circular conveyor is similar to a troughed conveyor, with the addition of support rollers that "fold" the conveyor belt into a circular shape to enclose cargo completely within the conveyor belt. The folded and circular conveyors are used in conveyor systems outside of the shipping industry. They minimize dust to a greater extent than troughed conveyors but would require significant retrofitting of ships and shoreside facilities. The circular conveyors could provide highly effective DCR control along the length of the conveyor belt, but may require additional controls at transfer points and discharge locations similar to conventional troughed conveyors.

## Potential Ship Installed Structural DCR Control Measures to Reduce Tunnel DCR

Several structural DCR control measures have the potential to minimize (or prevent) DCR from spilling in the tunnel of the ship during loading and unloading of cargo. The folded or circular conveyors discussed above also can reduce DCR in the tunnel. Other potential control measures to remove tunnel DCR include the following:

- Centrifuge
- High-rate treatment
- Filter media
- Geotextile filter bags

### Centrifuge

A centrifuge (or hydrocyclone) is a mechanical device that separates solids from water. The centrifuges are specifically designed to target certain specific gravities of particles ranging from small to gravel-sized particles. The centrifuge would remove solids from the tunnel washwater, and the water would be discharged overboard. If the solids were of a suitable material, they could be returned to the cargo hold. Otherwise, they could be disposed of at a shoreside facility. Returning the material to the cargo hold may not be possible for an extended period of time because some ships haul many types of cargo. Installing a centrifuge on each ship would require plumbing modifications to allow tunnel pumps to route tunnel washwater to the centrifuge and could require prescreening of coarse materials. Multiple centrifuges may be required based on different cargoes with different specific gravities.

### High-Rate Treatment

High-rate treatment is another process that could be used to separate solids from tunnel washwater. The process typically requires polymer addition with rapid mixing, flocculation, and settling basins. High-rate treatment has been used for municipal wastewater treatment but would require significant space and retrofitting for use on ships or at shoreside facilities.

### Filter Media

A filter media control measure would include a storage vault with internal filtering capacity, such as sand filters. Tunnel water would be pumped to a storage vault on the ship or at a shoreside facility. This measure would require retrofitting tunnel pump plumbing and could require significant storage space on the ship deck.

### Geotextile Filter Bags

Geotextile filter bags have been used to dredge lakes, rivers, marinas, lagoons, and wastewater treatment plant digesters. Solids and water are pumped to a filter bag, where polymer is typically added to increase the separation efficiency of the water and solids. The solids are retained in the bag, and the water filters through it for discharge overboard. A polymer system and shoreside support may be required to dispose of bags. The geotextile bags also would require space on the ship deck while in operation. This BMP would require modification to the tunnel pump plumbing to route tunnel washwater to the geotextile bags.

## Potential Shoreside Installed Structural DCR Control Measures

A clamshell bucket seal is a structural BMP that could be used shoreside during loading of cargo to minimize or prevent DCR from falling onto the deck of the ship.

### Clamshell Bucket Seal

Clamshell buckets are used by shoreside facilities for loading and unloading operations, though  older buckets may not have a tight seal to prevent spillage when loading or unloading. If the joint between the bucket halves is not tight, material can fall through the joint. A seal on the clamshell bucket could reduce spillage.

# Operational DCR Control Measures Not Currently in Use

Operational DCR control measures not used in the shipping industry have the potential to further reduce deck and tunnel DCR discharge from ships, and reduce spillage from the shoreside facilities on the ship deck.

## Potential Ship-Practiced Operational DCR Control Measures

Two operational DCR control measures that could be implemented on the ship during loading and unloading of cargo to prevent DCR from falling on to the deck of the ship are the following:

- Maximum cargo fill height below deck
- Develop DCR management plan

### Maximum Cargo Fill Height below Deck

During loading, cargo holds may be "topped off" by filling them above the deck elevation to the top of the hatch. The top of the hatch is roughly 2 feet above the deck elevation. As seen in Figure 14, operators can spill cargo on the deck while trying to top off the cargo hold. This DCR control measure would restrict the maximum fill height of each cargo hold to an elevation below deck and reduce the amount of material spilled.

