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**R&D for the Storage, Transport, and Handling
of Coal-Based Fuels**

**Quarterly Progress Report
for
April 1, 1990 - June 30, 1990**

Customer Order No.

DE-AC22-89PC89797

Westinghouse Electric Corporation

Advanced Energy Systems

P.O. Box 10864

Pittsburgh, PA 15236-0864

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TABLE OF CONTENTS

	<u>Page No.</u>
1.0 Introduction	1-1
2.0 Summary	2-1
3.0 Technical Discussion	3-1
3.1 Task 1: Project Control	3-1
3.1.1 Objective	3-1
3.1.2 Technical Status	3-1
3.2 Task 2: Acquisition of Dry, Ultrafine Coal	3-1
3.2.1 Objective	3-1
3.2.2 Technical Status	3-1
3.3 Task 3: Storage Systems	3-2
3.3.1 Subtask 3.1: Residential Storage Tank Testing	3-2
3.3.1.1 Objective	3-2
3.3.1.2 Technical Status	3-2
3.3.2 Subtask 3.2: Industrial/Commercial Storage System	3-4
3.3.2.1 Objective	3-4
3.3.2.2 Technical Status	3-4
3.3.3 Explosive Oxygen Limits	*
3.3.3.1 Objective	
3.3.3.2 Technical Status	
3.3.4 Explosion Prevention	*
3.3.4.1 Objective	
3.3.4.2 Technical Status	

TABLE OF CONTENTS (Cont'd.)

	<u>Page No.</u>
3.4 Task 4: Transportation	3-4
3.4.1 Subtask 4.1: Protective Systems for Short Distance DUC	*
3.4.1.1 Objective	
3.4.1.2 Technical Status	
3.4.2 Subtask 4.2: Modifications to Existing Systems for Transporting DUC	3-4
3.4.2.1 Objectives	3-4
3.4.2.2 Technical Status	3-5
3.4.3 Subtask 4.3: Advanced Transport Systems	3-22
3.4.3.1 Objective	3-22
3.4.3.2 Technical Status	3-22
3.5 Task 5: Handling	3-24
3.5.1 Subtask 5.1: Characterization of DUC	3-24
3.5.1.1 Objective	3-24
3.5.1.2 Technical Status	3-24
3.5.2 Subtask 5.2: Additives to Enhance Flowability of DUC	3-30
3.5.2.1 Objective	3-30
3.5.2.2 Technical Status	3-32
3.5.3 Subtask 5.3: Control Circuit	*
3.5.3.1 Objective	
3.5.3.2 Technical Status	

TABLE OF CONTENTS (Cont'd.)

	<u>Page No.</u>
3.5.4 Subtask 5.4: Pneumatic Testing	3-32
3.5.4.1 Objective	3-32
3.5.4.2 Technical Status	3-32
3.5.5 Subtask 5.5: Feeder Development	3-33
3.5.5.1 Objective	3-33
3.5.5.2 Technical Status	3-33
3.6 Task 6: Systems Engineering	*
3.6.1 Subtask 6.1: Systems Engineering	*
3.6.1.1 Objective	
3.6.1.2 Technical Status	
3.6.2 Subtask 6.2: Economic Analyses	*
3.6.2.1 Objective	
3.6.2.2 Technical Status	

*These tasks were not active
during this reporting period

LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
1	Schematic Diagram of Residential Storage System Test	3-3
2	Thermal Ignitability Limits for Pittsburgh Coal Dust (from Conti et al, Ref. 4)	3-7
3	Electrical Ignitability Limits for Pittsburgh Coal Dust (from Conti et al, Ref. 4)	3-8
4	Effect of Particle Diameter on Lean Flammability Limits (from Hertzberg and Cashdollar, Ref. 6)	3-9
5	Effect of Particle Diameter on Lean Flammability Limits at Different Oxygen Concentrations (from Hertzberg and Cashdollar, Ref. 6)	3-10
6	Effect of Pressure on Lean Flammability Limits (from Hertzberg and Cashdollar, Ref. 6)	3-11
7	Typical Design of a Pressurized, Self-Discharging Tank Car	3-13
8	Cutaway View of Interior of Airslide Car	3-14
9	Sectional View of an Air-Activated, Gravity-Discharge Hopper Car	3-15
10	Schematic Piping Arrangement of Pressure-In-Transit Covered Hopper Car	3-17
11	Schematic Views of Air-Activated, Gravity-Discharge Hopper Van and Pressure Differential Tank Trailer	3-19
12	Tap/Bulk Density Ratios (Hausner Ratios) for Illinois #6 Coal Powder from Bechtel Process	3-27
13	Fluidization Pressure Drop Vs. Gas Velocity	3-29
14	Collapsing Bed Expt.	3-31
15	Setup for Pickup Velocity: Multiple Particles (1 m plug)	3-34
16	Dune Formation (glass beads: 450 μ m)	3-35
17	Experimental Results	3-36
18	A Schematic of Peristaltic Pump Feeder Arrangement	3-37

LIST OF TABLES

<u>Table No.</u>		<u>Page No.</u>
1	Characteristics of Coal Samples	3-2
2	Types of Rail Cars for Bulk Handling of Solid Materials	3-18
3	Types of Truck Trailers of Bulk Handling of Solid Materials	3-21

1.0 INTRODUCTION

This is the third Quarterly Report summarizing technical progress from April 1, 1990 to June 30, 1990 on the R&D for the Storage, Transport, and Handling of Coal-Based Fuels, Contract DE-AC22-89PC89797, sponsored by the U.S. Department of Energy, Pittsburgh Energy Technology Center. Westinghouse Advanced Energy Systems is the prime contractor for this project with assistance from the Westinghouse Science and Technology Center and the University of Pittsburgh as principal subcontractor.

The product of several advanced physical coal cleaning processes is a dry, ultrafine coal (DUC), in the order of 10 microns mean mass diameter. To utilize this fuel commercially, cost-effective, environmentally safe systems must be provided for the storage, transport, and handling of this finely divided form of fuel. The objective of the project described herein is the development of total logistics systems for DUC, including experimental verification of key features. The systems to be developed will provide for safe, economic, and environmentally protective storage and delivery of DUC for residential, commercial, and industrial uses.

2.0 SUMMARY

All of the test coals selected for this project have been received, including 10 lbs. of Illinois No. 6 cleaned by the LICADO process.

The test system for the Residential Storage Tank has been installed, including piping and the components required to recycle the ultrafine coal. Shakedown operation is scheduled for early in the next quarter.

The design of the scale model test of the Industrial/Commercial Storage System is nearly complete. Piping and supports for the porous fluidization plates in the floor of the tanks have been completed. Final drawings and specifications for procurement of the test components are in progress.

Fine coal is defined as a hazardous material by the U.S. Department of Transportation. Coal which has been ground to less than 100 mesh (90%) must be stored for six days after grinding prior to shipment or it must be shipped in sealed cars or containers. Ground coal which has been dried by heating must be shipped in hermetically sealed, metal-lined wooden boxes or airtight metal containers. Because of the data obtained on allowable dust concentrations (130 gm/m^3) and the maximum allowable oxygen concentrations (12 to 16%), it was concluded that the existing loading and unloading practice is not suitable to handling DUC. Both excessive dust is generated and this dust is exposed to air. Therefore, specialized gravity-discharge, hopper cars, or truck trailers are recommended for transporting DUC. Information was also obtained on container systems for transporting DUC.

Preliminary results with the Illinois No. 6 coal cleaned by the Bechtel heptane/asphalt process indicate that this material is cohesive and difficult to fluidize. The powder moved as a plug upon initial attempts at fluidization, but could be fluidized by cycling the gas flow.

Studies of dune formation have been made with the Illinois No. 6 coal. These data provide information on the minimum velocity which will transport the particles.

The peristaltic pump failed to pump the fine powder resulting from crushing the pellets of Illinois No. 6 coal produced by the Bechtel heptane/asphalt process. These fines would not flow out of the storage hopper into the pump. Fines from the Texaco gasifier were also tested. These free-flowing fines flowed from the hopper into the pump, but packed solidly in the flexible tube of the peristaltic pump. Further testing of the peristaltic pump will be deferred and emphasis will be placed upon testing the flexible wall feeder.

3.0 TECHNICAL DISCUSSION

Technical progress for each of the tasks which were active during this quarter is discussed in this section.

3.1 Task 1: Project Control (M. H. Cooper)

3.1.1 Objective

Project management, including technical direction and cost control will be accomplished in this task.

3.1.2 Technical Status

Monthly technical and management reports and the quarterly report for January-March were submitted to DOE.

A project meeting was held to review progress in all tasks and specifically to review the final design of the industrial storage test system. The design of this test was approved with minor changes, primarily the addition of additional instrumentation.

3.2 Task 2: Acquisition of Dry, Ultrafine Coal (M. H. Cooper)

3.2.1 Objective

The objective of this task is the acquisition of dry, ultrafine coal for use in this project.

3.2.2 Technical Status

All of the four test coals selected for this project have been received. Ten pounds of Illinois No. 6 cleaned by the LICADO process were received for use in the explosion tests. Table 1 summarizes the characteristics of these coals measured to date.

