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CONVENTIONAL WASHROOM

ENERGY EFFICIENCY FROM WASH TO FINISH™
BRAUN

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Introduction

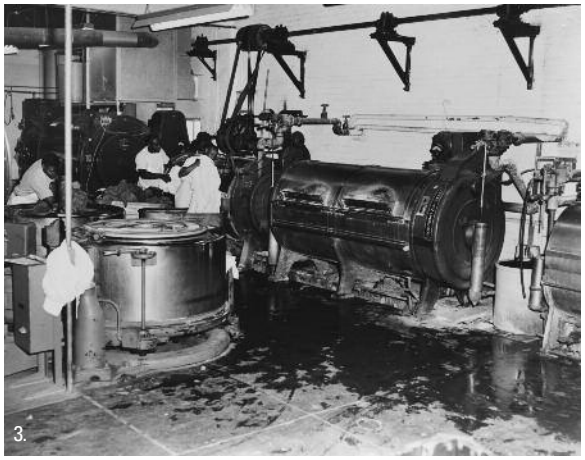
The purpose of this publication is to familiarize the reader with the processing solutions that are employed in the various conventional washroom environments. This publication will examine the four models of Washer/Extractors used in conventional washrooms as well as the drying process and the material handling solutions available. The washers will include Open Pocket Washer/Extractors, Top Side Loading Washer/Extractors, Tilting Side Loading Washer/Extractors, and End Loader Washer/Extractors. Each of these washer extractors serves a distinct environment while providing exceptional wash quality, versatility, flexibility and the ability to process a wide range of goods classifications. After covering the washer /extractors, this publication will examine dryer options available for all washrooms and the science behind drying technologies. We will then examine material handling solutions available for both the semi-automated and fully automated washroom environments.

Before we get into the specifics of each type of equipment utilized and the science behind them, a short history on the evolution of washer/extractors is in order.

Evolution Of The Washer/Extractor

Washers have evolved like most technologies…*to address a need*. These needs have been both process and product based in nature. The earliest machines were hand-operated and constructed from wood, while later machines made of metal permitted a fire to burn below the washtub, keeping the water warm throughout the day's washing.

The earliest special-purpose washing device was the scrub board, invented in 1797.[1] By the mid-1850s, steam driven commercial laundry machinery was on sale in the UK and US.[2] The rotary washing machine was patented by Hamilton Smith in 1858.[1] As electricity was not commonly available until 1930, some early washing machines were operated by a low-speed single-cylinder hit and miss gasoline engine. The National Chemical Company along with the Prosperity Company introduced two key patented technologies between 1920 and 1940. These were the Collar Molder and the Allprest System. These machines also began the formation of the manufacturing processes needed to produce electromechanical washing machines and chemical processing systems. In the early 1940s, the Prosperity Company launched the 20lb electromechanical washer that only washed.



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These early washers did not have an extraction capability. Early on this was done in a separate device known as an *"extractor."* The early extraction process was dangerous since unevenly distributed loads would cause the machine to violently shake. In the late 1940s, an offshoot of the Prosperity Company (G.A. Braun, Inc.) was founded, ushering in the next technological advancements. G.A. Braun, Inc. began experimenting in the late 1950s with a free-floating shock-absorbing frame to absorb minor imbalances, and a bump switch to detect severe movement and stop the machine so the load could be manually redistributed. Eventually the two machines, "Washer" and "Extractor" were combined into one machine by Braun in the late 1950s dubbing the name *"Washer/Extractor."*

Control and chemical addition was yet another area that was pioneered by the Prosperity Company and later by Braun. The first 20lb washer launched by the Prosperity Company held a number of patents and was controlled using the also patented *"Prosperity Formatrol"* chart control. Braun in the 1950s patented the Automatic Chemical Supply Injection System. This solved the problems associated with manual chemical dispensing. In the 1960s, Braun again pioneered the release of the first Pass-Thru Medicare machine, which allowed laundries to separate the soiled side of the machine from the clean side. Also, launched in the 1960s was the first Top Side Loading machine. This machine utilized gravity assistance when loading and unloading. The next major break through from Braun came in the late 1970s with the first washer/ extractor controlled via microprocessor. This truly revolutionized the industry providing precise control over formulas and all machine functions. It also spearheaded the way for automation to gain a foothold in

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the U.S. laundry industry. As can be seen by this short history of washer/extractor development, the Prosperity Company and ultimately Braun were the driving forces behind the successful introduction of washer/extractors into the commercial laundry industry within the U.S.

