

COST EFFECTIVE SOLID-LIQUID SEPARATION:

A SIMPLER AND MORE EFFECTIVE DEWATERING TECHNOLOGY

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Introduction

Cost effective solid-liquid separation technology is essential to the economical production of solids or filtrate in the chemical, food processing and mining industries. To achieve this, the plant engineer faces a wide selection of filter technology. The chosen technology should achieve the desired solids and filtrate properties, provide reliable operation as well as offer low installation, operating, and maintenance costs. Unfortunately, a great deal of the technology available today does not satisfy all of these requirements and a misguided decision may result in significant operating difficulties, high operating and maintenance costs, and a poor return on investment. This paper introduces a new technology that addresses these requirements and provides case studies from several applications where this technology has been successfully implemented.

Conventional Filter Technology

The most widely used conventional filter technology includes filter presses, vacuum filters, centrifuges, low-pressure automatic pressure filters and high-pressure or mechanical expression automatic pressure filters. Conventional filter presses suffer from unavoidable labor costs and solids build-up removal problems that may result in leakage and damage. Despite attempts at automating filter presses, there remains the need for a great amount of operator intervention and large volumes of wash water to clean the filter media. Vacuum filters often produce high cake moistures, high solids content in filtered liquid and require large amounts of floor space and peripheral equipment. Centrifugal separation often requires high maintenance and expensive installation for the rotating equipment, inefficient washing or dewatering of solids, extensive structural and foundation support, large amounts of surrounding equipment, and large areas of floor space. Low-pressure coolant type automatic pressure filters have been limited in capacity

and pressure differential for acceptable throughput and performance. High pressure or mechanical expression automatic pressure filters are very complex mechanically, have a multitude of expensive components and require intensive maintenance. Together, these result in unscheduled downtime and loss of production.

NEW FILTER TECHNOLOGY

In order to address the limitations of conventional filter technology as outlined above, the ***Pneumapress***® Filter Corporation introduced a new series of high-pressure automatic pressure filters (APF's). The focus for the design of the new high-pressure APF was to develop very effective filtration technology using mechanically simple and robust equipment available in a wide range of capacities. These filters are available either as a Single Module Filter with only one filter chamber (figure 1.0) or as a Multi Module Filter with multiple chambers (figure 2.0). A filter overview with operating sequence, process flow diagram, process parameters and case studies are provided below to illustrate the filters effectiveness and simplicity.



Figure 1.0 Single Module Filter

Filter Overview

A very simple mechanical structure is used to support the filter. The structure consists of two columns, an upper and lower support beam and two base beams. These components are illustrated in figures 1.0, 2.0 and 3.0. Within the support structure are the filter plate(s) and a single hydraulic cylinder. The hydraulic cylinder is used to open and close the filter plate(s) and keep the plate(s) closed when the filtration process is in progress. Each filter plate consists of an upper and lower chamber with two layers of filter belt between the chambers. Each filter plate has its own individual filter belt, belt drive system and belt wash system. Piping to feed the filter is typically supplied as shown in figure 3.0 and the filter is controlled using a PLC. Filter cakes are discharged into a cake removal system such as a mixing box, conveyor or tote box. A process flow diagram is shown in figure 5.0.

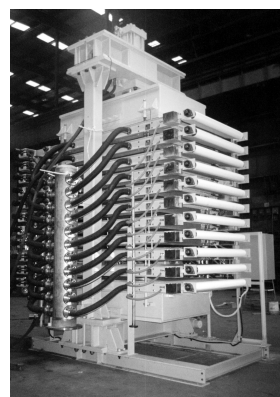


Figure 2.0 Multi Module Filter

Filter Operation

The filter cycle consists of a sequence of filtering steps that incorporate certain filtration principles to optimize the production of solids and filtrate. The sequence of filtering steps in a typical ***Pneumapress***® filter application, where slurry must be effectively washed and dewatered to produce substantially dry solids, is described below. These steps are illustrated in figures 4.1 to 4.4.

