”FLUIDIZATION HOSE SCIROCCO II” – A new transportation concept with many references within companies handling dry, fluidizeable bulk products.

It is estimated that the handling of goods represents 30 – 75 % of the production costs for different products, despite the fact that the handling does not enhance the value of the product. Therefore, efforts are being made in order to reduce the handling costs. In the following, a number of different concepts for the transportation of bulk goods will be described and the energy aspects will be discussed. The development towards reduction of the capital costs for handling systems for bulk goods will also be discussed, something that often contributes to lower energy consumption. As a rough general estimate, the operation and maintenance costs for a goods handling system represents 10 % of the investment costs.

EPRI - Electrotechnology Reference Guide 4527 – reckons that the U.S. industrial consumption of electricity for handling of goods (excl. gases and liquids) amounts to 18%. In other words, it is important to consider the energy costs when choosing a transport system. The transportation of goods can be divided into internal and external transports. This report will only deal with internal transports of bulk goods*⁾.

Transportation of bulk goods

At present, transportation of bulk goods within companies producing and processing bulk goods are characterised by:

- numerous kinds of bulk products with very varied properties.
- great differences with regard to transportation distance
- a broad spectrum of parameters within each industrial plant
- demanding environmental requirements
- individual implementation of specific technical processes

Choice of suitable transportation system for each specific bulk product

The difficulty of selecting the optimal transportation system is connected with the fact that it is hard in advance to define the properties of each individual particle as well as the properties of all the different kinds of bulk products, which are also influenced by the external environment.

Properties of each individual particle

- Size, shape and surface properties
- Porosity and pore characteristics
- Strength and hardness
- Density
- Chemical composition

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*⁾ **Definition of bulk goods:** “Bulk goods are unpacked goods with a state of aggregation that is neither firm, nor liquid, nor gaseous and that consist of an accumulation of firm particles.
In large quantities, bulk goods are reckoned as bulk cargo.

Properties of bulk goods

- Volume weight **), porosity and compressibility.
- The bulk good's internal angle of friction and angle of repose
- Compressive strength
- Tensile strength
- Cohesion
- Particle size distribution
- Component composition of the particles
- Elasticity
- Melting point

Properties of the bulk goods influenced by the external environment

- Angle of friction in relation to the structure of the transportation system
- Humidity and hygroscopicity
- Deposit tendency
- Electrostatic charging
- Magnetism
- Physical and chemical separation
- Self-induced fluidization, gas adsorption, fluidization and gas permeability
- Formation of dust, dust explosion limit and explosion index
- Flammability
- Crush sensitivity and abrasion resistance
- Adhesion
- Risk factor
- Chemical properties
- Biological properties
- Corrosion
- Abrasion

) Occasionally, one even distinguishes between four kinds of **volume weight or bulk density, one for each:

- fluidized bulk goods
- vibrated bulk goods
- stored bulk goods
- bulk goods in movement

There are no “constant” parameters that comprehensively describe a certain kind of bulk goods in an adequate way.
One way to make a rough judgement with regard to the free-flowing properties of certain kinds of bulk goods is to squeeze them in your hand and check if they form lumps. Another simple method is to measure the angle of repose. However, the most relevant method is to measure the internal friction angle of the bulk goods.

The purpose of the transportation systems and the transportation media.

The purpose of the transportation systems is to set the bulk goods in motion, while the transportation media guide the flow of the bulk goods. The most important transportation media are composed of differently constructed and sized tubes with all the necessary fittings and components.

The construction of the transportation media

Pneumatic transportation systems use firm or flexible tubes. The tube system often consists of horizontal and vertical tubes, horizontal and vertical tube bends and angles in order to guide the bulk goods flow. The material can be metal, ceramic, plastic, rubber etc.