FIGURE 14
Example of Cargo Spilled by "Topping Off"

### DCR Management Plan

A DCR management plan for each ship would include policies and procedures to minimize the amount of DCR generated during loading and unloading activities. The plan would include features similar to those of a stormwater pollution prevention plan and could consider the shoreside conveyor as a DCR source. Policies and procedures to prevent malfunctions and a dust control plan also could be included.

### Potential Shoreside-Practiced Operational DCR Control Measures

A DCR management plan similar to the ship plan for deck and tunnel DCR can be used for shoreside facilities. The following two operational DCR control measures can be used to reduce DCR generated by the shoreside facility:

- Prevent overfilling of clamshell bucket
- Loading discharge point below the deck

#### Prevent Overfilling of Clamshell Bucket

Clamshell buckets are sometimes used for loading and unloading of cargo. These buckets may spill cargo when the bucket is overfilled. Therefore, using care not to overfill clamshell buckets will reduce DCR spillage generated by the shoreside facility.

#### Loading Discharge Point below the Deck

This control measure requires the discharge point from the loading operation to discharge below the ship deck elevation. Discharging cargo below deck into the cargo hold reduces the potential spillage on the deck. This concept is demonstrated in Figure 15 using a loading chute.

FIGURE 15
Example of Cargo Loading Directly into the Cargo Hold with the Discharge Below the Deck Elevation

## Evaluation Criteria

### Methodology

After the range of DCR control measures used in the shipping industry, or in other industries and with the potential to be adopted by the shipping industry, were identified, they were evaluated to assess those most suitable for the control of DCR. Those control measures ranking highest were selected for inclusion in the Proposed Action with DCR Control Measures on Ships alternative and the Proposed Action with Shoreside DCR Control Measures alternative.

The evaluation was conducted as a two-step process. In the first step, DCR control measures were screened to evaluate their consistency with the Purpose and Need of the Proposed Action (Chapter 1) and strategic goals. Control measures were not eliminated after the initial screening, but were evaluated in more detail thereafter to determine the applicability, efficiency, and effectiveness of the DCR control measure to reduce ship DCR. Effectiveness was based on observation and best engineering judgment. Whether the control measure required additional time in port also was considered as a measure of potential economic effects.

In the first phase of the assessment, each DCR control measure was evaluated semi-quantitatively against the following screening criteria to determine its feasibility to

- Regulate within existing Coast Guard structure and resources
- Regulate without requiring additional time at port
- Regulate without threatening shipping safety
- Avoid energy use resulting in little or no reduction in DCR discharge
- Use proven technology

The first criterion, regulate within existing Coast Guard structure and resources, means that DCR control measure implementation will not require additional Coast Guard staffing or significant resource alignment to implement or monitor a control measure. The second criterion eliminates control measures that require significantly more time at port, because of the associated increase in cost. The third criterion, regulate without threatening safety, means that the control measure will not endanger or threaten the safety of shoreside crews, ship crews, or other waterborne transport. The fourth criterion avoids energy consumptive alternatives with limited benefit, and the last criterion, use proven technology, requires that a control measure be proven in some application, not necessarily in the shipping industry, but viable for shipboard use.

In the second phase of the assessment, control measures were evaluated for their effectiveness and the conditions under which they could be implemented. The more detailed assessment was conducted using the following evaluative criteria:

- Effectively minimize DCR discharge

- Operate without specialized equipment or training
- Function in adverse weather conditions
- Apply to most particle sizes and cargo types
- Operate without additional shoreside support
- Be used at port and in transit

The criterion "effectively minimize DCR discharge" was estimated as high, medium, or low, because of the limited availability of data to quantify measures of DCR reduction or removal efficiencies. Observation and best engineering judgment were the basis for the high, medium, or low determination.

The criterion "operate without specialized equipment or training" was used to distinguish between control measures that rely on standard equipment or practices and those not commonly used in the shipping industry (centrifuges, high-rate treatment) or those requiring specialized training.

The criterion "function in adverse weather" describes control measures that would be expected to function during an average range of weather conditions, including rainfall. Control measures that would not function well in adverse weather conditions are those affected by high winds.

The criterion "apply to all particle sizes and cargo types" is a measure of versatility of the measure to be used with the variety of cargoes transported on the Great Lakes.