TABLE 1 CHARACTERISTICS OF COAL SAMPLES			
Sample	Moisture %	Ash %	d ₅₀ (Microns)
Upper Elkhorn	0.78	3.06	5.46
Wyodak	10.41	9.20	22.50
Illinois No. 6*	1.28	2.09	9.73

*Cleaned with the heptane/asphalt process by Bechtel

3.3 Task 3: Storage Systems

3.3.1 Subtask 3.1: Residential Storage Tank Testing (S. H. Chiang)

3.3.1.1 Objective

The objective of this subtask is the testing of a scale model of a storage tank for DUC for residential application. Tests will be performed to confirm satisfactory performance of operations and components of this tank, which includes: filling, discharge, bladder operation, and level detection.

3.3.1.2 Technical Status

During this quarter, the tank and associated hardware with the flow loop have been installed. Shakedown tests will be carried out during the next quarter. A final schematic of the tank and flow system is shown in Figure 1.

Continuous delivery from the storage system will be achieved by recycling the discharged coal pneumatically to a 55 gallon drum mounted above the storage tank. The coal will be periodically recharged into the storage tank by opening the pinch valve.

Figure 1. Schematic Diagram of Residential Storage System Test

3.3.2 Subtask 3.2: Industrial/Commercial Storage System (B. M. Woodle)

3.3.2.1 Objective

The objective of this subtask is the design and testing of a reduced scale model of an industrial storage system for dry, ultrafine coal. Tests will be performed to demonstrate satisfactory filling and discharge of this system.

3.3.2.2 Technical Status

Equipment for the industrial/commercial test assembly was designed. Additional drafting was performed on the test assembly layout drawing for the piping and the floor of the fluidization tanks. The floor structure was analyzed for the DUC loading and a design was selected to support the fluidizing screen. Commercially available structural steel grating will be used to support the screen. The grating will be installed in four quadrants and each quadrant will have a separate fluidizing screen.

Drawings of these tanks are being prepared in sufficient detail for vendors to respond with competitive quotations for these items.

3.4 Task 4: Transportation

3.4.2 Subtask 4.2: Modifications to Existing Systems for Transporting DUC

3.4.2.1 Objectives

Under this subtask, the existing transportation systems for coal will be surveyed and their applicability to transportation of dry, ultrafine coal (DUC) is evaluated and assessed. Necessary modifications to the existing systems will then be proposed. Existing transportation systems for various fine chemicals which have similar chemical characteristics as the DUC, such as sensitivity to oxidation, explosiveness, inflammability, and very small particle sizes, may be directly applicable to handling the DUC.

Those technologies will also be surveyed and evaluated.

3.4.2.2 Technical Status

The fine coal is classified as a hazardous material (flammable solid) in the Department of Transportation's Code of Federal Regulations, Title 49, Part 172, Section 172.101. The "hazardous material" is defined here as "a substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce". Specific transportation requirement is outlined in Section 173.165.

Section 173.165 Coal, ground bituminous, sea coal, coal facings.

(a) Coal, ground bituminous, sea coal, coal facings, 90 percent of which will pass through a 100-mesh sieve, must be stored for at least six days after grinding, or if not so stored must be shipped in tight metal tank cars or in tight metal containers on container cars, or in permanently covered metal hopper cars, or in other tight metal containers, or in tight, metal-bodied, covered motor vehicles. (b) Coal, ground bituminous, which has been dried by heating before grinding must be packed in hermetically sealed metal-lined wooden boxes or airtight metal containers.

There are no specific regulations for transportation of dry, ultrafine coal powder (DUC) with average particle size between 10 to 15 μm . Safe transportation and handling of DUC can be evaluated from studies on flammability and explosibility of fine coal powders. The results of various studies on maximum allowable oxygen concentration, minimum autoignition temperature, and maximum allowable dust concentration are summarized below.

<u>Max. O₂ Conc.</u> <u>%</u>	<u>Max. Dust Conc.</u> <u>g/m³</u>	<u>Min. Ignit. Temp.</u> <u>°C</u>	<u>References</u>
15.8	---	610	(1)
12 - 14	30 - 60	---	(2)
---	130	560	(3), (4)

The maximum allowable dust concentration depends on temperature. The dependence for Pittsburgh coal is shown in Figure 2, obtained by Conti, et al (Ref. 4). The maximum dust concentration of 130 g/m³ is for handling at room temperature. At other temperatures, it is predictable by the modified Burgess-Wheeler (B-W) theory (Ref. 5) as follows:

$$C_T = C_{298} (298/T) [1 - 0.000721 (T - 298)] \quad (1)$$

where

T is in °K, C_T is in g/m³, and C_{298} is 130 g/m³.

In the region where the dust mixture is "flammable but thermally nonignitable", the dust can be ignited by sparks as shown in Figure 3. The dependence on the particle size for different coals is presented in Figure 4 (Ref. 6). Generally, particles larger than about 50 μm for low volatile bituminous coals or larger than about 95 μm for high volatile bituminous coals will not cause explosion. A limiting particle size of 250 μm was cited in Ref. (2), however. A coal moisture content of larger than 16% will also eliminate explosion hazard (Ref. 2). The effect of particle diameter at different oxygen concentrations is shown in Figure 5 and the effect of pressure, in Figure 6.

On the basis of the above information, it is clear that the existing coal transportation equipment and system are not suitable for transportation and handling of DUC. The existing loading and unloading practice not only exposes the DUC to an oxygen concentration above the minimum recommended concentration but also generates excessive dust concentration beyond the recommended limits. Modification of the existing equipment and system is not simple and practical because all open hopper cars and gondolas will have to be made gastight so that a partial inert gas blanket can be provided during transportation. Even with this modification, the existing coal cars cannot be unloaded easily because they are not designed for close-loop loading and unloading of cohesive powders. All existing open coal loading and unloading systems (see review in previous monthly reports) cannot be employed for handling DUC.

Figure 2. Thermal Ignitability Limits for Pittsburgh Coal Dust (from Conti et al, Ref. 4)

Figure 3. Electrical Ignitability Limits for Pittsburgh Coal Dust (from Conti et al, Ref. 4)

Figure 4. Effect of Particle Diameter on Lean Flammability Limits (from Hertzberg and Cashdollar, Ref. 6)

Figure 5. Effect of Particle Diameter on Lean Flammability Limits at Different Oxygen Concentrations
(from Hertzberg and Cashdollar, Ref. 6)

Figure 6. Effect of Pressure on Lean Flammability Limits
(from Hertzberg and Cashdollar, Ref. 6)

If further studies on flammability and explosibility remove the requirement for a minimum oxygen concentration during transportation and handling of DUC, this preliminary conclusion may have to be modified.

Rather than spending the resources on modifying the existing equipment and system, it is better to employ the standard covered hopper car, the container car, the air-activated, gravity-discharge hopper car, and the truck trailer for handling DUC. Those specialized hopper cars and trailers are originally designed for handling bulk solids which require protection from inclement weather and special handling. Close-loop loading and unloading systems are usually standard and can be easily implemented. Some of the cars are already gastight and an inert atmosphere can be provided easily during transportation. A summary review is briefly presented here again.

Review of Existing Bulk Solids Transportation Systems

Special railroad cars are available to suit the handling characteristics of almost any commodity that can be pneumatically conveyed under any loading and unloading conditions (Ref. 7). Those cars can be adapted to handle the DUC. The container car shown in Figure 7 is intended to handle less-than-carload shipments. It consists of four to six air-activated pressure vessels mounted on a flat car or gondola car. Each container is, in essence, a blow tank with capacity of 250 to 800 ft³ using high pressure air from an external source. The air-activated, gravity-discharge hopper car depicted in Figures 8 and 9 is designed specifically to handle fluidizable dry, powdered materials such as flour and starch. This type is commonly known as the "airslide" car. Loading and unloading can be accomplished by gravity, mechanical, or pneumatic means. ACF Industries Inc. at Earth City, Missouri manufactures a pressure-in-transit covered hopper car that can be purged and pressurized up to 10 psig with an inert gas such as nitrogen. The car will maintain a positive pressure for up to 14 days (sufficient for most transit times) and can be connected to a gas supply at the

Figure 7. Typical Design of a Pressurized, Self-Discharging Tank Car

AIRSLIDE FABRIC

Figure 8. Cutaway View of Interior of Airslide Car

Figure 9. Sectional View of an Air-Activated, Gravity-Discharge Hopper Car

unloading site for holding if necessary. It is then unloaded using a closed loop nitrogen atmosphere "push-pull" vacuum system. The car has a volume of 5000 ft³, four compartments, pressure tight hatches, and special vacuum pneumatic outlets. A schematic of the loading and unloading piping arrangement is shown in Figure 10. In addition, ACF makes a pressure unloading car (known as center flow Pressuraide) that could be used for powdered coal. This car is not as pressure tight as the pressure-in-transit cars, but with extra care during manufacture, ACF believed that the car might be good enough for powdered coal. GATX (General American Transportation Corporation) also manufactures a similar rail car, power FLO car, for pressurized pneumatic unloading with pressure up to 15 psig. Thrall Car Manufacturing Company offers a similar line of covered hopper cars as well. Other types of rail cars designed for bulk handling of solid materials are summarized in Table 2.