In conventional *air-supported gravitation conveyors*, the transportation medium consists of circular or square metal tubes. Internally, the tube has a porous intermediate division that forms one lower section with airflow and one upper section in which the bulk goods are transported. The air that is channelled through the lower section of the tube is pressed through the porous intermediate division and fluidises the bulk goods in the upper section.
In this metal construction, gravitation is used as a driving force. Therefore, the transportation medium has to slope so that bulk goods are transported forward by their own gravity.
In the *fluid hose air-supported gravitation conveyor SCIROCCO II,* the transportation medium consists of a flexible rubber hose with a fluidization bottom that is vulcunized into the wall of the hose.

The current fluid hose dimensions vary between 2” and 10” and the standard lengths are 6 m or 10 m. To give an example, the radius of the tube bend is 800 mm for a 4” fluid hose, 1,000 mm for a 6” fluid hose and 1,200 mm for an 8” fluid hose. Conventional flange connectors can be used. The hose must be aligned in a downward slope.

The *Gatty System* uses a transport medium consisting of firm or flexible tubes for pneumatic transportation with an internal fluidization hose for partial fluidization of the bulk goods in order to improve the transportation properties and reduce the risk for jamming of the tube system. It is mainly used for horizontal transportation.

The *Fuidcon System* can be regarded as a variant of the *Gatty System.* The transportation medium is composed of a metal tube for pneumatic transportation, in which the fluidization unit is located outside the tube system meaning that there is no reduction of the transportation area, a concept very similar to that of SCIROCCO II. The system allows horizontal transportation – even via horizontal tube bends.

In *mechanical conveyors*, as in screw conveyors and spiral conveyors, the transportation medium consists of a mounted conveyor structure in the shape of a tube or a closed container with an internal propelled screw or spiral axle that propels or pulls the goods. In order to cope with transportation bends, these screw or spiral conveyors normally have to be duplicated, unloading one conveyor before the bend and reloading a new conveyor after to bend. It is possible to use these conveyors for horizontal, vertical or sloping transportation of the bulk goods.

There are also screw and spiral conveyors for smaller bulk goods quantities that can be bent in all directions and transport the bulk goods horizontally, sloping or vertically. The outer covering, screws and spirals are of various metal qualities and the bendable, flexible conveyors are made of rubber and plastic.

Choice of conveyor system

The following criteria have to be considered when choosing a bulk goods conveyor:

- The properties of the bulk goods
- Transportation volume per time unit
- Direction and length of the transportation distance
- Unloading and loading conditions

Like most new transportation technical solutions, the SCIROCCO II fluid hose is no innovation but an elegant and optimal further development of the air-supported gravitation systems that are available on the market. In other words, by utilising the fluidization and gravitation effect of the bulk goods, conventional technology is used in order to transport bulk goods using a suitable downward slope of the conveyor. Since 1998, more than hundred SCIROCCO II fluid hose systems have been successfully installed and it has been shown that this new technical transportation concept really offers substantial advantages.

Installation example 1

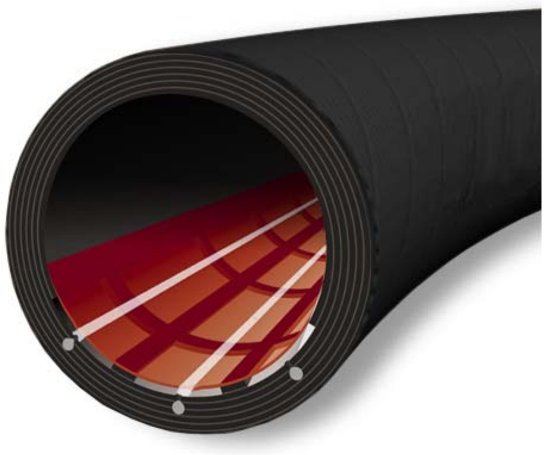
Installation example 2

Installation example 3

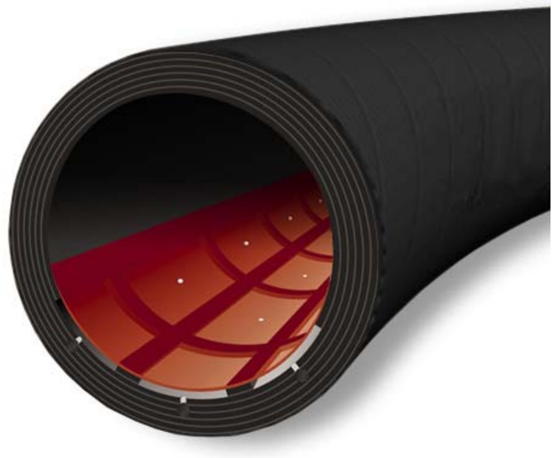

Installation example 4

Once again, it is evident that one always underestimates the number of possible improvements available within the framework of conventional technologies.