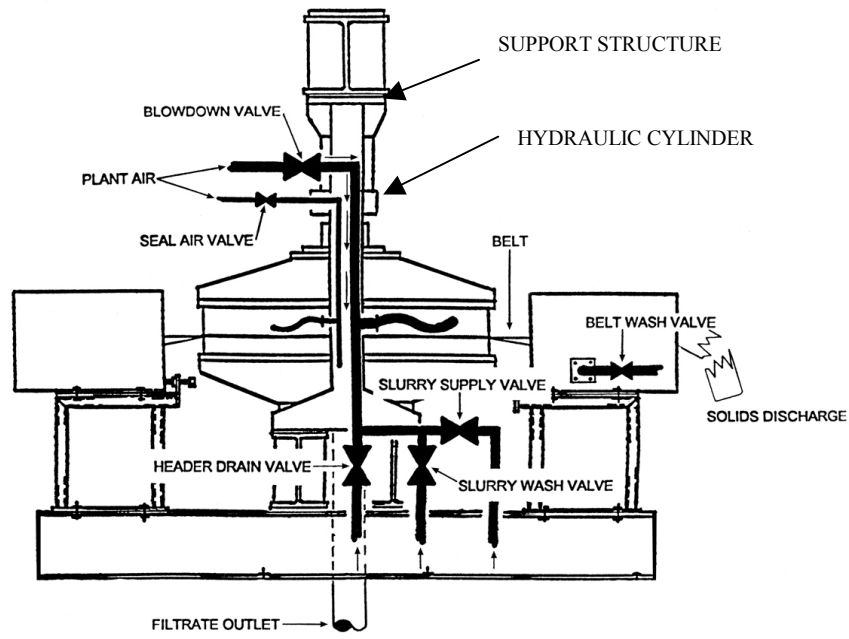


Figure 3.0 Single plate filter showing piping layout

Sequence Of Operation

Step 1 – Filter Plate Closes

In Step 1, the upper chamber closes on a double layer of filter media that is supported by a grid on the lower chamber.

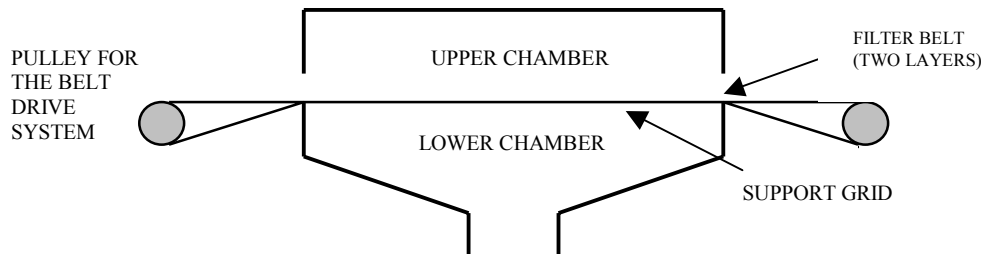


Figure 4.1 Filter Plate Closes (shown open)

Step 2 – Slurry Fill

In Step 2, slurry is pumped into the upper chamber of the filter plate (figure 4.2). A filter cake begins to form on the filter belt as the solids are retained on the filter belt and the clean filtrate passes into the lower chamber of the filter plate and out of the filter. The slurry fill period or duration may be controlled using time, slurry pressure, weight, or a flow monitoring system. The optimum slurry fill time or slurry inlet pressure set point may be the fill time or pressure set point that produces the most solids or filtrate per cycle without a decrease in cake dryness or loss of wash liquid effectiveness. Increased cake size and a double layer of woven filter media provide a more tortuous path for the slurry, thus improving filtrate clarity and minimizing product loss.

Step 3 – Cake Wash

In Step 3, which is implemented if washing of the filtered solids is desired, wash liquid is introduced into the upper chamber of the filter plate to wash dissolved material from the solids retained on the filter belt (figure 4.2). With other filtration methods, obstacles in the filter chamber have hampered effective washing of dissolved material from the slurry. The obstacles include squeeze mechanisms, structural components, and filter inlet and outlet components. The design of the *Pneumapress*® filter chamber optimizes molecular contact between the slurry solids and the wash fluids.