Now fast forward to the 21st century. The modern industrial washer/extractor has made remarkable progress from these early days of manual intervention and dangerous processes. The modern washer/extractor is capable of washing and extracting over 1,000 pounds of goods in one cycle including extracting water at the end of the wash/rinse steps. The modern washers have also incorporated many safety improvements to make their use in commercial laundries commonplace. These modern washer/extractors are used to launder goods in every industry including hospitality, healthcare, industrial, prison systems, cruise ships, textile mills, and many others. Some still run manually by hand loading and unloading, but many are being used in semi-automated and fully-automated operating environments, reducing labor and increasing productivity. Also, all washers have the ability to reuse water making them highly efficient. As automation became more prevalent, the need for advanced safety solutions also took shape. This automation with the associated safety solutions creates a safer work environment for the laundry operator. G.A. Braun continues to pioneer new designs and improvements to existing machines, especially in the areas of safety and automation with a number of patented and patent-pending solutions that are available today.

Modern washer/extractors clean goods by a process of combining water, time, mechanical action, chemistry and temperature. The washing process is a combination of a number of controlled factors that are balanced. This is commonly known as the *"Wash Pie."* The interaction of the Wash Pie with the washer extractor will be examined in detail later in this publication; however, every washer/extractor functions in generally the same manner. Goods are loaded into the machine either by hand, conveyor, or sling system. Once loaded, the washer/extractor adds water and chemicals to begin the process of soil removal. An important part of this process is the mechanical action generated by the ribs built into the cylinder of the washer/extractor. As the cylinder agitates back and forth, the goods are lifted and dropped by these ribs allowing the chemicals to penetrate the goods and loosen the soil. Once the wash step is complete, a washer typically rinses the goods to remove the chemicals and then neutralizes the goods. Again, mechanical action plays an important role in accomplishing this rinsing step. Once rinsed, the washer begins to spin at increasing speed to evenly distribute the goods around the cylinder diameter. This step is called balancing the load. It is a vital step to ensure that the machine will not violently shake during the next step – extraction. Extraction is accomplished by increasing the speed at which the cylinder spins removing water from the goods by centrifugal force. Most modern industrial washer extractors spin at speeds generating up to 300 times the force of gravity *(or 300g)*. This extraction process typically removes 50-70 percent of the water *(depending on fabric/material type)* allowing for decreased drying times or allowing for faster ironing speeds for those products that do not go through the drying process. The extraction of water in the washer results in energy savings in the down stream processing steps. The energy savings in gas, propane, or steam is often significantly more than the small amount of additional electrical energy used in the additional extraction time.


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Now that we have a general knowledge of the evolution of the washer/extractor and the basics of operation, it is time to take a closer look at the science surrounding the conventional washroom and then the four types of washer/extractors that utilize this science.

Fundamentals of Washing and the Wash Pie

This next section provides the foundation for a more detailed look at the washing process and a comparison of the features of each washer/extractor solution. First up are the fundamentals of washing and the Wash Pie. Second, four types of washer/extractors will be examined in more detail and provide a brief look at the processing environments they serve. Next is a comparison of the Braun features as compared to other competitive offerings in the industry and a general look at some of the green initiatives as they relate to washer/extractors. The publication will continue with a detailed overview of dryer technology and material handling solutions.

The most important aspect of any washer/extractor is the end result…*quality of the wash*. Cylinder volume per pound of goods processed is commonly used as a guide to obtain a quality wash. This is just that, only a guide. Cylinder volume certainly plays a role in wash quality, especially pertaining to mechanical action. However, the overall wash process must be balanced to all aspects of the wash pie in order to obtain high wash quality standards.

Condition Measured	Acceptability per DLI Standard	Braun Results
Final Whiteness Degree	80.0 or more	100 (25% better than standard)
Final Yellowness	-2.0 or lower	-3.3 (65% better than standard)
Blood Stain Removal	40.0 or more	96.6 (142% better than standard)
Bleach Effectiveness	52.0 or more	76.0 (46% better than standard)
Tensile Strength Loss	5% or less	1% (500% better than standard)

Figure 1 – Braun 650 Open Pocket Washer/Extractor DLI Wash Quality Test Results

Braun's washer/extractors have been tested using independent testing from the ***Dry-cleaning and Laundry Institute***[3] ***(DLI). Figure 1*** summarizes the results from a Braun Open Pocket Washer/Extractor at its maximum rated clean dry load weight of 700lbs. All of Braun's washer/extractors including the Top Side Loaders and End Loaders achieved similar results. In general, there are six primary steps used in the washing process. These are flush, break, bleach, rinse, sour, and extraction. They aren't all used in every wash formula and the composition of the wash formula is dependent on goods type, soil factor, etc. to be processed.