The environmental-friendly SCIROCCO II has a low consumption of energy, flexible mounting possibilities and low investment costs. The SCIROCCO II fluid hose is an enclosed system along the entire transportation distance. Thanks to the fact that the fluidization bottom is vulcanized into the wall of the hose, the entire cross section of the hose can be utilized for the bulk goods flow. For example, the fluidization bottom of a 4" fluid hose with a length of six meters, consists of 300 rectangular fluidization sections (40 x 60 mm). Each section is individually fed with air, or some other kind of gas, through three separate channels. The separate flow of air or gas through each fluidization section reduces the amount of bulk goods deposits after each completed transport operation, which also means that it is easier, when using SCIROCCO II, to start up a new transportation operation. The number of fluidization sections and channels variate depending on the dimension of the fluid hose. The circle sector's central angle φ of the fluidization cross section is set at an optimal 120 degrees. This means that the bend of the circle sector forms the fluidization basis and that it only represents one third of the inner surface of the hose fluidizing the bulk goods. The regulation of the air volume is optimal and can be controlled by means of simple FESTO components.



Air channels



Perforation of the fluidization section

Fluidization cloth

Fluidization bed

The above illustrations show the detailed construction of the fluid hose and the fluidization of the bulk goods.

No surplus air could be observed in a 30 meter interconnected fluid hose.

During January, 2005, a 45 meter SCIROCCO II twin system is to be installed at a Spanish plant.

Suitable bulk products for air-supported gravitation conveyors.

As a principle, all powder and fine-grain bulk products that can be transported by way of conventional air-supported gravitation conveyors are also suitable for bulk transportation in the SCIROCCO II fluid hose. For grain diameters of 3 mm and below, one can observe an increasing use of air-supported gravity conveyors. The grain size has a considerable influence on the viscosity of the fluidized bed and, consequently, the transportability of the bulk goods. In this context, one must remember that the air volume required in order to create a fluidized bed increases quadratically with an increasing grain diameter. Air-supported gravitation conveyors are therefore less interesting for bulk goods with a grain size that is larger than 3 mm. It must also be mentioned that very fine-grain particles have a negative effect on the transportation. Bulk goods containing particles smaller than 10 µm have a tendency to agglomerate. Apart from this effect, particles that are even smaller (grain diameter around 1 µm) may cause adhesion problems that disturb the air-supported gravitation transport or may even make it impossible.

The first air-supported gravitation conveyors were used for transportation of cement and this is still their main application. Today, many other bulk products are transported by means of fluidization. The use of air-supported gravitation conveyors is limited to powder or fine-grain bulk products that can easily be fluidized by air or another gas.
The moisture content, hygroscopicity and electrostatic charging of the bulk goods may cause considerable problems in air-supported gravitation conveyors.

The following bulk products lend themselves well to this technology:

Cement
Ash
Aluminium Oxide
Aluminium Hydrate
Fe-II Sulphate
Titanium Ore
Gypsum
Micro Silica
Quartz grain
Starch
Phosphate
Sintering powder
Washing powder
Lead Oxide etc.

The predominant grain diameters for the above bulk products range between 15 µm and 200 µm. The volume weights range between 0.80 tons and two tons per cubic meter. The density may vary between two and four tons per cubic meter.