The criterion "operate without additional shoreside support" pertains to control measures that could operate without additional staff, equipment, or infrastructure.

Control measures also were characterized in terms of whether they reduce tunnel or deck DCR sources, prevent or capture DCR, and whether they are used at port, in transit, or both. This information was used to ensure that control measures included in the alternatives addressed deck and tunnel sources of DCR, and included measures to capture DCR deposition that was not prevented by other control measures.

Industrywide capital, operational, and maintenance costs to implement DCR control measures were not considered at this stage, although cost considerations were built into some of the criteria (e.g., regulate without requiring additional time in port, operate without

specialized equipment or training, operate without additional shoreside support). Industrywide costs associated with implementing alternatives requiring control measures will be addressed during the impact evaluation.

### Evaluation

Table 1 summarizes the Phase 1 and 2 evaluations of structural and operational DCR control measures in use in the shipping industry. Table 2 summarizes the Phase 1 and 2 evaluations of structural and operational control measures used in other applications with the potential to be applied to the shipping industry.

By definition, the control measures voluntarily in use (Table 1) meet all of the Phase 1 criteria. They would not be used if they required additional time at port, threatened safety, or required energy use (had a cost associated with them) without the benefit of reducing DCR discharges. Because they are in use, they may be considered a proven technology.

When control measures potentially applicable to the shipping industry (Table 2) were evaluated against the Phase 1 criteria, several control measures did not meet some of the criteria. For example, mechanical sweeping, coamings, and using filter media did not meet several of the Phase 1 criteria. However, a Phase 2 evaluation was performed to provide a more complete understanding of the potential advantages and disadvantages of the control measures. Other control measures, such as limiting hatch removal during poor weather, met the Phase 1 criteria but received a low effectiveness rating and compared unfavorably with control measures such as enclosing the conveyor belt, which is highly effective at reducing DCR.

## Categories of DCR Control Measures

After the Phase 1 and 2 evaluations were completed, DCR control measures were further categorized to identify those with the highest rank, which would be included as elements of Proposed Action with DCR Control Measures on Ships alternative or the Proposed Action with Shoreside DCR Control Measures alternative. For a control measure to be included in one of the alternatives, it must satisfy all Phase 1 and 2 criteria and have a medium or high rating for effectively minimizing DCR discharges (Category 1).

Category 1 control measures are practiced in some capacity on U.S. flag vessels, effectively control DCR for most cargo types, and are compatible with current shipping practices. Control measures were excluded from Category 1 if they would require major ship modifications or require significant shoreside support. Category 2 DCR control measures are in use and provide only medium- or low-level DCR control or are not in broad use but could be economically implemented to provide a high level of DCR control. Category 3 control measures are not in use in the shipping industry and would require significant modifications to ships or significant shoreside support. Table 3 summarizes the evaluation process and identifies Category 1 control measures, many of which are included in the alternatives to be evaluated in more detail in Chapter 2. As described previously, not all Category 1 control measures were included in the Proposed Action with DCR Control Measures on Ships alternative or the Proposed Action with Shoreside DCR Control Measures alternative. Despite their effectiveness, Category 1 control measures may not have been included in alternatives selected for further evaluation if they were duplicating the control provided by other measures or if they prescribed an implementation approach (e.g., a management plan), rather than a control measure.

# References

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TABLE 1

Evaluation of DCR Control Measures in Use in Shipping Industry

| DCR Controls | Description of Control Measure | Ship-Implemented Measures | | Shoreside Control Measures | Category | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather Conditions | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| **Structural Control Measures in Use** | | | | | | | | | | | | | | | |
| Enclosed conveyor | Covers installed on the loading or unloading conveyors to prevent spillage | | X | X | X | | | High | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Deck tarps | Collects spilled cargo that may fall on the deck or between the ship and the shore side facility. May also be installed on the loading or unloading conveyors to prevent spillage. Used in small areas of high spillage. | | X | X | X | | | High | Yes | No | Yes | Yes | Port | C | Minimal |
| Troughed (U-shaped) conveyor | Conveyor belts for moving dry cargo that are 'U shaped to minimize spillage from the sides | X | X | X | X | | | High | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Conveyor skirts | Skirts installed at gate openings, along the length of conveyor belts, or at the bottom of cargo holds to reduce DCR from falling over the side of the conveyor | X | X | X | X | | | High | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Belt scrapers | Metal or synthetic scrapers that rub against the conveyor belts to dislodge cargo that may be stuck on the conveyor belt | X | X | X | X | | | High | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Water/mist for dust control | Water or chemical misters that sprays cargo during loading or unloading to minimize the amount of dust that is produced | X | X | X | X | | | Low | No | Yes | No | Yes | Port | P | To be determined for impact evaluation |
| Broom and shovel | Collect spilled material using brooms and/or shovels | X | X | | X | | | High | Yes | No | Yes | Yes | Both | C | Minimal |