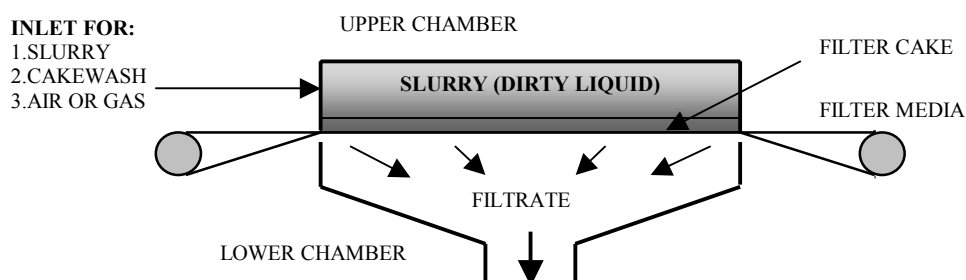


Figure 4.2 Steps 2 and 3 of the filter cycle

Step 4 – Gas Squeeze

In Step 4, compressed air or gas is introduced into the filter chamber to force liquid from the solids and to squeeze and dry the solids retained on the filter media (figure 4.3). As the air or gas enters the filter chamber it displaces the slurry and de-waters the solids that have formed on the filter media. No diaphragm or other squeeze mechanisms are used within the filter chamber to dewater and dry the filter cake – the air or gas does all the de-watering and drying. A sufficient supply of compressed air used at optimum pressure differential results in decreased air use and very fast and effective dewatering.

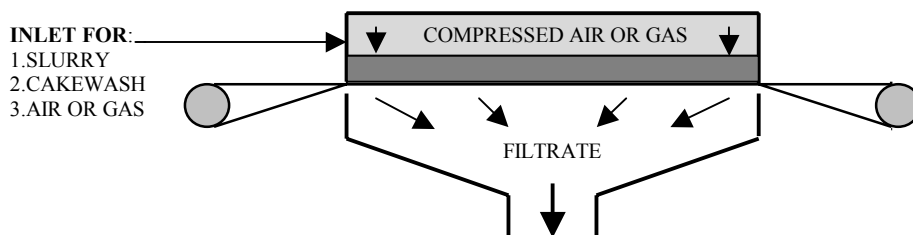


Figure 4.3 Step 4 of the filter cycle

Step 5 – Plates Open

In Step 5, the filter plate opens and the newly formed dry filter cake is retained on the filter belt.

Step 6 – Cake Discharge

In Step 6, the final step of the filtration cycle, the filter belt advances and the dry filter cake is discharged into a mixing box, tote box or onto a conveyor belt (figure 4.4). As the belt advances, it is washed and a clean section of filter belt moves into the filter chambers in preparation for the

next filter cycle. No operator intervention is required at any time during the filter cycle – the filter cycle is fully automatic.

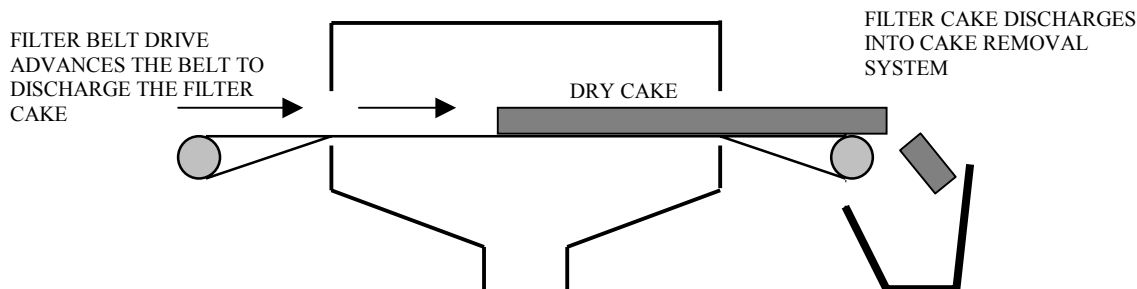


Figure 4.4 Step 6 of the filter cycle

After the filter cake is discharged, the filtration cycle is automatically repeated. Typical cycle times vary from less than one minute to several minutes, depending on the application. The operating principle of a single-module filter with one filter plate is virtually identical to that of a multi-module filter with a number of filter plates.

Process Flow Diagram

A typical process flow diagram for the installation of a *Pneumapress*® single or multi-module filter is illustrated below in figure 5.0. As illustrated in the process flow diagram, the installation of the filter is very simple and does not require complex peripheral equipment.