Performance and function of the conveyors

There are no moving parts in the air-supported gravitation conveyor. It is cost-effective but has the disadvantage that it must be aligned in a downward slope. This means that there might be considerable height differences between infeed and outfeed. The possible slope angle depends on the horizontal distance to be covered and the available level difference between the two conveyor ends. Normally, the speed of the bulk goods flow ranges between 0.5 m/s and 2 m/s. In principle, it is directly proportional to the conveyor slope, which should not have a smaller gradient angle than four degrees. As a rule, the gradient angle of the slope ranges between 3 and 18 degrees. The air-supported gravitation conveyor is suitable for simple and varying transportation tasks. Construction and operation is simple. This kind of conveyor is especially appreciated when used as connecting links between mechanical conveyors in more complex cases of transportation, as infeed devices for machines and as stationary or mobile silos. Despite the necessary investments in auxiliary container conveyors and pneumatic conveyors in order to create new height differences, large processing plants have found it profitable to use air-supported gravitation conveyors. Mechanical conveyors are suitable for a greater variety of bulk products – not only for powder or grain bulk products, but, under certain circumstances, also for viscous and small component bulk products. However, the particle size should not exceed one fourth of the conveyor's screw or spiral diameter. In practise, it is not unusual to find that belt, screw and spiral conveyors are used instead of air-supported gravity conveyors for bulk products with an internal friction angle that ranges between 0 and 30 degrees. This erroneous use can be compared with the transportation of water or loose sand. With their different constructional solutions, screw and spiral conveyors can (apart from the actual transportation process) carry out functions like silo discharge, dosage, screening, mixing etc. On the other hand, the bulk goods must not be sensitive to the mixing and crushing that may be caused by the movements of the screw or the spiral within the container or tube system. The motor drive and the movements of the screws and spirals give rise to a high noise level. Special constructional material is needed for these conveyors if the bulk goods are very rough and abrasive. For instance, a stainless construction also enables the transportation of foodstuffs and aggressive chemical bulk products. A higher yield can be achieved when using a spiral conveyor, which is a screw conveyor without an axle, than with a screw conveyor, even for difficult kinds of bulk goods. In the case of long transportation distances, the screw conveyor needs to be equipped with supporting bearings. The spiral conveyor can cope with a transportation distance of 80 meters without supporting bearings and does not therefore obstruct the bulk goods flow. Each of the conveyors available on the market is the result of a number of compromises between costs, capacity, energy consumption, operational reliability and technical length of life.

On the basis of gained experience and data from different installations, we will now show how to achieve the most cost-effective way to transport cement for certain set transportation distances. It is well known that the energy requirement for pneumatic conveyors – suction, low pressure and high pressure conveyors – is considerably larger than that of mechanical conveyors. On the other hand, the investment costs for mechanical conveyors are much higher than those for equivalent pneumatic systems. In comparison with mechanical conveyors, pneumatic conveyors are more flexible and adaptable to the plant's existing conditions and transportation logistics. In other words, the disadvantage with the pneumatic conveyor is the high energy requirements. The disadvantage with the air-supported conventional gravitation conveyor is that it is difficult to achieve a stable transportation and a sufficient discharge of deposits at the conveyor slope and alignment. Residual bulk goods that are unevenly distributed over the entire porous intermediate bottom after completed transportation make it difficult to start up the next transport process. This is due to the fact that air – or another gas – uses the way of least resistance to pass beside these deposits and it cannot therefore form an effective fluidization at the start-up of the transportation process. The power requirement in connection with transportation by means of conventional air-supported gravitation conveyors can be compared with that of a belt conveyor while the power requirement of pneumatic tube transportation is more than twenty times higher.

Then, how does the new SCIROCCO II fluid hose compare with conventional conveyors for different kinds of bulk products? As an example, transportation of cement was selected for a distance of 10 respectively 20 meters (transportation capacity: 50 tons per hour). For this transport example, there is standardised equipment, constructions and data available on the market for a number of different conveyor systems. Consequently, their function and performance can be accurately predicted since the properties of the selected bulk goods – cement – are well-known. For the 20 meter distance, the factory layout made it necessary to apply a conveyer bend section after a straight distance of 10 meters. The following picture emerged with regard to the energy requirement:

Technical menu for effective energy utilization

Conveyor	10 m straight/at a gradient Transport distance	20 m straight/at a gradient Transport distance including partial bend section
	Energy requirement (kWh/ton)	**Energy requirement (kWh/ton)**
SCIROCCO II fluid hose	0.004	0.008
Conventional air-supported gravitation conveyors and belt conveyors	0.06	0.06
Spiral conveyors	0.11	0.25
Screw conveyors	0.3 – 0.44	0.5 – 0.9
Gatty and fluid systems	0.4 – 0.8	0.4 – 0.8
Pneumatic systems	0.8 – 1.5	0.8 – 1.5

Table 1.
A comparison of the different conveyor's specific energy requirements

The energy requirement is very much dependant on the application and is influenced by the properties of the bulk goods, the alignment of the conveyor and the transport distance.

Technical menu for investment & operational costs

Investment and operational costs of the SCIROCCO II fluid-hose concept in comparison with conventional gravitation conveyors, spiral conveyors and screw conveyors.

Conveyor	10 m straight/at a gradient Transport distance	20 m straight/at a gradient Transport distance including partial bend section
	Investment costs per running transport distance meter	**Investment costs per running transport distance meter**
SCIROCCO II fluid hose	580 € (754 USD)	600 € (780 USD)
Conventional air-supported gravitation conveyors and belt conveyors	1,050 € (1,365 USD)	990 € (1,287 USD)
Spiral conveyors	1,590 € (2,067 USD)	1,720 € (2,236 USD)
Screw conveyors	1,220 € (1,586 USD)	1,290 € (1,677 USD)
Gatty and fluid systems	650 € (845 USD)	660 € (858 USD) (estimated)
Pneumatic systems	510 € (663 USD)	520 € (676 USD)

Table 2
Investment costs for different conveyor systems per running transport distance meter

The transport capacity of the mechanical conveyors can be adjusted by changing the number of revolutions of the screws and the spirals while the bulk goods flow of air-supported gravitation conveyors can be influenced by changing the alignment of the downward slope and the air supply. The volume capacity of tray and tube screw conveyors normally ranges between 6 and 230 cubic meters per hour, which is equivalent to the performance of the SCIROCCO II fluid hose (see diagram 1). It should be mentioned that it has been possible to achieve such high capacities as 3,000 cubic meters per hour in conventional air-supported gravitation conveyors.
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Diagram 1
Volume capacity as a function of the transportation speed (m/s) for different fluid hose dimensions
The use of the fluid hose is limited to the kinds of bulk goods that can also be handled by conventional air-supported gravitation conveyors. The flexible fluid hose is characterised by its low air and energy consumption, its unique fluidization system, its easy installation, its performance to produce a good flow all through the transportation distance and its low investment costs. Unfortunately, many similar innovations within the transportation technical area are confronted by conservatism within the market.

Typical counter-arguments are:

- Since many years, we use sloping containers, screw conveyors and other conveyors and we do not want additional alternatives.
- We already have too many different conveyor systems
- We have no place for new conveyors
- We want to keep to our existing systems because we know how to operate them.
- What can SCIROCCO II add to competing systems? We have managed without SCIROCCO II and will continue to do so.

True, it is equally difficult for a manager or a scientist to predict whether the fluid hose will soon have a break-through or whether the market will keep to conservative solutions. The fluid hose is already a superior substitute to mechanical and conventional air-supported gravity conveyors for powder and fine-grain bulk products within many branches, something that has been proven by the plus hundred SCIROCCO II units in operation. In order to succeed even better on the market and to achieve a broad break-through, certain modifications should be made. The fluid- hose concept must be extended to cover other system components, such as bulk product gearings, loading equipment etc. The fluid-hose principle and the existing hose concept opens up new possibilities for pneumatic devices that can contribute to increased transportation capacity, improved yield and higher operational reliability. Such expectations have to be fulfilled and tested. Comprehensive research and development work has to be carried out. The transport technical innovation represented by the SCIROCCO II fluid-hose concept is a typical result of successful efforts made in order to achieve an energy and operational effective handling system for bulk goods.

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