A *"flush"* is typically used at the beginning of the wash process for removing heavy soils and/or residual chemistry. A flush is similar to a rinse, but typically a rinse is used after the bleach step versus at the beginning of the wash process. A flush may include alkali, especially in healthcare to prevent setting blood stains. The flush's primary function is to saturate the goods prior to the break and remove large solids from the goods.

The next step is typically a *"break"*, which is most often the first wash step in the washing process. In many wash formulas, all the surfactant and alkali are added during this step. Surfactants are one of the many different compounds that make up a detergent. Surfactants function by breaking down the interface between water and oils and/or dirt. They also hold these oils and dirt in suspension and allow their removal. Alkali contains strong bases like sodium hydroxide and/or potassium hydroxide. The alkali is used to dissolve grease, oils, fats and protein based deposits. The break step typically uses low water levels and is considered the most important step in the wash process as far as soil removal is concerned. There may be a suds operation step following the break to utilize residual concentrations of chemistry remaining from the break to further facilitate removal of residue oils and/or dirt.

The next step, although not always used depending on goods type, is the *"bleach"* step. As the name implies, this is the step that adds oxidation chemistry to remove any remaining stains or residual soil. Bleach effectiveness is

highly dependent on temperature, one of the fundamental pieces of the Wash Pie, and pH *(concentration)*.

Following the bleach step comes the *"rinse"* step(s). The rinse may be structured identical to the flush, but serves the purpose of not only removing any residual soils, but also is vital in removing any remaining chemistry and is used to gradually lower the temperature of the goods prior to extraction. In many cases, more than one rinse is necessary; however, water consumption should be taken into account as rinsing almost always involves a high water level in the washer/extractor. Antichlor may be used to neutralize and remove any residual chlorine that may have been used in the bleach step during the rinse process.

Next is the *"sour"* bath. This is normally the final step in the laundering process prior to extraction. The purpose is to neutralize the alkalinity of the water in the goods. Sour baths are typically run at low water levels and usually at the temperature desired for extracting and finishing. Higher sour bath temperatures will improve extraction and reduce drying time. During the sour, other finish chemicals may be added such as fabric softeners, antibacterial chemicals, brighteners and possibly starch.

The last step of the washing process is the *"extraction"* step. The first phase of extraction involves ramping the speed of the washer/extractor up toward its balance speed, which is usually between 50 – 100 rpm. Once the load has been balanced, the washer/extractor continues to gain speed toward the programmed final extraction speed. This final speed (ω) *(in RPM)* squared times the diameter of the cylinder (D) *(inches)* divided by 70,500 equates to the centrifugal force *(or "g" force)* used to extract water from the goods.

g Force = $(\omega^2 \times D)/70{,}500$

Most commercial washer/extractors have a maximum rpm rating or g force. This is based on the structural design of the machine. A common misnomer is that the higher the g force applied the more water that will be extracted in a given period of time. This isn't necessarily true and typical extraction curves are depicted in **Figures 2 and 3**. Also shown in **Figure 3** is extraction as a function of time. As can be seen in the graphs, g forces above 275 g really have a negligible effect and don't equate to lower moisture retention in most cases. Adding additional time is slightly more effective than running at higher g force. Higher g forces can also cause damage to the goods processed, so larger g forces are not necessarily better and may actually cost the operator more in higher energy consumption, linen replacement and machine maintenance costs. So the conclusion is that if more moisture needs to be removed, time is probably a better option than adding more g force. This additional time is typically offset in shorter dryer times or faster ironer speeds *(for bypass linens)*.