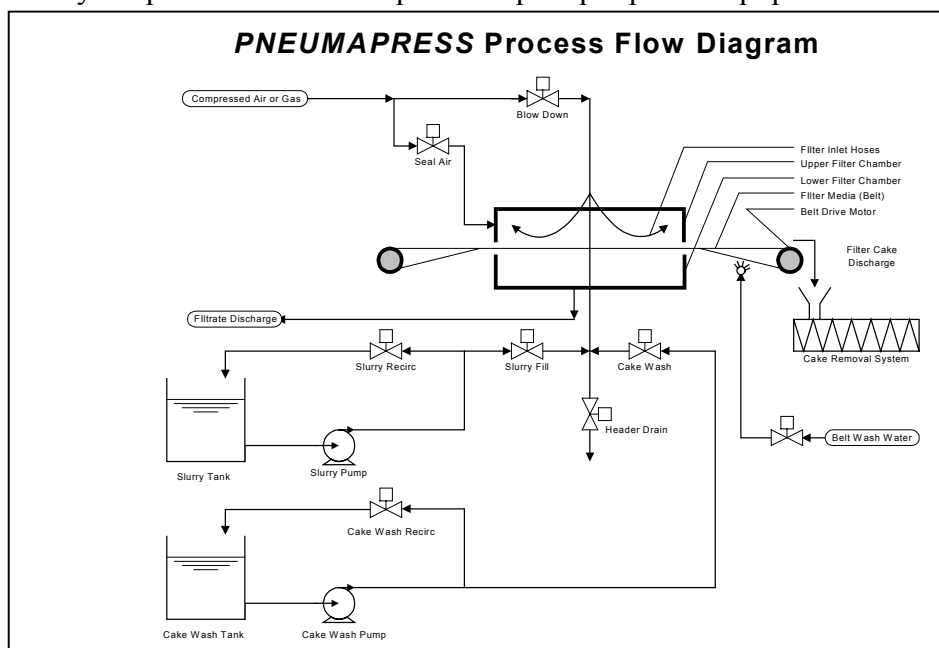


Figure 5.0 A typical process flow diagram for a *Pneumapress*® single or multi-module filter.

Filter Process Parameters

Typical *Pneumapress*® filter operating parameters are provided in Table 1.0 below. Actual operating parameters vary with each product being filtered.

Individual Filter Plate Area	Plates are manufactured in 1.3 ft ² , 3 ft ² , 8 ft ² , 12 ft ² , 19 ft ² , 30 ft ² (.12m ² , .28m ² , .74m ² , 1.11m ² , 1.76m ² , 2.78m ²)
Number of filter plates per filter	Filters are available with 1 to 24 plates
Total filter area per filter	Filters are available in sizes of 1.3 ft ² to 720ft ² (.12m ² to 67 m ²)
Slurry capacity	Filters are available to process from 1 to 10,000 gpm (.22 m ³ /hr to 2,271m ³ /hr)
Solids capacity	Filters may produce 1 to 250,000 lbs/hr of de-watered solids (.45kg/hr to 113,000kg/hr)
Operating pressure	Filters are available to operate at up to 360 PSI (25 Bar)
Operating temperature	Filters are available to operate at up to 400°F (204°C)
Filter cycle time	Cycle times vary from 30sec to 5mins
Materials of construction	Carbon Steel, Stainless Steel and many specialized materials
Floor space requirements	Smallest models require 30ft ² – largest 150ft ² (2.8m ² to 14m ²)

Table 1.0 Typical *Pneumapress*® filter operating parameters

ADVANTAGES OF THE PNEUMAPRESS® FILTER

The *Pneumapress*® single and multi-module filters differ from conventional filters in several ways. These key differences greatly enhance the effectiveness of the *Pneumapress*® filter by providing many operational advantages. Some of these advantages are discussed below:

1. Low Installation Costs – minimal structural installation requirements, minimal floor space requirements, simple assembly, few process connections and minimal peripheral equipment results in low installation costs.
2. Low Maintenance Costs – because of the mechanical simplicity of the filter and the selection of components to ensure local availability for the end user, maintenance costs are minimized.
3. Mechanical Simplicity – each *Pneumapress*® filter is designed and constructed with the objective of minimizing the number of components required. The filter uses a fraction of the mechanical components used on other filter equipment.
4. Operational Simplicity – each filter is extremely simple to operate. The filter is completely automatic and no operator intervention is required at any time during the filter

cycle. The filter may be operated from a control panel next to the filter or from a remote control point using a DCS or other control system.