TABLE 1

Evaluation of DCR Control Measures in Use in Shipping Industry

| DCR Controls | Description of Control Measure | Ship-Implemented Measures | | Shoreside Control Measures | Category | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather Conditions | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| Conveyor capacity indicators | Lighting system on conveyors allows operators to accurately adjust cargo loading to conveyor belt capacity. | X | X | X | | X | | Medium | No | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Remote controls of conveyors | Remote control of the conveyors through programmable logic controls provide more control of the loading and unloading operation by the deck crew | | X | X | | X | | Medium | No | Yes | Yes | No | Port | P | — |
| **Structural Control Measures in Use (Continued)** | | | | | | | | | | | | | | | |
| Cargo hold vibrator | Vibrator mounted to the underside of the cargo hold to help with the steady flow of cargo from the cargo hold. | X | | | X | | | Medium | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Watertight gate seal | Water tight seal at the gate at the bottom of the cargo hold that reduces DCR that may leak through the cargo hold gate during loading and unloading of cargo. | X | | | | X | | Low | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Cargo hold lining | Liner on the inside of the cargo hold to prevent cargo from sticking to the cargo holds. | X | | | | X | | Low | No | Yes | No | Yes | Port | P | — |
| Fire hose | Water spray to dislodge stuck cargo to promote uniform cargo unloading from the cargo hold. | X | | | X | | | Low | Yes | Yes | Yes | Yes | Port | P | Minimal |
| Plowfeeder | Located at the end of a conveyor, it accurately directs the cargo from the conveyor into the cargo hold. | | | X | | | | Medium | Yes | Yes | Yes | No | Port | P | To be determined for impact evaluation |

TABLE 1

Evaluation of DCR Control Measures in Use in Shipping Industry

| DCR Controls | Description of Control Measure | Ship-Implemented Measures | | Shoreside Control Measures | Category | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather Conditions | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| Loading Chute | A device or enclosure at the end of a conveyor belt that directs cargo into the hold and reduces the potential for wind drift and spillage; includes telescoping loading chutes. | | | X | | X | | High | Yes | Yes | Yes | Yes | Port | P | To be determined for impact evaluation |
| Chemical surfactants | Chemical addition of surfactants in material stock piles to minimize the amount of dust that is produced. | | | X | | X | | Low | No | Yes | Yes | No | Port | P | — |
| Suctioned/ pumped cargo, slurry transport, pneumatic or screw conveyors | Alternative methods of cargo loading through pumping or screw devices. | | | X | | X | | High | No | Yes | No | N/A | Port | P | To be determined for impact evaluation |
| **Operational Control Measures in Use** | | | | | | | | | | | | | | | |
| Start/stop loading conveyor | Start/stop loading conveyor belt while the ship, conveyor belt, or other equipment is repositioned. | | X | X | X | | | High | Yes | Yes | Yes | Yes | Port | P | No equipment cost (see note 1) |
| Suspend loading/ unloading during "high" winds | Stop loading or unloading operations during high winds to prevent wind blown DCR. | | X | X | X | | | Medium | Yes | Yes | Yes | Yes | Port | P | No equipment cost (see note 1) |
| Radio communication | Radio communication between the deck crew and the loading operator. | | X | X | X | | | Low | Yes | Yes | Yes | Yes | Port | P | Part of existing operation |
| Crew/operator training | Provide crew and operator with additional information, policies and procedures to reduce DCR. | X | X | X | X | | | High | Yes | Yes | Yes | Yes | Both | P | No additional cost as training already required |
| Reduce vertical angle of conveyor booms | Reducing the vertical angle of the conveyor belt will minimize spilled material. | | X | X | | X | | Low | Yes | Yes | Yes | Yes | Port | P | No cost (see note 1) |