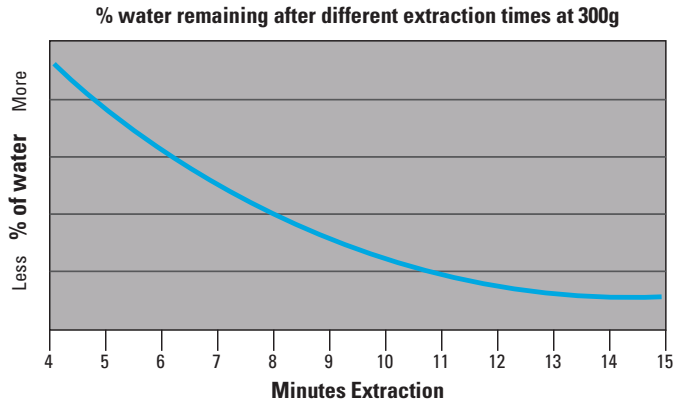


Figure 2 - VariableTime/Constant g Force

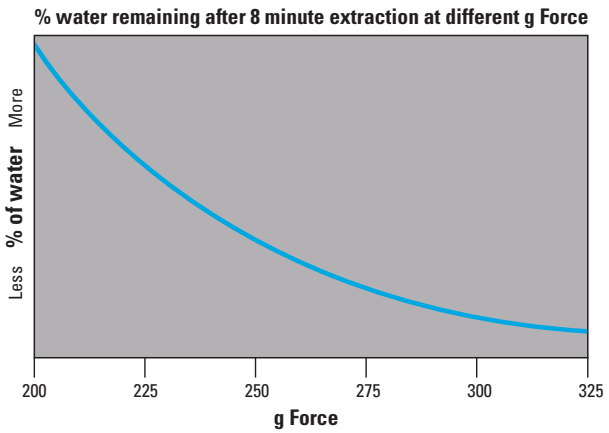


Figure 3 - Variable g force, Constant Time and Moisture Retention

The washing process as previously described in detail is a combination of a number of controlled factors that are balanced. A balanced wash pie is shown in **Figure 4** (adapted from TRSA[4] by Braun).

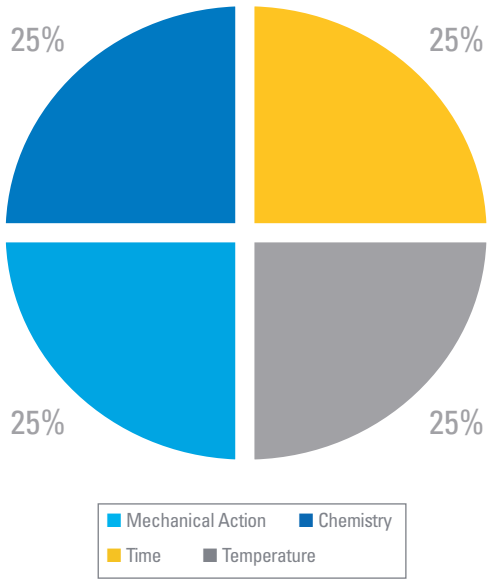


Figure 4

As the wash pie discussion develops, scenarios will be presented that alter the individual contributions of each component. All Braun washer/extractors offer great flexibility and control over all four aspects of the wash pie. Let's look at each piece and how the Braun washer/extractors control and contribute to each.

Mechanical Action

The first piece to consider is *"Mechanical Action."* This fundamental wash function ensures that added chemistry is evenly distributed throughout the goods and contributes highly to the removal of soils. Washer/extractors provide this mechanical action from the rib design used in all washer cylinders. The ribs act as a lifting device picking the goods up as the washer rotates in one direction and dropping them back to the bottom of the cylinder and this continues until the washer reverses direction. The washer then rotates back in the other direction repeating the process of lift and drop. Mechanical action is extremely important, but too much mechanical action can be detrimental. Overly aggressive mechanical action can cause goods/linen damage; especially in fragile materials and can redeposit removed particulate. A degradation of whiteness can also be seen if there is too much mechanical action. If the mechanical action is decreased, one or more of the other pieces of the wash pie must be increased to compensate.

Chemistry

One piece of the wash pie that might be increased due to reduced mechanical action is the *"chemistry"* piece. Most washer/extractors offer three types of chemical dispensing methods. There is a manual chemical chute, an above the water line and below the water line injection port, and an optional manifold for connection of multiple chemical supply lines. With this flexibility, most washer/extractors can handle any situation demanded by the chemical suppliers. If mechanical action, temperature or time is reduced chemistry is often adjusted. The downside is obvious as additional expenses will be incurred for the additional chemistry needed to compensate for the reduction of one or more of the other pieces. This added chemistry may result in a loss of linen life. In some cases, it might be more prudent to add more time to the wash step in order to hold chemical expenses down and reduce the potential for shortened linen life. Temperature might be an alternative depending on the tolerance of the chemistry being used to compensate for a reduction in mechanical action. The point here is that giving up a part of one piece

of the wash pie usually means adjusting one of the other pieces. Time is an easy addition, but it too has a trade off.