5. Reliability – because of the mechanical simplicity of the filter and the low maintenance required, filter reliability and minimum downtime is ensured.
6. High Performance – very high throughput per unit of filter area is achievable because of the fast filtration cycles.
7. Highly Effective Cake Washing – the design of the filter chamber optimizes molecular contact between the cake wash and the filter cake. This ensures consistent cake wash results with a minimum use of wash water.
8. Isolatable Filter Plates – the heavy duty design and construction of the filter plates allows the individual filter plates of a multi-module filter to be isolated during production. This design also eliminates the risk of damage to the filter plates that results when process malfunctions create internal pressure differences within the filter.

CASE STUDIES

Case Study No. 1: Removal of Precipitated Silica From a Clarifier Underflow

In the Imperial Valley of California a geothermal power generation facility uses a dual flash, crystallizer-clarifier process to control solids precipitated as the geothermal stream cools. Precipitated silica solids must be continuously removed from the system to maintain effective operation. The solids are removed at the clarifier underflows from a 224°F stream containing approximately 33% solids by weight and approximately 30% dissolved salts.

Among equipment previously utilized to de-water underflow sludge were plate & frame filter presses, cavity filter presses, centrifuges, sludge drying beds, vacuum trucks, horizontal plate filters (low pressure APF's) and high-pressure mechanical expression filters (high pressure APF's).

In the past, horizontal plate filters (low pressure APF's) and expression or squeeze filters (high-pressure APF's) have been the most attractive equipment to dewater geothermal sludge. Benefits of utilizing horizontal plate filtration include uniform distribution of filtered solids and a large filter area. However, the hot corrosive geothermal slurry limits the choice of materials utilized in the filters. Elastomer products such as gaskets, diaphragms, and chamber seals became consumables requiring a significant amount of manpower for disassembly of the filter and removal and replacement of the consumable parts at regular intervals. Problems such as joint leakage, separation of components, and crushing of horizontal divider plates occurred with the low pressure APF. Elastomer diaphragms used to squeeze the hot brine slurry through woven filter media with the high pressure (mechanical squeeze) APF's failed at regular intervals and therefore required frequent replacement. Also, the diaphragm filters require a separate skid, reservoir and piping equipment for diaphragm filling and retraction.

A factor limiting production with the expression (mechanical squeeze) high pressure APF's is the operating cycle and configuration of the filter chamber. Due to the chamber configuration of the high pressure expression APF and non-uniform resistance to flow through the cake, effective cake washing to remove solubles required a large amount of wash water both increasing cycle time and water use. Another factor limiting production is the time involved to fill and retract diaphragms and inflatable seals (when used). A typical expression filter produced a filter cake every 8 to 12 minutes when the filter was in good working order. The **Pneumapress®** filter, which used shorter cycle times (2 to 4 minutes) combined with more effective solids and filtrate production, substantially outperformed the expression filter with much less filter area – see figure 6.0.

The limitations in production with the low pressure APF and expression high pressure APF were overcome with the **Pneumapress®** filter by eliminating diaphragms and expression mechanical equipment, inflatable chamber seals, and diaphragm fill and retract equipment. The problem of crushing filter plate components was overcome by using more suitable filter components and incorporating design parameters better adapted to service the filtering application. To accommodate the severe operating environment of the hot corrosive geothermal slurry and maintain structural integrity, wetted filter components were fabricated from a corrosion resistant alloy using fabrication techniques that remove internal residual stresses from the structure, eliminate deformation while in service and prevent sensitization of the filter components. Furthermore, the filter structure is designed to provide effective distribution of the internal pressure and resulting forces, thus enabling the filter to withstand high operating pressures. The **Pneumapress®** Filter is also designed to accommodate unrestricted flow through an optimum chamber configuration to maximize particle contact in the filter chamber for effective washing of slurry solids. Another benefit of the **Pneumapress®** Filter is the introduction of technology to eliminate leakage of slurry and filtrate during filter operation without the use of consumables such as gaskets, o-rings or inflatable seals.

Eliminating specialized equipment, eliminating consumable components and adapting appropriate fabrication techniques using corrosion resistant alloys have enhanced the reliability of the **Pneumapress®** Filter and reduced the cost of operating the Geothermal Plant.