TABLE 1

Evaluation of DCR Control Measures in Use in Shipping Industry

| DCR Controls | Description of Control Measure | Ship-Implemented Measures | | Shoreside Control Measures | Category | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather Conditions | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| Limit hatch removal during poor weather | Limit the number of cargo hold hatches that are removed during loading to minimize precipitation entering the cargo hold. | X | | | | X | | Low | Yes | Yes | Yes | Yes | Port | P | No cost |
| Careful gate operation | Carefully control the cargo gates during unloading and limit flow as necessary so that the cargo is unloaded in a steady stream. | X | | | X | | | High | Yes | Yes | Yes | Yes | Port | P | No cost--part of crew/operator training |

*Note:*

1. The DCR control measure may not have an associated cost. However implementing the measure may "cost" the ship or shoreside facility money by delaying loading or unloading, ultimately reducing the efficiency of the cargo movements.

TABLE 2
Evaluation of Potential DCR Control Measures

| | | Ship Implemented BMPs | | | Category | | | Phase 1 Evaluation | | | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DCR Controls | Control Measure Description | Tunnel DCR | Deck DCR | Shoreside DCR Control Measures | 1 | 2 | 3 | Regulate Within Existing Coast Guard Structure & Resources | Regulate without Requiring Additional Time at Port | Regulate without Threatening Shipping Safety | Avoid Energy Use Resulting in Little or No Reduction in DCR Discharge | Uses Proven Technology | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| **Potential Structural DCR Control** | | | | | | | | | | | | | | | | | | | | |
| Mechanical sweeper | Small motorized street sweeper used to collect deck DCR. | | X | | | | X | Yes | No | No | Yes | Yes | Medium | No | No | No | Yes | Port | C | To Be Determined For Impact Evaluation |
| Small sweeper/ Vacuum | Industrial walk-behind sweeper or vacuum. | | X | | | | X | Yes | Yes | No | Yes | Yes | Medium | No | No | Yes | Yes | Port | C | To Be Determined For Impact Evaluation |
| Coamings (and/or sump) and deck sump with storage | Ribbings on the deck to direct wash water to a sump pump located on the deck. | | X | | | | X | Yes | No | No | Yes | No | Medium | Yes | No | Yes | Yes | Both | C | — |
| Centrifuge | Mechanical device to will separate solids from water. | X | | | | | X | Yes | No | Yes | Yes | Yes | Medium | No | Yes | Yes | Yes | Both | C | — |
| High rate treatment | Series of mechanical devices that will separate solids from water and provide additional treatment to DCR slurry. | X | | | | | X | Yes | No | No | Yes | Yes | High | No | Yes | Yes | Yes | Both | C | — |
| Filter media | Filter media such as sand filters to separate solids from water. | X | | | | | X | Yes | No | No | Yes | Yes | High | No | Yes | Yes | Yes | Both | C | — |
| Geotextile filter bags | Geotextile "tubes" that retain solids in the tube while allowing water to pass through the tube. | X | | | | | X | Yes | No | No | Yes | Yes | Medium | No | Yes | No | No | Both | C | — |
| Folded or circular conveyor | Conveyor belt that is "folded" into a circular shape by the support rollers to completely enclose the material by the conveyor belt. | X | X | X | | X | | Yes | No | Yes | Yes | Yes | High | Yes | Yes | Yes | Yes | Port | P | — |
| Clamshell bucket seal | Seal between the clamshell bucket openings. | | | X | | X | | Yes | Yes | Yes | Yes | Yes | Medium | Yes | Yes | Yes | Yes | Port | P | — |