Similar to the rail cars, there are specialty truck trailers available for transporting the fluidizable powders. They are shown in Figure 11 for the air-activated, gravity-discharge hopper van and the pressure differential tank trailer. Pressurized bulk tank trucks can retain a low pressure blanketing charge of nitrogen gas for about three days while in transit. The Heil Co. of Chattanooga, Tennessee, manufactures two types of tank trailer known in the industry as Super-Flow and Super-Jet models which allow loading and unloading of bulk solids with air pressure or inert nitrogen. They have been employed for handling bulk solids ranging from cement, fly ash, sand, lime, ground coal, sugar, fertilizers, plastics, chemicals, and feed grain materials. For those materials requiring aeration to unload, three patented FloCone nozzles are located at each hopper to provide not only the aeration but also mild vibration to improve solids flow and cleanout. Heil also provides service to characterize the bulk solids and makes recommendations on loading and unloading of the material. Typical unloading rate for ground coal with a 4-in pneumatic transport line ranges from 12 tons/hr at a conveying distance of 300 ft to 30 tons/hr at a conveying distance of 50 ft employing a 60 hp motor to provide an air flow of 570 scfm. Fruehauf Corporation also manufactures

Figure 10. Schematic Piping Arrangement of Pressure-In-Transit Covered Hopper Car

Figure 10.

TABLE 2
TYPES OF RAIL CARS FOR BULK HANDLING OF SOLID MATERIALS

Type of Transport	Volume (ft ³)	Means of Discharging Cargo	Equipment Required to Discharge Cargo	Equipment Required in Plant for Conveying
R.R. box car	3,900 to 5,800	Manually guided vacuum pickup nozzle	Vacuum unloading hose and pickup nozzle	Vacuum or V-P conveying system
Container car	1,400 to 2,400	High-pressure air fluidi- zation of contents	Air supply hose and material discharge hose	Compressed air system
Air-activated gravity-dis- charge hopper car	2,600 to 4,180	Integral vacuum pickup nozzle Hose or chute to feeders of vacuum or pressure systems	Aeration air supply hose Material discharge hose or chute Discharge outlet adapter connection Car breather vent	Aeration blower system Vacuum, V-P or pressure conveying system
Closed compartmented hopper car with integral vacuum unloading nozzles (at each hopper)	2,450 to 5,700	Hose connection to vacuum system	Material discharge hose	Vacuum or V-P conveying system
Pressurized tank car (com- partmented)	2,400	High-pressure air fluidi- zation of contents	Air supply hose and material discharge hose	Compressed air system
Standard covered hopper car	1,900 to 4,800	Gravity discharge with vibrator or car shaker assistance	Car shaker or vibrators Discharge chutes or vacuum pickup adapter connections	Vacuum, V-P, or pressure conveying system
Pressurized hopper car with aerated slope sheets	3,500 to 4,500	Low-pressure air fluidi- zation of contents (440 cfm at 15 psi)	Air supply hose (3 inch size) Material discharge hose (4 inch size; hoses may be made larger for high conveying rates)	4 inch size conveying line to a vented bin (larger for high conveying rates) Aeration blower system

Air-activated, gravity-discharge hopper van.

Pressure differential tank trailer—schematic view.

Figure 11. Schematic Views of Air-Activated, Gravity-Discharge Hopper Van and Pressure Differential Tank Trailer

both aluminum and steel hopper pressure bulk trailers to handle cement as well as a wide variety of dry bulk commodities. Standard aeration system is a 16" diameter air pad on a 33 degree slope base at each of 45 degree conical hoppers. Pulverants are fluidized for smooth and rapid pneumatic discharge. Other types of truck trailers for bulk powder handling are summarized in Table 3.

Survey of the existing transportation technology for coal and commercial bulk solids has been completed. The current economics for transportation via barge, truck, and rail have also been obtained. The existing technology is adaptable for transporting DUC, even with an inert gas blanket, via truck and rail and to a lesser extent, barge. However, there is not enough hardware available for the DUC tonnage envisioned in the future. A more important concern is the loading and unloading of DUC at the terminals. Safety and environmental considerations necessitate loading and unloading of DUC in a close-loop system under an inert atmosphere. There is currently no large-scale commercial operation under this scenario. Companies specialized in bulk solids handling are being contacted to propose a workable system.

Economics of Coal Transportation

In order to have a more complete estimate of the costs for transporting DUC by river barge, Mr. Wayne Christy of American Commercial Bargeline Co. was contacted again. He was asked to provide us with an estimate of the cost for transporting coal from St. Louis to New Orleans. This new information is added to the previously obtained information as shown below:

Huntington, WV to Pittsburgh, PA --- \$5/net ton for the 308 miles trip, or \$0.016 per ton-mile (1,400 ton minimum).

Pittsburgh, PA to St. Louis, MO -- \$6.25/net ton for the 1,171 miles trip, or \$0.005 per ton-mile (1,400 ton minimum).

TABLE 3
TYPES OF TRUCK TRAILERS FOR
BULK HANDLING OF SOLID MATERIALS

Type of Transport	Volume (ft ³)	Means of Discharging Cargo	Equipment Required to Discharge Cargo	Equipment Required in Plant for Conveying
Air-activated gravity-dis- charge hopper van	700 to 850	Integral aeration blower, conveying air blower, and pressure feeder at outlet connections	Material discharge hose	Conveying line to vented bin and a power supply receptacle
Pressurized container trailer	700 to 800	High-pressure air fluidi- zation of contents (250 cfm at 25 psi)	Material discharge hose	Conveying line to vented bin
Combination gravity and pneumatic discharge tank trailer	700	Aeration and conveying air fluidizes powder (400 cfm at 15 psi); tilting of trailer causes flow of material to rear discharge outlet	Material discharge hose Aeration air supply hose	Conveying line to vented bin or vacuum, V-P, or pressure conveying system
Pressurized tank trailer with aerated slope sheets	850 to 1,600	Low-pressure air fluidi- zation of contents (400 cfm at 15 psi)	Material discharge hose	Conveying line to vented bin
Self-loading and unloading hopper trailer	700 to 2,100	Screw conveyor discharge into built-in pressure system	Material discharge hose	Conveying line to vented bin
Covered hopper trailer	700 to 800	Gravity discharge with vibrator assistance	Vibrators, discharge chutes, or vacuum pickup adapter connections	Vacuum, V-P, or pressure conveying systems
Standard van trailer	700 to 800	Bags or containers fork truck lifted to dumping station	Bag or container dump chute or hopper	Vacuum, V-P, or pressure conveying systems

St. Louis to New Orleans -- \$5.40/net ton for the 1,049 miles trip, or \$0.005 per ton-mile (1,400 net ton minimum).

3.4.3 Subtask 4.3: Advanced Transport Systems

3.4.3.1 Objective

The objective of this subtask is to identify and to design and size an advanced transport system for application in bulk handling of DUC.

3.4.3.2 Technical Status

Container transportation was identified as the most promising advanced transport system for the DUC because of its intermodal transport capability. This will minimize the necessity for loading and unloading of DUC at the transshipment terminals. The transportation can be handled via containers among various transportation modes of barge, truck, rail, and lake or oceangoing freighters. There are international standards for container dimensions. However, the details of container design varies from manufacturer to manufacturer. According to Jane's Freight Containers (Ref. 8), there is no container manufacturer in the U.S. Container manufacturers outside of the U.S. were contacted for detailed description of available containers.

Information was requested and received from SeaLand (Pittsburgh office) regarding their Sea Bulk Powerliner, plastic liners for converting 20, 35 or 40-foot standard box containers into dry bulk containers. These 6 mil thick liners are fitted into a standard container and are filled pneumatically with the bulk material (see Appendix A for more details). Inert gas, such as nitrogen, can be used during loading operation. Unloading operation is accomplished by elevating one end of the container and removing the material by pneumatic transport under vacuum. Materials that can be shipped are resins, aluminum powder, carbon black, cement, coal, flour, mill powder, pigments, zinc powder, and many others. If an inert atmospheric blanket can be maintained inside the plastic liner during

transportation, the same simple modification of existing standard containers may be applicable for DUC transport. The vacuum during unloading will collapse the flexible liner wall and help unloading of the DUC. The Sea Bulk Powerliner is also disposable and the empty container can be loaded with other commodities for the return trip to reduce transportation cost.

Information was also requested and received from Westerwaelder Eisenwerk (WEW) of West Germany concerning their intermodal dry bulk containers. These containers can be filled and blanketed with nitrogen or CO₂ (if necessary) for shipment on sea, road, rail or river barge (see Appendix B). The unloading of bulk solids is by tipping discharge and possibly by fluidization. Hopper bottom can also be built in with the containers. However, this tends to reduce the holding capacity of the containers.

The Montgomery Tank Lines in Philadelphia is a supplier of containers to Sealand and we are discussing the technical aspects of our bulk transportation requirements with them and requesting information on leasing or purchase costs. We also contacted Triphook Co., a container leasing company, and they will send us information and drawings on an intermodal bulk tank manufactured by Spitzer of W. Germany.