Case Study No. 2: Metal Hydroxides, Metal Sulfides and Calcium Compounds

In the chemical industry, filtration (and often cake washing) is essential to many processes. Aluminum and magnesium hydroxide can be difficult to both filter and to wash the filtered solids. Conventional methods such as centrifuges, vacuum filters or filter presses often result in high cake moisture and ineffective cake washing. Centrifuges produced wet, unwashed solids

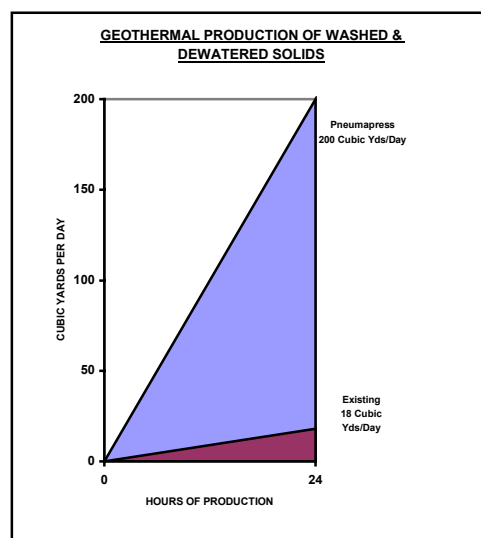


Figure 6.0 Geothermal Production

and required intensive maintenance. Vacuum filters allowed high levels of solids in the filtrate that must be thickened downstream and reprocessed. Vacuum filters would not produce dry cake nor wash the solids uniformly. With the introduction of new filtration methods and variable pressure differentials using ***Pneumapress***® filtration technology, metal hydroxides were easily and effectively washed and dewatered in a short period of time, resulting in efficient production of dry, washed filter cake.

Dewatering molybdenum sulfide and leaching impurities from molybdenum sulfide requires the filter cake be dewatered, or dewatered and washed of cyanide salts. The filter cake dryness is essential to economical thermal processing. Vacuum filters and diaphragm type APF filters have been used to process molybdenum sulfide. Vacuum equipment consumed extensive energy and manpower to maintain, and resulted in unwashed, moist filter cake having high thermal processing requirements. Diaphragm type APF filters required intense maintenance to keep the filters operational. ***Pneumapress***® filters substantially reduce energy and maintenance requirements while efficiently washing the cake and producing dry solids.

Arsenic sulfide and copper sulfide must be efficiently and thoroughly washed, then dewatered to low moistures for economical processing. Vacuum belt filters had been used prior to the introduction of ***Pneumapress***® technology; however, the vacuum filters allowed high levels of solids into the filtrate and would produce cake with a maximum of only 60 % cake solids. ***Pneumapress***® filters effectively washed and dewatered the solids with much less equipment in very short filtration cycles and brought cake solids above 75%. New methods being introduced using ***Pneumapress***® technology will result in substantially higher cake dryness.

Precipitated calcium carbonate and calcium sulfate processing can significantly benefit from high cake solids content. The nature of the dewatering process allows a higher quality and more uniform crystalline structure to be produced using the ***Pneumapress***® filter. With the introduction of new methods by ***Pneumapress***®, cake solids as high as 98.5% have been achieved in a very short filtration cycle time.

OPERATING BENEFITS AND SUMMARY

Because the ***Pneumapress***® filters are simple, versatile, and almost free of consumable items, they can be suited to many applications, including specialized applications such as processing corrosive and/or high temperature streams. The filters produce dry and uniform solids, high quality filtrate and are simple to operate and maintain. Very dry (up to 98.5% solids) can be produced, which can reduce or eliminate dryer requirements. Containment of toxic gases or volatile materials can be controlled with the simple design. Steam or non-reactive gas may be used to displace liquids from solids to prevent oxidation or avoid reactive mixtures during separation.

Versatility of the filter also means adaptability to rapid advances in filter media technology. Technical advances in filtration media at ***Pneumapress***® are used to produce dry cake, effective cake washing, clean filtrate and high filter media cycle life. The filter is adaptable to the most efficient filter media suited for each application.

The result of using the ***Pneumapress***® filter to displace existing equipment simplifies operations, reduces floor space requirements, simplifies CIP and greatly increases efficiency in separating solids and filtrate.

The impact of the single and multi-module ***Pneumapress***® filters in reducing operating and production costs will motivate many cost conscience companies, who want to retain competitive operations for the future, to utilize a ***Pneumapress***® filter.