Time

"Time" is the third piece of the wash pie and most washer/extractors in the industry today offer PLC touchscreen controls, offering almost limitless flexibility on programmable time parameters within each formula and step. Many consider the addition of time a better alternative when adjustment is needed because of a reduction in one of the other pieces of the wash pie. However, adding time has some downfalls as well. The obvious downside is the reduction in productivity by lengthening the overall wash formula and thus lowering the maximum possible turns per washer per day.

8.

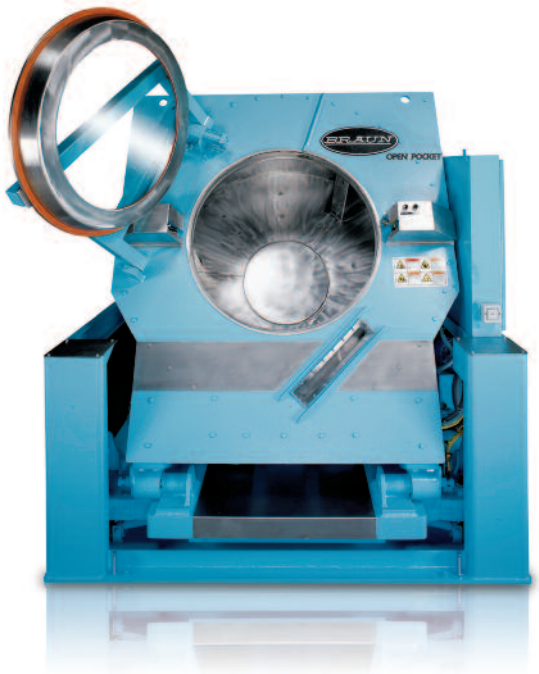
Temperature

The last piece of the wash pie is "temperature." Typically temperature isn't a parameter that is easily adjusted. The reason is that most chemistry used today requires a fairly tight window of temperature to be effective. Too much or too little temperature can have a profound impact on the overall wash quality. As an example, if too much temperature is used in the flush step in a healthcare laundry situation, it is possible that blood stains may be set leading to increased rewash costs and possibly ragout material. On the other hand, if acceptable whiteness levels aren't being achieved, it may be possible to increase the temperature in the bleach step to increase the whiteness and/or bleach effectiveness. The other area temperature can play a big roll is in the sour step. Additional temperature in this step can help open up the fibers in the goods and allow for better moisture removal during the extract step leading to reduced energy costs to operate dryers, ironers or steam tunnels. As with the other three steps, there are downsides to adding additional temperature in this phase of the wash formula. An example is when too much temperature added in the sour step leads to wrinkles being set in the fabric, which then impacts the quality of finish on the garments

Although brief, this description of the wash pie is an important concept to understand as each piece can be used to compensate for each other to develop the most efficient wash formula for the given circumstances of each individual laundry operation.

Machine Features by Washer Type

Washer/extractors come in four general types with specific sizes within each category. These are the Open Pocket, Top Side Loader, Tilting Side Loader, and End Loader. There are a number of features that are common to all four types. All are typically controlled by some type of microprocessor control, many now using touchscreens to enhance the ease of programming. Also, all use either a suspension made up of coil springs and shocks or one that utilizes air bags, and most run with inverter-driven, single-motor drives. Specifically, the washer/extractors this publication will examine are not your average machines. These machines are built exceptionally rugged and serve industrial applications where other types of washers/extractors may not be suitable. Most industrial washers, with proper preventative maintenance, will last for many years of service. In fact, there are many Braun washers still operating today that have well over 30 years of active service.



9.

Open Pocket

The first type of washer/extractor we'll review is the Open Pocket. Open Pocket Washer/Extractors are the typical choice for the commercial laundry, processing larger batches of various goods types. They are front loading machines and as stated earlier, are used in manual and semi/fully automated wash alleys. Let's take a look at each operating scenario.