We also received information on FLEXAIR bulk transportation system (included here as Appendix C). This system uses two collapsible plastic containers which fit inside a conventional box trailer van. The van is modified to allow for top loading and bottom unloading. This system, if applicable to DUC, would also allow for the dual use of trailer vans; i.e., shipping DUC one way and other commodities the other way. The FLEXAIR system can be fitted into a standard size container and be transported as a container. The flexible wall design will help to unload DUC efficiently. If the system can be made gastight, it will be a simple and ideal application for DUC.

3.5 Task 5: Handling (W. C. Yang, G. E. Klinzing)

3.5.1 Subtask 5.1: Characterization of DUC

3.5.1.1 Objective

A variety of different tests are to be performed to characterize DUC.

3.5.1.2 Technical Status

Westinghouse:

FLUIDIZATION

Fluidization properties of fine powder are important indices for assessing the behavior of fine particles. Tests will be carried out to determine if fine coal can be handled and fed using fluidization principles. Flow characteristics of the DUC will be measured by three separate techniques - fluidization, bed collapse, and flow from an orifice. The ratio of tap to aerated bulk density will also be determined to assess the cohesiveness and flowability of the DUC.

The agglomerated coal pellets from Bechtel's coal beneficiation process (Illinois No. 6 coal) were crushed in a mortar with a pestle. Without additional sieving and pretreatment, the resulted fine coal powder could not be fluidized by nitrogen. Particle segregation occurred in the bed with the fine fraction readily fluidized on top of a packed bed of larger particles. When a strong light was shined on the particles, the transparent container immediately showed condensation of a white substance, presumably heptane added as a binder in Bechtel's process. It was decided to pass the powder through an 80-mesh screen. The -80 mesh powder was then vacuum-dried at 90°C for three hours. The 90°C temperature was selected based on the boiling point of heptane. The crushed powder, after sieving and pretreatment, could be fluidized without much trouble and

behaved like a powder between Geldart's group A and group C. When the fluidizing flow was initiated, the bed tended to move up as a single slug. This slug could be destroyed by cycling the gas flow on and off several times or by vibrating the bed column. Once the slug disintegrated, the fluidization ensued.

The bulk density and tap density of pretreated Illinois No. 6 powder from the Bechtel process were also determined. The bulk density was determined by using two different methods, one employing an apparatus manufactured by Fisher Scientific and the other one, employing an apparatus fabricated at Westinghouse STC. The Fisher Scientific device allows powder to be poured through a mesh screen and flows down a zigzag path made of flat glass plates into a cubic container of 1 cubic in. capacity. The powder pile is then smoothed off the container and the powder is weighed. The resulting bulk density can then be calculated. The difference in the in-house device is that the 20-mesh screen is vibrated while the powder is being poured and that the container is cylindrical and has a capacity of 100 cubic cm. The in-house device was fabricated following that described by Geldart and Wong (Ref. 9). The same features are apparently available in a commercial Hosokawa powder tester.

Ten different determinations were carried out using both devices with a 4.29% variation employing Fisher Scientific apparatus and only a 0.58% variation with the in-house device. The bulk density determined with the in-house device (0.343 g/cu. cm) is approximately 5% higher compared to that obtained from the Fisher Scientific apparatus (0.326 g/cu. cm). It is suspected that the sharp 90-degree corners in the small powder receiver used in the Fisher Scientific device may prevent normal powder packing and thus gave a lower bulk density. The apparatus fabricated in-house will be employed for future bulk density determination.

The tap density of the powder was determined by putting an extension piece on the cylindrical powder container with additional powder. The container was then mounted on a tapping machine (Model JEL ST2) manufactured by J. Engelsmann of West Germany and subjected to different numbers of tapping.

After tapping, the extension piece was removed and the excess powder was smoothed off the container. The powder in the container was then weighed to obtain the tap density. Geldart and Wong recommended to subject the powder to 180 taps. In our preliminary determination, the powder was subjected to tapping from 20 taps up to 10,000 taps to evaluate the consolidation properties of the powder. Based on extensive studies of Geldart et al (Ref. 10) on cohesive powders, the powders are cohesive if their ratios of tap density to bulk density (also called Hausner's ratio) are larger than 1.4. The Hausner's ratio for the Illinois No. 6 coal from Bechtel process is shown in Figure 12 for tapping up to 10,000 taps. Based on Geldart's criterion, the powder is a cohesive powder because the Hausner's ratio is larger than 1.4 beyond 180 taps, although the tapping machine used in this study is different from that of Geldart's study. On the basis of Figure 12, high degree of consolidation apparently continues until about 300 taps. Future samples of powder will continuously be subjected to more than 180 taps to provide a better understanding of powder consolidation characteristics.

Although the humidity or moisture content affects the flow properties of powders, it does not change the value of Hausner's ratio (Ref. 10). Hence, the determination of Hausner's ratio is a simple and effective way to provide initial indication of handleability of dry powders.

SHEAR MEASUREMENT

Shear stresses of the DUC will be measured with a Jenike shear cell to evaluate the flow characteristics of the DUC. The shear stress, together with other parameters measured under Task 5, will allow ranking of different powders in term of handling difficulty.

A batch of agglomerated coal pellets from Bechtel's coal beneficiation process was ground to powder form in a mortar and the shear stress measurement with the Jenike shear cell was conducted at three different levels of consolidation. The powder did not yield a steady consolidation shear stress even after preconsolidation, a phenomenon also reported by

Figure 12. Tap/Bulk Density Ratios (Hausner Ratios) for Illinois #6 Coal Powder from Bechtel Process

Hogg et al (Ref. 11) for -400 mesh coal powder. For those difficult to handle powders, Jenike has recommended a modified method for testing. Method D in Jenike's recommendation was adopted for this testing. During the data analysis, it was also found that a consolidation Mohr circle could not be found which was simultaneously tangent to the yield locus and also passing through the consolidation point for levels 2 and 3 of consolidation. The new method for describing the consolidation Mohr circle suggested by Hogg et al was employed to bypass this difficulty.

The flow function thus obtained showed a slight negative slope rather than a positive slope as expected. It was not known whether this peculiarity was a characteristic of the powder or resulted because of the presence of heptane and asphalt as binders. This particular batch of powder was not subjected to sieving and vacuum drying as the batch used in the fluidization tests. The shear stress measurement will be repeated with a batch of sieved and vacuum-dried powder.

University of Pittsburgh:

PARTICLE SIZE ANALYSIS

The particle size analysis of three coals was carried out using the Leeds and Northrup Microtrak. Two of the coals (Upper Elkhorn and Bechtel pellets of Illinois No. 6) were further ground for the explosion testing. The Wyodak coal was not further ground. Table 1 has a tabulation of the d_{50} size in microns as well as the moisture and ash contents.

FLUIDIZATION

A 3.25 inch I.D. Plexiglas fluidization bed was filled with a coal sample (micronized coal from DOE) to a height of 40 cm. Regulated gas flow rates were measured using the Brooks mass flowmeter. Pressure drops across the bed were measured from various gas flow rates (Figure 13). Since this material is a typical Geldart type C (cohesive) powder, there is a strong tendency for the gas to channel. From visual observations at a gas

FLUIDIZATION TEST OF UPPER ELKHORN COAL PARTICLES

Figure 13. Fluidization Pressure Drop Vs. Gas Velocity

velocity of 0.32 cm/s, the first evidence of channeling appeared. At 0.5 cm/s channeling was well established. The bed was found to take at least five minutes to respond to changes in the gas velocity. For the cohesive material, a finer distributor may be necessary.

COLLAPSING BED EXPERIMENTS

The sample experimental setup that was used for the fluidization was also employed for the collapsing bed experiments. A high resolution camera, WV-V3 (Panasonic), and Video Cassette Recorder, NV-8959 (Panasonic), were employed to record the bed movement. An on-screen stopwatch with a resolution of 0.1 second was found to be adequate for the experiments. Coating of the walls of the unit impeded the visual process. A typical de-aeration curve is shown in Figure 14. This information will be compared with the other coals to assess air retention abilities of the coals.

SONIC VELOCITY MEASUREMENT

While testing did not commence on this parameter, review of the attenuation process of pressure signals was carried out to ascertain its relevance to the coal transport area. This information was found to be of utility in identifying the proper manner in having vibrations affect the flow of the cohesive coals.

3.5.2 Subtask 5.2: Additives to Enhance Flowability of DUC

3.5.2.1 Objective

Addition of a small amount of fine silica, alumina, or anthracite powders (up to about 1%) to cohesive materials has been found to improve their flowability substantially. The DUC will be mixed with the flow aids identified in the literature search to evaluate their effectiveness.

Figure 14. Collapsing Bed Expt.

3.5.2.2 Technical Status

Different amount of flow aids are being mixed with the Illinois No. 6 coal powder from Bechtel process. The bulk and tap density of the prepared samples will be measured to determine their Hausner's ratio. The fluidization behavior of the prepared samples will also be investigated.

3.5.4 Subtask 5.4: Pneumatic Testing

3.5.4.1 Objective

In this subtask, the conveying characteristics of DUC will be investigated.