TABLE 2
Evaluation of Potential DCR Control Measures

| | | Ship Implemented BMPs | | | Category | | | Phase 1 Evaluation | | | | | Phase 2 Evaluation | | | | | Other Considerations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DCR Controls | Control Measure Description | Tunnel DCR | Deck DCR | Shoreside DCR Control Measures | 1 | 2 | 3 | Regulate Within Existing Coast Guard Structure & Resources | Regulate without Requiring Additional Time at Port | Regulate without Threatening Shipping Safety | Avoid Energy Use Resulting in Little or No Reduction in DCR Discharge | Uses Proven Technology | Effectively Minimize DCR Discharge | Operate without Specialized Equipment or Training | Function in Adverse Weather | Apply to Most Particle Sizes and Cargo Types | Operate without Additional Shoreside Support | Use at Port and in Transit | Prevention (P) or Capture (C) | Cost |
| **Potential Operational DCR Control** | | | | | | | | | | | | | | | | | | | | |
| Maximum cargo fill height below deck | Stop filling the cargo hold when the top of the cargo is at or below the deck elevation. | | X | | X | | | Yes | Yes | Yes | Yes | Yes | High | Yes | Yes | Yes | Yes | Port | P | No cost (see note 2) |
| DCR Management Plan | Each ship develop a management plan for DCR control that would provide policies and procedures to reduce DCR and implement control measures. | X | X | X | X | | | Yes | Yes | Yes | Yes | Yes | High | Yes | Yes | Yes | Yes | Both | P/C | Minimal |
| Prevent overfilling of clamshell bucket | Preventing overfilling will reduce DCR spillage. | | | X | X | | | Yes | Yes | Yes | Yes | Yes | High | Yes | Yes | Yes | N/A | Port | P | No cost (see note 1). Loading completed predominantly by conveyors. |
| Loading discharge point below the deck | Discharge point of loading conveyor/chute below the deck, as close as reasonably possible to the top of the cargo. | | | X | X | | | Yes | Yes | Yes | Yes | Yes | High | Yes | Yes | Yes | Yes | Port | P | No cost (see note 3) |

*Note:*

1. The DCR control measure may not have an associated cost. However implementing the control measure may "cost" the ship or shoreside facility money by delaying loading or unloading, ultimately reducing the efficiency of the cargo movements.

2. Limiting filling to the area below the deck may reduce the quantity of cargo transferred, but it is not expect to be significant as it may only apply to coal.

3. Shoreside facilities that have the ability to discharge below the deck will not have an additional cost. If a shoreside facility requires retrofit to discharge cargo below the ship deck elevation, a cost similar to the "Loading Chute" control measure could be expected.

**TABLE 3**
DCR Control Measures and Category Designations

| Control Measure | Description | Ship-Implemented DCR Control Measures | | Shoreside Control DCR Control Measures | Category | | |
|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 |
| **Structural DCR Control Measures in Use** | | | | | | | |
| Enclosed conveyor | Covers installed on the loading or unloading conveyors prevent spillage | | x | x | x | | |
| Deck tarps | Collects spilled cargo that may fall on the deck or between the ship and the shore side facility. May be installed on the loading or unloading conveyors to prevent spillage | | x | x | x | | |
| Troughed (U-shaped) conveyor | Conveyor belts for moving dry cargo that are U-shaped to minimize spillage from the sides | x | x | x | x | | |
| Conveyor skirts | Skirts installed at gate openings, along the length of conveyor belts, or at the bottom of cargo holds to reduce DCR from falling over the side of the conveyor | x | x | x | x | | |
| Belt scrapers | Metal or synthetic scrapers that rub against the conveyor belts to dislodge cargo that may be stuck on the conveyor belt | x | x | x | x | | |
| Water/mist for dust control | Water or chemical misters that spray cargo during loading or unloading to minimize the amount of dust produced | x | x | x | x | | |
| Broom and shovel | Collect spilled material using brooms or shovels | x | x | | x | | |
| Conveyor capacity indicators | Lighting system on conveyors allows operators to accurately adjust cargo loading to conveyor belt capacity | x | x | x | | x | |
| Deck remote controls of conveyors | Remote control of the conveyors through programmable logic controls provide more control of the loading and unloading operation by the deck crew | | x | x | | x | |
| Cargo hold vibrator | Vibrator mounted to the underside of the cargo hold to help with the steady flow of cargo from the cargo hold | x | | | x | | |