Manual Washroom

Many of the early commercial wash alleys were configured to process large loads of varying goods types. Prior to the advent of more sophisticated automation techniques and controls, these wash alleys were setup with 3-10 open pocket washer/extractors and 1-5 industrial dryers. In the typical manual wash alley, the washer/extractor tilts back using a set of hydraulically actuated cylinders. The tilt angle is very important, as it allows for easier loading than if the washer/ extractor was loaded in the upright position. Most Open Pockets utilize a 20-28 degree angle of tilt for optimal positioning during the loading step. Clothes are then loaded either directly from a laundry cart, or more commonly with a sling system using bags hung from a rail. The operator first positions the bag over the open door, and then pushes the bag fully into the opening while pulling the draw string allowing the goods to fall into the spinning cylinder. This manual loading process is still in use in many laundries today and is an area that has magnified the need for a safer and more ergonomic solution. There have been systems developed to address this need that we will discuss in the material handling section of this publication.

The second step in the manual wash alley is unloading the washer/extractor and getting the goods transferred to the dryers. The Open Pocket Washer/Extractors allow for a forward tilt angle of between 15-20 degrees providing optimal positioning to unload into a cart. During the manual unload process, the operator spins the basket manually allowing the clothes to exit the washer into a cart. Again, this process requires the cart to be held close to the machine and typically takes at least two carts depending on the size of the washer. In many cases a sling bag lines

the cart and when full is attached to a hoist. The sling bag is then raised back up into the rail system allowing movement over to the dryer. These systems are typically labor intensive and do not provide the best ergonomic environment for the operators.

Besides the safety concerns noted, the other obvious downside is the amount of labor needed to run the wash alley, and the reduced productivity associated with a completely manual environment. With the potential for injury, ergonomic issues and an aging workforce, many commercial laundries have evolved in recent years to use semi-automated or fully automated systems.

10.

Semi-Automated Washroom

The semi-automated system still carries with it the requirement to manually load washers; thus the term *"semi-automated."* In this system, the washer/extractor unloading process as well as the dryer loading process has been automated. The Open Pocket Washer/Extractor allows the machine to automatically tilt forward and unload to a Loose Goods Shuttle, conveyor, or to one of the Braun SafeLoad® solutions. Once unloaded to the automated shuttle system, the shuttle then transports the goods to a dryer and automatically loads them. This eliminates the manual unload step saving time and the potential ergonomic issues associated with this process.

The different Braun Shuttle and SafeLoad® systems will be described in greater detail later in this publication. Braun and another machine manufacturer also offer a "shuttleless" solution allowing greater flexibility and increased productivity for fully automated environments. These options will also be covered later in the publication.

Fully Automated Washroom

The last operating environment is the fully automated wash alley. In this type of operating environment, the Open Pocket Washer/Extractors are loaded from an automated rail system using sling bags or from an automated conveyor system. Most typically the washer/extractor is equipped with an automated load chute that deploys in place during the loading step allowing the overhead sling to drop directly into the washer/extractor. Once loading is complete, the chute swings up and out of the way, the door closes and the washer tilts level *(note slight tilt that is recommended for the wash process)* to begin the washing process. When washing is complete, the washer automatically unloads using the same method(s) as described in the semi-automated systems above. There are a number of obvious advantages to the fully automated system.

First, the obvious advantage is the labor savings achieved by removing the need for operators to manually move soiled goods around in carts or sling bags and manually load them into the washer extractors or dryers. Hand in hand, fully automated systems remove the safety hazards associated with the manual loading and unloading process. However, both the semi-automated and fully automated systems must be protected, as there is now automated equipment moving without human intervention *("hazardous motion")*.

11.

Certainly another advantage of the fully automated systems is productivity. There is typically no lag in the loading phase of the washer/extractors. When a washer completes the unloading step, it immediately readies itself to be loaded again. Most fully automated systems have the next load pre-staged and as soon as the washer is ready to load, it is loaded. There is no waiting for the operator to move in the carts or pull in the sling bags. Also, the automated loading process is usually much faster than the manual loading process assuming the rail delivery system is properly designed. This solution is obviously safer for the operators. There is also one other less obvious advantage and that is capacity *(increased productivity)*.