3.5.4.2 Technical Status

The placement of the orders for all the component parts of the pneumatic testing rig were completed and delivery is anticipated on the final elements in July. The elements purchased were:

Feeder.....	MSA
Filter-Receiver.....	American Filter
Blower.....	Roots Blower (Harris Pump)
Oxygen Meter.....	MSA
Load Cells.....	BLH
Delivery Tank.....	Fischer (Nalgene)
Transducers.....	Omega

Modifications were made to an existing stainless steel tank that will be incorporated in the coal flow loop.

Testings were carried out on the pickup velocity arrangement. The pickup velocity is the minimum gas velocity required to entrain the particles from a layer of solids on the bottom of the pipe. Maintaining pickup

velocities in all sections of the conveying line ensures no accumulation in the system. Single particle pickup velocities are sometimes related to the settling velocity. This relationship is very indirect in the case of fine particles where clustering and agglomeration prevails. To obtain the exact velocity at which the particles on the surface of a layer are in dynamic equilibrium with the gas flowing above, a new technique has been proposed.

As shown in Figure 15, a horizontal plug with approximately 75% of the cross-sectional area of the pipe is created. This plug erodes slowly as the gas flowing at the top picks up solids. Because of the reduced cross-sectional area, the actual gas velocity at the top of the plug is much higher than the superficial gas velocity. As the free cross-sectional area increases, the actual gas velocity drops until an equilibrium is reached. Figure 16 shows various dune formations during the pickup phase. Experiments are being conducted on DUC to assess the various coal properties on the pickup velocity. Some of the experimental results to date are summarized in Figure 17.

3.5.5 Subtask 5.5: Feeder Development

3.5.5.1 Objective

The objective of this task is to develop a reliable feeder to supply the DUC from the Residential Storage Tank. Two feeders will be tested: the external massaging/flexible wall feeder and the peristaltic pump. The feeders will be evaluated on performance, capital cost, and operating cost.

3.5.5.2 Technical Status

A batch of coal pellets from Bechtel's process was crushed in a mortar and placed in the storage hopper of the peristaltic pump feeding system as shown in Figure 18. The hopper was then pressurized with nitrogen and the pump started. A major problem was encountered in the flow of powder out

Figure 15. Setup for Pickup Velocity: Multiple Particles (1 m plug)

Dune Formation (glass beads: 450 μm)

Figure 16. Dune Formation (glass beads: 450 μm)

Figure 17. Experimental Results

Figure 18. A Schematic of Peristaltic Pump Feeder Arrangement

of the storage hopper. The vibrator installed at the hopper did not help the flow of powder and apparently contributed to the severe packing at the 1/2-in outlet of the hopper. This batch of powder was not sieved and vacuum dried. The presence of heptane and asphalt binders might contribute to the blockage.

A batch of fines from Texaco gasifier was also tried unsuccessfully in the peristaltic pump. The Texaco material has sizes similar to the DUC and is readily available in our laboratory for other programs. The material is known to be free-flowing based on studies carried out for other ongoing research programs. Because of its free-flowing characteristic, the plugging previously experienced at the outlet of feed hopper can be eliminated and the potential of the peristaltic pump application in transporting DUC can be evaluated. Use of free-flowing Texaco fines indeed eliminated the material feeding problem from the hopper, however, the peristaltic pump was jammed due to the packed bed of solids in the flexible tube. The solids did not behave like a fluid as anticipated. The feasibility of employing the peristaltic pump will be reevaluated later for the Wyodak and Upper Elkhorn coals.

An AccuRate flexible wall feeder was ordered. The feeder utilizes the massaging action of double external paddles on flexible hopper walls to provide accurate feeding of even cohesive powders. The manufacturer's claim will be tested under this subtask. Delivery of this feeder will be four to six weeks.

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APPENDIX A : SEA BULK POWERLINER FOR STANDARD CONTAINERS

SEA BULK® POWERLINER®

24 TON DISPOSABLE BULK CONTAINER LINER

VERSUS CONVENTIONAL PACKAGING

	SEA BULK® POWERLINER 40 ft. liner	BAGS 4 or 5 ply w/liner, 50#	PALLETIZED BAGS Pallet 40" x 48" hardwood	PALLETIZED CARTONS Pallet 34" x 42" expandable
Tare weight per unit	140 lbs	1.0 lbs /bag	1.0 lbs /bag 60 lbs /pallet	44 lbs /carton 42 lbs /pallet
Total tare weight and units for 45,000 lbs. gross	1.58 tons 180 lbs	800 bags 800 lbs	22 pallets 800 bags 2,200 lbs.	41 units 3,526 lbs
Net product weight 45,000 lbs. gross	44,820 lbs.	44,120 lbs.	42,800 lbs	41,474 lbs
Deficit net product weight - others vs SEA BULK		-700 lbs.	-2,020 lbs	-3,546 lbs
Surplus product based on five shipments using SEA BULK vs others		3,500 lbs.	10,100 lbs.	10,730 lbs
Packaging cost per unit	F.O.B. Rouses Point, NY \$200.00	\$0.375/Unit	\$0.375/Bags \$ 8.00/Pallet	\$12.59/Carton \$ 4.75/Pallet
Total cost of packaging material for 45,000 lbs. gross	\$350.00	\$690.00	\$366.00	\$1,071.00
Increased packaging costs others vs SEA BULK for 45,000 lbs. gross		\$340.00	\$516.00	\$721.00
Packaging savings based on five shipments using SEA BULK vs others		\$1700.00	\$2580.00	\$3605.00
Packaging cost - cents/lb.	0.84/lb.	1.54/lb.	1.36/lb.	2.44/lb.

SEA BULK IS AVAILABLE IN STANDARD SIZES OF
30-FOOT, 40-FOOT AND 50-FOOT LENGTHS

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POWERTEX INC.

U.S. ROUTE 2, ROUSES POINT, NEW YORK, U.S.A. 12979 - TEL.: 518-237-4000 - TELEX: 65-5605

SEA BULK® POWERLINER®

24 TON DISPOSABLE BULK CONTAINER LINER

FOR SHIPPING YOUR
BULK COMMODITIES
CONTAMINATION
FREE...

...ANYWHERE
IN THE WORLD

* PATENTED AROUND THE WORLD
© REG. TRADE MARKS
SEA BULK IS AVAILABLE IN STANDARD SIZES OF
30-FOOT, 40-FOOT AND 50-FOOT LENGTHS

POWERTEX INC.

U.S. ROUTE 2, ROUSES POINT, NEW YORK, U.S.A. 12979 - TEL.: 518-237-4000 - TELEX: 65-5605

WHY HANDLE & SHIP 880 BAGS?

WHEN ONLY ONE

SEA BULK® POWERLINER®

24 TON DISPOSABLE BULK CONTAINER LINER

WILL DO THE JOB!

Let Sea Bulk work some magic for you and watch 2,500 lbs. of costly bags, drums and pallets dissolve into 170 lbs. of profit.

Suddenly, you'd be averaging a \$500 saving on packaging materials alone. Not to mention the enormous savings in labor and excess tare weight.

You'd be amazed, too, at how Sea Bulk can transform any standard intermodal container or trailer truck, whatever length, into a contamination-free enclosure for dry flowable bulk.

PRODUCTS THAT CAN BE SHIPPED

ABC resins	Fertilizer	Rice
Aluminum powder	Fish meal	Salt
Asbestos	Flour	Seeds
Barley	Ground nuts	Soda ash
Carbon black	Malt	Soya beans
Cattle feed	Milk powder	Sugar
Cement	Nuts	Tea
Clay	PE resins	Urea
Coal	PP resins	Wheat
Cocoa	PS resins	Zinc Powder
Coffee	PVC resins	Many other
Corn	Pigments	Products
Feldspar	Potato flour	

How DuPont cut packaging costs

75%

Efficiency, quite simply, means getting more out of less. But many shipping systems have it in reverse. They also require more manpower.

That's why DuPont switched to the Sea Bulk® system for international shipments of dry flowable resin.

Dupont discovered that just one Sea Bulk unit could hold 42,000 pounds of resin. So it replaced 42 pallets, boxes and liners. That's how bottlenecks—along with manpower costs—were cut.

What worked for DuPont can work for your company. If you ship at least 5 million lbs. of dry flowables a year, contact us for a demonstration of the Sea Bulk system. After all, can you afford not to?

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

The Economical Way To Protect Sensitive Bulk Cargo From Moisture And Contamination

More and more shippers are discovering that shipping dry bulk materials with the Sea Bulk system is much easier — and much cheaper — than shipping in bags, barrels, or drums.

The unique system consists of a heavy-duty polyethylene liner that fits into a standard intermodal cargo container or truck-trailer.

You load your bulk material into the liner, seal it, and the cargo stays dry, clean and secure. The polyethylene liner keeps out dust, dirt, and moisture — through any kind of weather, any kind of travel conditions.

Sea Bulk can save you plenty in shipping costs, too. First, because you can do away with all the special packaging

operations. And second, because Sea Bulk saves weight. A Sea Bulk unit weighs only about 170 pounds, while bags and pallets can add more than a ton of unnecessary weight to your shipment.

The Sea Bulk system has been proven in thousands of shipments around the world, with many different commodities: resins, plastics, dry chemicals, and sterile grade foodstuffs like sugar and cornstarch.