**TABLE 3**
DCR Control Measures and Category Designations

| Control Measure | Description | Ship-Implemented DCR Control Measures | | Shoreside Control DCR Control Measures | Category | | |
|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 |
| Watertight gate seal | Watertight seal at the gate at the bottom at the bottom of the cargo hold which reduces DCR that may leak through the cargo hold gate during loading and unloading of cargo | x | | | | x | |
| Cargo hold lining | Coating on the inside of the cargo holds to prevent cargo from sticking to them | x | | | | x | |
| Fire hose | Water spray to dislodge stuck cargo to promote uniform cargo unloading from the cargo hold | x | | | x | | |
| Plowfeeder | Located at the end of a conveyor, it accurately directs the cargo from the conveyor into the cargo hold | | | x | | x | |
| Loading chutes, including telescoping | A conveyor or chute that can move in and out to direct cargo from the conveyor into the cargo hold | | | x | x | x | |
| Chemical surfactants | Chemical addition of surfactants in material stockpiles to minimize the amount of dust produced | | | x | | x | |
| Suctioned/pumped cargo, slurry transport, pneumatic or screw conveyors | Alternative methods of cargo loading through pumping or screw devices | | | x | | x | |
| **Operational DCR control measures in Use** | | | | | | | |
| Start/stop loading conveyor | Stop conveyor belt while the ship or the conveyor belt is repositioned | | x | x | x | | |
| Suspend loading/unloading during "high" winds | Stop loading or unloading operations during high winds to prevent wind blown DCR | | x | x | x | | |
| Radio communication | Radio communication between the deck crew and the loading operator | | x | x | x | | |
| Crew/operator training | Provide crew and operator with additional information, policies and procedures to reduce DCR | x | x | x | x | | |

**TABLE 3**
DCR Control Measures and Category Designations

| Control Measure | Description | Ship-Implemented DCR Control Measures | | Shoreside Control DCR Control Measures | Category | | |
|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 |
| Reduce vertical angle of conveyor booms | Reducing the vertical angle of the conveyor belt will minimize spilled material | | x | x | | x | |
| Limit hatch removal during poor weather | Limit the number of cargo hold hatches that are removed during loading to minimize precipitation entering the cargo hold | x | | | | x | |
| Careful gate operation | Carefully control the cargo gates during unloading so that the cargo is unloaded in a steady stream | x | | | x | | |
| **Potential Structural DCR Control Measures** | | | | | | | |
| Mechanical sweeper | Small motorized mechanical sweeper that collects deck DCR. | | x | | | | x |
| Small sweeper / vacuum | Industrial walk-behind sweeper or vacuum. | | x | | | | x |
| Coamings (or sump) and deck sump with storage | Ribbings on deck direct washwater to a sump pump located on the deck. | | x | | | | x |
| Centrifuge | Mechanical device separates solids from water. | x | | | | | x |
| High-rate treatment | Series of mechanical devices that separate solids from water and provide additional treatment to DCR slurry | x | | | | | x |
| Filter media | Filter media, such as sand, separates solids from water | x | | | | | x |
| Geotextile filter bags | Geotextile "tubes" retain solids in the tube while allowing water to pass through | x | | | | | x |
| Loading chute | Install a device at the end of a conveyor belt to direct cargo from the conveyor belt into the cargo hatch | | | x | | x | |
| Folded or circular conveyor | Conveyor belt that is “folded” in a circular shape by the support rollers to completely enclose the material in the conveyor belt | x | x | x | | x | |
| Clamshell bucket seal | Install seal between the clamshell bucket openings | | | x | | x | |

**TABLE 3**
DCR Control Measures and Category Designations

| Control Measure | Description | Ship-Implemented DCR Control Measures | | Shoreside Control DCR Control Measures | Category | | |
|---|---|---|---|---|---|---|---|
| | | Tunnel DCR | Deck DCR | | 1 | 2 | 3 |
| **Potential Operational DCR Control Measures** | | | | | | | |
| Maximum cargo fill height below deck | Stop filling the cargo hold when the top of the cargo is at or below the deck elevation | | x | | x | | |
| DCR management plan | Each ship develops a management plan for DCR control that would provide policies and procedures to reduce DCR and implement control measures | x | x | x | x | | |
| Prevention of overfilling of clamshell bucket | Preventing overfilling will reduce DCR spillage | | | x | x | | |
| Loading discharge point below the deck | Discharge point of loading conveyor/chute below the deck, as close as reasonably possible to the top of the cargo | | | x | x | | |