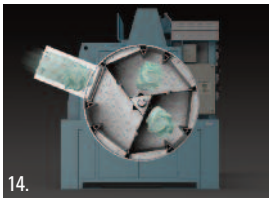
When manually loading, the washer/extractor is often under loaded as compared to its rated capacity. This is because of the inability of the operator to hand load this rated capacity into the washer in a safe manner. Using the fully automated solution guarantees that the washer/extractors will be loaded to full stated capacity each and every time, improving throughput. Even in a completely manual loading scenario, the Braun SafeLoad® Manual Loader allows easy loading to rated capacities on Braun and non-Braun Open Pocket Washer/Extractors. There is also another loading solution offered by another manufacturer, and both will be examined in more detail later in the publication.

This general overview has focused primarily on the Open Pocket solutions, but there are also three other washer/extractor solutions used throughout the commercial industry. These solutions are the Top Side Loader, the Tilting Side Loader, and the End Loader. The following section provides a brief description of these machines. Each type will be covered in much more detail to include features and options after the wash pie section of this publication.

Top Side Loader (TSL)

12.

First let's examine the Top Side Loading Washer Extractor (TSL). The side loader as the name implies is loaded from the side of the cylinder versus the front. Unlike the open pocket washer/extractors, the side loader comes in a split-pocket configuration. Most offer either a two or three pocket solution. This split-pocket configuration allows for smaller batch sizes of like goods to be washed simultaneously. These machines are an outstanding solution for clients who process customer owned goods (COGs) as they allow for distinct batch separation in each pocket of the washer/extractor. Top Side Loaders can be loaded by hand or can be loaded using sling bags; however, the cylinder is not spun during the loading process taking the dangers associated with a spinning cylinder out of play. Some TSLs also allow for a gravity assist unloading process. This is done by positioning the cylinder at a downward angle on each pocket allowing the operator to easily unload the goods from each pocket into separate carts. Top side loaders come in three different configurations. These are a standard configuration allowing



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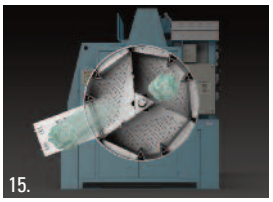
Gravity Assist Loading



15.
Gravity Assist Unloading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loading and unloading from the same side. The other configurations are a Medicare or Cleanroom configuration allowing the operator to load from one side and unload from the opposite side of the washer/extractor. In the Medicare and Cleanroom options, the load and unload side is separated by a barrier wall keeping the soiled side isolated from the clean unload side of the machine.

Tilting Side Loader

16.

The third machine offered is the Tilting Side Loader. This machine is an open pocket side loader utilizing up to four pockets. Loading is done either by hand or by sling bag. It also allows for distinct batch separation. The advantage of this machine is that when the load is complete, the operator tilts the entire cylinder forward allowing all the pockets to be unloaded simultaneously into separate carts. This speeds up the load and unload process, as the operator does not have to jog the basket to each individual pocket during the loading and unloading phase. These machines are typically offered in 675 lb. and 900 lb. capacities with each pocket holding 225 lbs.


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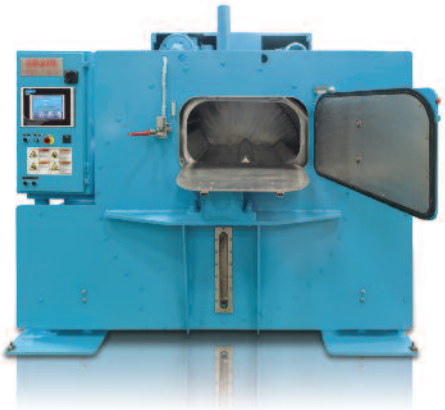
End Loader (EL)


18.

Our fourth machine is the End Loader. Like the top side loader, the end loader is also a split pocket machine. However, the end loader provides a distinct advantage over the open pocket and top side loader in the height of the machine per stated capacity. The end loaders are a low profile washer/extractor allowing them to be utilized in areas with very low ceiling height such as on large cruise liners. They are also utilized in small areas with low ceiling heights like hotels and small on-premise laundries (OPLs). Manufacturers typically offer multiple sizes ranging from 100lb to 400lb machines. These machines are typically loaded by hand and not from sling bags as the machine does not tilt nor provide an upward angled cylinder opening conducive to loading with a sling bag. They provide the same rugged construction as their counterparts, the open pocket and top side loader and are built for many years of service.

This general overview has given the reader a glimpse at the four types of conventional washer/extractors and a broad overview of their typical uses within the commercial laundry industry.