Sea Bulk units are available for 20-foot, 35-foot, 40-foot, and 45-foot containers — or can be manufactured to customer specifications. They can be obtained worldwide through containerized carriers and Powertex, Inc.

Turns Any Intermodal Container Into A Dust-Proof, Moisture-Proof Bulk Shipping Unit

The Sea Bulk liner is six mils thick, and is manufactured under clean conditions, ready for loading. It is designed with ample slack so the weight of the cargo is supported by the container walls, not by the liner. The liner will remain intact even if the cargo shifts during transport. You can safely ship up to 24 tons of cargo in a 40-foot container.

The Sea Bulk unit is supported fore and aft by sturdy bulkheads made of triple-fluted (AAA) corrugated fiberboard. Cargo is loaded through the upper ports in the rear bulkhead. You can specify ports designed for conveyor loading, or ports designed for pneumatic loading as shown here. The lower ports are opened at destination for unloading.

Easy To Set Up And Load...

Sea Bulk units are furnished collapsed for easy handling and storage.

Two people can install a Sea Bulk system in about ten minutes. The front bulkhead is positioned at the front wall of the container, and the liner is pulled back.

Bulk cargo is loaded through one of the upper ports while the other is left open to act as a vent or filter. After loading, both ports are sealed to keep cargo clean and dry.

...Fast And Simple To Unload.

At destination, the lower ports are opened and the bulk cargo is simply poured out. By a tilt platform ...

... A hydraulic tilt chassis ...

Hydraulic tilt wheel, or any other similar mechanism. Many users have successfully incorporated the Sea Bulk system into their flow-through production system with very profitable results.

SEA BULK® POWERLINER®

24 TON DISPOSABLE BULK CONTAINER LINER

INSTALLATION INSTRUCTIONS

USE 2" x 8" x 8' LUMBER, CUT TO FIT
TIGHTLY TO INSIDE WIDTH OF CONTAINER
AND PLACE BEHIND CORNER POSTS. USE
3-1/2" NAILS TO ASSEMBLE AS INDICATED.

FIGURE 1
INSTALLATION OF 100-24
BULK-PACK

STEP 1

Inspect bulk package for shipping damage.
WARNING! BE SURE CONTAINER IS FREE OF NAILS AND SPLINTERS AND HAS BEEN SWEPT CLEAN.

Cover any damaged areas in floor with cardboard.

Walk the entire pack to the front of the container as shown in Figure #2.

STEP 2

Position pack close to the front wall and remove the metal retaining straps. Remove the straps from the container.

STEP 3

Pull the bulkhead with circular openings to one side and push the solid bulkhead into position at the front wall until it wedges itself tightly between the container's doors as shown in Figure #3.

WARNING! BE SURE THE BAG IS NOT CAUGHT BETWEEN OR UNDER THE THREE LIPS OF CARDBOARD.

FIGURE 2
UNFOLDING THE PLASTIC BAG

If the solid bulkhead is loose at the front wall, use the supplied strips of cardboard to wedge bulkhead tightly in place. Cut open one hole located at the top of the pack with a razor blade or knife to allow air into bag.

FIGURE 3
POSITIONING THE BULK BULKHEAD IN PLACE

STEP 4

Pull the rear bulkhead towards the rear of the container by firmly gripping the pulling brace underneath with two hands, and proceed to "walk" the bulkhead towards the rear as shown in Figure #3.

STEP 5

Place one corner of the bulkhead in position at the rear of the container as shown in Figure #4. Swing the opposite end toward the rear of the container until it is wedged between the sides of the container as shown. The bulk package is now fully installed.

STEP 6

LOADING THE BULK PACKAGE
Cut open the second round hole in the bulkhead. Be certain that no plastic film falls inside the bag.

Position the blow loading tube as close as possible to the round hole through which the product is to be loaded, as shown in Figure #5.

STEP 7

Insert the blow loading tube through the hole at least ten feet at the start of loading. Aim the blow loading tube in a slightly downward direction to prevent product from hitting roof of liner. (As shown in Figure #5). This will insure even distribution of the product throughout the liner.

STEP 8

Slowly pull the blow loading tube out as the bag fills to the required load.

STEP 9

After filling, the product inlet spout is secured with a tie band to prevent moisture contamination. The inlet spout is then rolled up and tucked into the bulkhead of the container. The container is then sealed and shipped to the customer.

NOTE: FROM PAGE 7

THE BASIC INSTALLATION FOR THE SEABULK HEAD INCLUDES SECURING WOODEN STRIP & FLAP WITH 3" NAILS NAILED 10" APART ALONG THE TOTAL WIDTH. NAILING THE WOOD & FLAP TO THE FLOOR OF THE CONTAINER ASSURES THAT THE SEABULK WILL REMAIN IN POSITION DURING SHIPPING AND UNLOADING.

FIGURE 5
LOADING THE BULK PACKAGE

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

UNLOADING TRANSFER SYSTEMS

A bulk container can be unloaded by gravity, vacuum or pneumatics, in each instance however, the unit has to be tilted so that constant product feed can be maintained during discharge.

Normally it is necessary to tilt a container 5° over angle of repose of the product; being carried, so as to achieve a constant flow.

For gravity discharge the product simply pours through the rear mounted roll out sleeve of the liner. Vacuum discharge is effected by screwing on an attachment to the rear bulkhead.

By tipping product onto a rotary valve from the container a pneumatic system can be achieved

PROBLEM-SOLVING

IDEAS

SEA BULK POWERLINER 24 TON DISPOSABLE BULK CONTAINER LINER

UNLOADING TRANSFER SYSTEMS

SEA BULK POWERLINER 24 TON DISPOSABLE BULK CONTAINER LINER

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

PROBLEM-SOLVING IDEAS

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

PROBLEM-SOLVING IDEAS

Liner converts a van container to a bulk shipping unit

What the shipper uses inside the container is a disposable plastic bag between two corrugated bulkheads. The bulkheads are placed at the front and rear.

A shipper quickly prepares a bulk shipping unit for plastic pellets by installing a protective liner. It's easy to load.

Trailer-size containers—inter-modal types for overseas shipments—are quickly converted into bulk shipping units for polyethylene resin pellets, at East-Tex Plastic, Inc., Orange, Texas. First, a plastic bag and two corrugated bulkheads are installed in a 34-ft container. Then a 42,000-lb shipment of pellets is blown through an opening in the rear bulkhead into the bag.

The lined container is loaded in about two hours. It then protects the contents all the way to England, for use in manufacturing pipe. It's also quickly unloaded by gravity. At destination, the container is tilted. Pellets flow out through a discharge opening at the bottom of the rear bulkhead.

East-Tex receives polyethylene resin in dry pellet form, from E. I. Du Pont de Nemours & Company's nearby plant.

Container loading is fast. In about two hours, a 42,000-lb shipment of plastic pellets is blown through the bulkhead into the plastic bag.

After the loading operation, portholes are sealed, and container doors are closed.

Our overall savings are tremendous, reports East-Tex plant supervisor Rusty Howell. "Only two men are needed to operate the system. They can unload a hopper car in six hours."

Intermodal container has pre-cut portholes in the rear bulkhead for pneumatic loading.

Intermodal shipping system slashes costs by two-thirds

CP Staff

New Solutions to Plant Problems

Problem: U.S. Industrial Chemicals Co. (U.S.I.), Deer Park, TX, was faced with the complex task of shipping low-density resin from their plants in that location and Thibodaux, IL, to Finland. The resin is marketed by U.S.I. under the trademark Petrothene and used in Finland for milk cartons.

Several requirements made the job difficult: large quantities of Petrothene pellets (more than two million pounds) had to be delivered as quickly as possible to the buyer, and it had to arrive dry and uncontaminated. The

customer also requested that the product be shipped in large bulk containers, not in the 50-lb bags and 1000-lb boxes usually employed by U.S.I. To top it off, the Illinois product, which was transported to Texas in Dry-Flow cars, could not be shipped directly to the Deer Park plant because of a conflict in loading schedules.

The logistics were difficult, but U.S.I.'s Deer Park plant personnel and a contract packager and warehouse based in Houston worked together to come up with a solution. Paul R. Golding, U.S.I.'s senior chemical engineer, was assigned to direct and follow the work. Factored into their decision-making

process were additional considerations. Once Petrothene is manufactured by U.S.I., the product is stored in large vertical silos made of aluminum or lined concrete. In order to ship it, the resin must be air-conveyed into Dry-Flow rail cars which transport it to the warehouse.

"Further," according to Golding, "if any contamination enters the resin during these processes, it could cause our Finnish client to shut down their plant or, at the very least, slow down operations. The result would be a tremendous dollar loss."

Solution: To solve this involved shipping problem, U.S.I. decided to use

Extended between bulkheads constructed by two layers of triple-layer corrugated fiberboard disposable heavy-duty polyethylene liner seals two working doors 12 minutes to install in an empty container.

a special, intermodal shipping system. Packaging consists of a disposable, heavy-duty polyethylene liner extended between bulkheads constructed of triple-fluted, corrugated fiberboard. It is available in 20, 35 and 40' lengths to accommodate intermodal containers. In this particular case, the 20' length, which holds 35,000-lb of Petrothene, was used.

The liner takes two workers about 10 minutes to install in an empty container. They position and wedge it close to the front wall and then pull the rear bulkhead back, unfolding the plastic bag. The rear bulkhead is then securely fastened into place.

Portholes are pre-cut into the top of the rear bulkhead for loading, which is done pneumatically. "In 45 to 50 minutes," reports Golding, "the container is full. It would have taken us three hours to package, staple and warehouse a similar amount of product in ordinary boxes."

The new system also frees valuable warehouse space at U.S.I. Says Golding, "The product can now go directly from our silos to our bulk-railroad cars

and then be transported to the warehouse's location for unloading."

Results: High packaging cost savings are achieved. Palletized payload containers cost over \$15 a unit and hold 1000-lb each. Thus, to package 35,000 pounds, the price could be upwards of \$525. On the other hand, each new shipper costs only \$175, or one-third the cost of the 5400s.

Golding says that another reason he was attracted to using the new system is its impressive durability. "We had noted in the past that individual boxes and bags were sometimes susceptible to damage from handling and storing," he explains. "Though our forklift operators were careful, damage was sometimes caused by handling, and holes were accidentally made in the cardboard container or bags. Now, we no longer have that worry."

Once the resin is loaded in the new containers, the freight is trucked to a terminal. There, the intermodal container is lifted off the truck bed with the container intact and placed aboard Finn Lines container ships. After arriving at a port in Sweden, the container is

carried by train and ferry to its final destination in Finland, where the resin is unloaded through gravity discharge by means of a porthole at the bottom of the rear bulkhead. This results in additional labor savings at the receiver end.

U.S.I. reports that it is pleased with the results, and is now using the container in shipping high-density resins made at the Deer Park plant to other customers. "We're happy with this innovative means of shipping," says plant manager Ken Carpenter, "and will continue using the units in addition to bags and payload containers. We found that the initial set-up to use the process was easy—we only had to adapt an existing pneumatic conveyor system. Also, in this recessionary economy, it's gratifying to find an economical and efficient method of loose bulk shipping."

Reprinted from November 1981 CHEMICAL PROCESSING

SEA BULK POWERLINER 24 TON DISPOSABLE BULK CONTAINER LINER

LOADING TRANSFER EQUIPMENT GRAVITY/AIR PUSH SYSTEM

OPEN
GATE VALVE AT
SILO 15 TO 25%
TO DETERMINE PROPER
PRODUCT TO AIR MIXTURE

45% ANGLE

QUICK
DISCONNECT
COUPLINGS

DETAIL A

2" AIR OR
NITROGEN HOSE
WITH 150 LBS. PRESSURE

NOTE

THIS SYSTEM CAN DISCHARGE 44,000 LBS. IN 12 MINUTES DEPENDING ON THE PRODUCT BEING LOADED. INFLATE SEABULK COMPLETLEY (MAX. 3 PSI) BEFORE STARTING TO BLOW PRODUCT INTO THE LINER. DURING LOADING, AIR PRESSURE SHOULD BE EQUALIZED THROUGH THE EXHAUST PORT.

SEA BULK POWERLINER 24 TON DISPOSABLE BULK CONTAINER LINER

LOADING TRANSFER EQUIPMENT

PowerTex has developed specialized systems designed for loading a wide range of products into containers fitted with Seabulk Powerliners

Basic hose mounts or fully equipped gantries transforming gravity feed into pneumatic systems are available.

PowerTex's engineering department can advise and provide equipment handling on-site transfer systems. For those companies who use Seabulk liners for shipment of their products, PowerTex can supply the loading equipment quickly and efficiently. All machinery is portable and can be moved in place at short notice on a sale or lease basis.

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

LOADING TRANSFER EQUIPMENT

60,000 LBS./HR....

RESINS • PELLETS • FOODS • CHEMICALS

ONE MACHINE HANDLES IT ALL

- 30 cu. ft. P.D. pot — all inside welds ground and polished
- 100% maintenance free VENTURI system
- Fully automatic controls — count and shutdown
- Compact later design for highway speeds
- Accuracy ± 1% for 100% visual inside inspection
- 100% gas or electric powered — completely self contained
- Full electrical except for starting system
- 100% telescoping vacuum pick-up tube

SEA BULK POWERLINER

24 TON DISPOSABLE BULK CONTAINER LINER

UNLOADING TRANSFER SYSTEMS

"A-Frame" Cylinder Mounting (Pitless)

The "A-Frame" mode is designed and built for ground level or above ground installation. This type of truck dumper is very desirable in areas with a high water table or locations where the soil does not allow the digging of a cylinder pit. The "A-Frame" arrangement allows for easy access to the deck cylinders.

UNDER DECK CYLINDER MOUNTING (Pit Type)

This mode is sometimes preferred when the water table permits and the cost of excavating a cylinder pit is prohibitive. It leaves clearance (flush with the ground) when in the down position.

CYLINDERS

Phelps telescopic hydraulic cylinders are the heart of our dumpers. They are designed for each specific truck dumper application and are produced by our machinists with infinite care... specifically engineered for safety, strength and long life.

POWER UNIT

The shock resistant hydraulic circuit used on Phelps dumpers provides smooth start and stop when raising and lowering the platform. The circuit cuts heat build-up and prevents leaks in the line caused by shock.

All power units are equipped with totally enclosed fan-cooled motors in sizes to match the application. Hydraulic components are carefully matched to the rest of the system.

APPENDIX B : STANDARD CONTAINERS
BY WESTERWAELDER EISERWERK (WEW) OF WEST GERMANY

Maxicube Tanks

for the intermodal
land and sea transport
of liquids and dry bulk

All ISO and domestic sizes + modules;
all current materials, codes + approvals

Großraum Tanks

für den kombinierten
Land- und Seetransport
von Flüssigkeiten und Schüttgut

Alle ISO-Binnenmodule + Größen;
alle üblichen Werkstoffe, Regelwerke + Zulassungen

Cargo Hazard Classes

Gefahrgutklassen

(1) TOL 6 • 25 • 26 R₁E₁H₁ 4,0 • 30 m³

Multi purpose, insulated, steam heated / 20' IMO 1 / Vielzweck, isoliert, dampfbeheizt

+18 %
Capacity

(2) TCL 6 • 25 • 27 R_{4b}E 2,6 • 29 m³

Bulk, tipping discharge / 20' IMO 2 / Schüttgut, Kippentleerung

(3) TCL 6 • 25 • 26 R₄Eh₂ 2,65 • 30 m³

Multi purpose, insulated, steam heated / 20' IMO 2 / Vielzweck, isoliert, dampfbeheizt

(5) TCL 6 • 25 • 26 R₄Elh₂ 2,65 • 30 m³

Multi purpose, insulated, steam heated / 20' IMO 2 / Vielzweck, isoliert, dampfbeheizt

(6) 2086 R₄Elh₂ 2,65 • 27,7 m³

Multi purpose, insulated, steam heated / 20' IMO 2 / Vielzweck, isoliert, dampfbeheizt

(8) TCL 6 • 25 • 26 R₄EIh₄ 2,65 • 30 m³

Multi purpose, insulated, steam heated / 20' IMO 2 / Vielzweck, isoliert, dampfbeheizt

(9) TCL 6 • 25 • 26 R₄EIh₄ 4,0 • 30 m³

Multi purpose, insulated, steam heated / 20' IMO 1 / Vielzweck, isoliert, dampfbeheizt

CODES, INSPECTION, APPROVAL						REGELWERKE, ABNAHME, ZULASSUNG		
Scope Geltungsbereich		Cargo Ladung	Hazard Gefahr		Safety Sicherheit	Pressure Druck	Transport	others andere
		Inter- modal	Sea See	Rail Schiene	Road Straße			
Codes	International	UN-MM	IMO IMDG	RID	ADR		ISO CSC URC	ATP CCC
	National	TRTC IM DOT 51 CTC	GGVSee Blue Book	GGVE AAR	GGVS	AD-Merkblatt ASME VIII Div. 1 BS 5500 STOOMWEZEN	DB SNCF AAR 600	Calibration Eichung
Testing + Inspection Prüfung + Abnahme		GL, LRI, DV, RINA, ABS, NK, Hartford, BIE, TÜV, Stoomwezen, National Board, DB, SNCF Customs.						
Approvals Zulassung		National competent authorities Nationale Zulassungsstellen (BAM, US-DOT, DOT (UK), CTC, DLI (AUS), NMBS + MV (B))

WESTERWALDER EISENWERK

☎ Telephone (027 43) 10 71 (5) Telex 875323

MAXICUBE STACKABLE INTERMODAL TANKS

KEY DATA	DRY BULK/SCHÜTTGUT		LIQUIDS / FLÜSSIGKEITEN		HAUPTDATEN
Tank Type	IMO 2	IMO 2	IMO 2	IMO 1	Tanktyp
Frame Dimensions	20' x 2500 x 2743 mm	20' x 2500 x 2600 mm (20' x 8' x 8'6" ISO)	20' x 2500 x 2600 mm (20' x 8' x 8'6" ISO)	20' x 2500 x 2600 mm (20' x 8' x 8'6" ISO)	Rahmenmaße
Cargoes	IMO Type 2 dry bulk	IMO Type 2 Liquids	IMO Type 2 Liquids	IMO Type 1 Liquids	Ladegüter
Transport Modes	Road, rail, ro/ro	Road, rail, ro/ro (+ short and deep sea for 8' width)	Road, rail, ro/ro (+ short and deep sea for 8' width)	Road, rail, ro/ro (+ short and deep sea for 8' width)	Transportarten
NOMINAL CAPACITY	29 000 liter 7 872 US gal 6 556 Imp gal	30 070 liter 7 944 US gal 6 615 Imp gal	30 070 liter 7 944 US gal 6 615 Imp gal	30 000 liter 7 920 US gal 6 600 Imp gal	NENNINHALT
WEW-Model	TCL 6 x 5 x 2,7 R ₄ but 2,6 · 29 m ³	TCL 6x2,5x2,6 R ₄ ih _d 2,65 · 30 m ³	TCL 6x2,5x2,6 R ₄ ih _d 2,65 · 30 m ³	TCL 6x2,5x2,6 R ₄ ih _d 4,0 · 30 m ³	WEW-Typ
WEIGHTS appr.					ca. GEWICHTE
Tare	4 970 kg	4 280 kg	4 280 kg	5 200 kg	Tara
Max Gross	32 000 kg	32 000 kg	32 000 kg	32 000 kg	max. Brutto
Stacking	1 + (2 x R)	1 + (2 x R) Domestic (192.000 kg ISO)	1 + (2 x R) Domestic (192.000 kg ISO)	1 + (2 x R) Domestic (192.000 kg ISO)	Stapeln
MATERIALS					WERKSTOFFE
Tank	321, 1.4541 or equiv.	316Ti, 1.4571 or equiv.	316Ti, 1.4571 or equiv.	316Ti, 1.4571 or equiv.	Tank
Frame	RSt37-2 / St52-3	RSt 37-2 / St 52-3	RSt 37-2 / St 52-3	RSt 37-2 / St 52-3	Rahmen
SHELL THICKNESS					WANDDICKEN
Cylinders	3,5 mm	3,2 mm	3,2 mm	4,4 mm	Mantel
Ends	5,6 mm	6,0 mm	6,0 mm	6,3 mm	Böden
TEMPERATURE	50°C	130°C	130°C	130°C	TEMPERATUR
(steam heating)					(Dampfheizung)
Heating surface		2 m ²	2 m ²	2 m ²	Heizfläche
(net)					(netto)
Insulation		50 mm	50 mm	50 mm	Isolierung
PPRESSURES					DRÜCKE
MAWP	2.0 bar	1.74 bar	1.74 bar	3.0 bar	Betriebs
Test	2.6 bar	2.65 bar	2.65 bar	4.0 bar	Prüf
Start-to-	2.2 bar	2.21 bar	2.21 bar	3.3 bar	Ansprech
discharge SV					SV
External	0.21 bar	0.21 bar	0.21 bar	0.4 bar	äußerer
DISCHARGE	Bottom, gravity tipping fluidized	Bottom / Top	Bottom / Top	Bottom / Top	ENTLEERUNG
CODES					REGELWERKE
Hazard/ Safety	IMO 2, RID, ADR, GGVSee, GGVE, GGVS, TRTC	IMO 2, RID, ADR, GGVSee, GGVE, GGVS, TRTC	IMO 2, RID, ADR, GGVSee, GGVE, GGVS, TRTC	IMO 1, RID, ADR, GGVSee, GGVE, GGVS, TRTC	Gefahrgut/ Sicherheit
Pressure	AD-Merkblätter	AD-Merkblätter	AD-Merkblätter	AD-Merkblätter	Druck
Transport	UIC 592-2	UIC 592-2	UIC 592-2	UIC 592-2	Transport
others	CCC	CCC	CCC	CCC	andere
TESTING					PRÜFUNG
dynamic impact	GL SNCF, BV (AAR600, CTC)	GL, TÜV SNCF, BV (AAR600, CTC)	GL, TÜV SNCF, BV (AAR600, CTC)	GL, TÜV SNCF, BV (AAR600, CTC)	Auflauf
APPROVALS	BAM, GL, Customs, CSC	BAM, GL, Customs, CSC	BAM, GL, Customs, CSC	BAM, GL, Customs, CSC	ZULASSUNGEN

APPENDIX C : FLEXAIR BULK TRANSPORTATION SYSTEM

FLEXAIR

BULK TRANSPORT SYSTEMS

The FLEXAIR Bulk System

When installed in a new or used trailer, the system permits the hauling of both bulk and/or palletized shipments.

Costs can be cut significantly by eliminating the use of a specialized bulk tanker, which is often only loaded one way, and by eliminating unprofitable and/or empty backhauls for your van trailers.

The FLEXAIR Bulk Transport System has been engineered and designed to meet the rigorous demands of the trucking industry. When not in use, both units of the system are stowed in the front of the trailer. To convert from piece goods to bulk takes about 10 minutes.

OTHER FEATURES:

- Aluminum Frame Construction (Durable and Lightweight)
- FDA Approved Systems Available
- Complete Clean-Out Guaranteed
- Safe and Simple Operation
- Easily Installed and Removed From a Trailer
- Interfaces Easily with Pneumatic Unloading Equipment

The FLEXAIR Sy

1. As the bulk material is unloaded, flow may be interrupted when the material reaches it's natural angle of repose.

2. As the heavy-duty air bag is inflated, the frame tilts inward, causing the bulk material to flow. (Only 1-2 PSI required)

1. When not in use, both Flexair Bulk storage units are stowed in the front of the trailer. Each unit is 12" wide.

2. Once moved into position (via the overhead tracks), the operator activates the pendant control which opens the unit.

3. The bulk units are filled through weather tight hatches mounted on the trailer roof.

4. The system is filled with bulk material. (1250 cu. ft. capacity)

5. As the new air bag is inflated, the air flows inward, causing the material to flow.

6. For the inflation of the air bag, the material continues to dump until each unit is empty.

7. For unloading, the discharge hopper door opens, providing easy access and inspection.

8. UL Approved electronic controls and blower provide simple and safe operation of the system.

Designed for use in dry van and reefer trailers.

stem: How It Works

3. Further inflation by the blower causes more material to be discharged from the unit. "Dumping" action occurs simultaneously with activation of the blower.

4. When the left side becomes empty, the air bag deflates automatically. At that time, the other side begins the "dumping" cycle. Complete clean-out is guaranteed.

FLEXAIR's Test/Demonstration Lab

Full Scale Demonstration Lab

To learn more about the FLEXAIR Bulk System, and other FLEXAIR Products, we welcome you to visit our full scale test and demonstration facility. The facility is located approximately 48 miles north of Boston's Logan Airport.

The FLEXAIR Demonstrator Trailer is Available for "Over The Road" Customer Testing.

To provide our customers with the best possible service and equipment, we are pleased to make our demonstrator trailer and pneumatic unloader available for testing within your operation.

Special Note: The FLEXAIR Bulk Transport System received special consideration from the U.S. Department of Patents and Trademarks for its potential to save energy.

Patents Pending.
U.S. Patents # 4,722,655
4,854,801

FLEXAIR

FLEXAIR, INC.
180 Lafayette Road
North Hampton, New Hampshire 03862
603-961-7474

APPENDIX C : FLEXAIR BULK TRANSPORTATION SYSTEM

FLEXAIR

BULK TRANSPORT SYSTEMS

The FLEXAIR Bulk Transport System permits the hauling of both BULK and/or PALLETIZED GOODS in the same van trailer.

The FLEXAIR Bulk System

When installed in a new or used trailer, the system permits the hauling of both bulk and/or palletized shipments.

Costs can be cut significantly by eliminating the use of a specialized bulk tanker, which is often only loaded one way, and by eliminating unprofitable and/or empty backhauls for your van trailers.

The FLEXAIR Bulk Transport System has been engineered and designed to meet the rigorous demands of the trucking industry. When not in use, both units of the system are stowed in the front of the trailer. To convert from piece goods to bulk takes about 10 minutes.

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- Interfaces Easily with Pneumatic Unloading Equipment

The FLEXAIR Sys

1. As the bulk material is unloaded, flow may be interrupted when the material reaches it's natural angle of repose.

2. As the heavy-duty air bag is inflated, the frame tilts inward, causing the bulk material to flow. (Only 1-2 PSI required)

1. When not in use, both Flexair Bulk storage units are stowed in the front of the trailer. Each unit is 12' wide

2. Once moved into position (via the overhead tracks), the operator activates the pendant control which opens the unit

3. The bulk units are filled through weather tight hatches mounted on the trailer roof

4. The system is filled with bulk material. (1250 cu. ft. capacity)

5. As the heavy-duty air bag is inflated, the frame tilts inward, causing the material to flow.

6. Further inflation of the air bag (1-2 PSI) continues to "dump" the material until each side is empty

7. For unloading, the discharge hopper door opens, providing easy access and inspection.

8. UL Approved electronic controls and blower provide simple and safe operation of the system.

Designed for use in dry van and reefer trailers.

stem: How It Works

3. Further inflation by the blower causes more material to be discharged from the unit. "Dumping" action occurs simultaneously with activation of the blower.

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