A Closer Look at Braun Washer/ Extractor Features and Options

This section will examine the features and options of Braun's washer/extractors and point out other competitive alternatives by comparing and contrasting them, where applicable. Let's look at the Braun Open Pocket Washer/Extractors first.

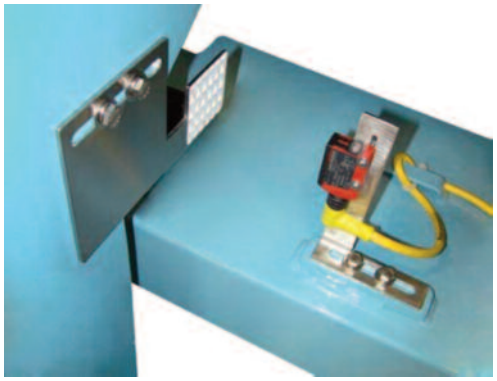
19.

One fact that sums up the Braun Open Pocket washer/ extractors is that there are more Braun Open Pocket Systems in the industry than all others combined. Coupled with the extremely rugged design and the largest processing capacity per square foot of floor space utilized, makes these machines stand out as the leader in the industry.

The first feature examined is the suspension used on all Braun washer /extractors with the exception of the tilting side loader. Braun's Neutron Suspension combines the use of coil springs and shocks to isolate vibration from the workspace. This allows unmatched vibration isolation. Braun washer/extractors with the Neutron Suspension can actually be mounted without a foundation and can be installed on the upper floors of buildings as long as they have suitable structure to handle the washer's weight and dynamic load. The alternative that many others use for suspension dampening is the air bag. Air bags are simple pneumatically filled rubber bags that act as cushions during operation. The advantage that air bags bring is the ability to release all the air from them and lower the washer onto load cells to obtain the weight of the goods loaded in the washer/extractor automatically. This weight is used by some to allow for ratiometric washing. This will be discussed further in the next paragraph. One major disadvantage of air bags is their durability. The loss of one air bag disables the washer/extractor causing machine downtime until the air bag is replaced. Unlike the Neutron Suspension with rugged components, air bags are more prone to wear and tear. Coil springs used on the Braun washer/extractors, with proper care, will last for many years and in fact, may last the entire lifetime of the machine.

20.

As mentioned above, one of the advantages of air bags is that they allow the washer to be lowered onto load cells. This weight is used to calculate the loaded weight in the washer/extractor, which is then used to adjust the water level and chemistry based on that calculated load weight.



21.

On the surface, this sounds like an advantage. However, the simple truth is that it promotes underloading of the washer/extractor, which in turn, shortens the life of suspension components, reduces throughput, and causes high energy usage when drying these undersized loads.

All washer/extractors are designed to handle their rated load. When underloaded, the washer/extractor will have more problems balancing the load, leading to a more violent movement of the machine. This in turn puts stress on the air bags causing them to fail more often, increasing downtime and the expense of replacing wear items.

There is also the reduction in productivity because the washer/extractor is not turning out loads at rated capacity. When the undersized load reaches the dryers, the inefficiencies continue.

When dryers are run at below rated load weight, air bypasses the tumbling goods leading to significant increases in natural gas, propane or steam consumption. Also, smaller loads tend to take longer to fully dry, compounding the hit to productivity. Ratiometric washing is a sound concept for saving water and chemistry in the washer/extractor when undersized loads are processed, but those efficiencies are lost in downstream processing and capacity reductions. These undersized loads can also lead to out-of-balance conditions causing the washer to attempt rebalance. The additional rebalance attempts result in longer cycle times. This further negatively impacts capacity, energy consumption and causes added wear and tear on the machine. The capacity reductions may also lead to additional processing hours, causing increased labor costs per pound processed. The bottom line that the operator must understand is that when purchasing a new washer/extractor, the size should be based on the average clean dry weight loads expected to be processed in the facility. Buying machines oversized for the average load weight will ultimately cost more up front in capital expenditures and continue to cost the laundry in added expense for energy and premature component failures. Running undersized loads also adds to the need for additional maintenance to ensure machines remain operational. This additional maintenance is on top of the normal preventative maintenance that all washer /extractors require.

The Drying Process

22.

Just like the wash process, the fundamentals of commercial textile drying haven't changed much over the years. The science is still the same, but technology has evolved allowing for greater energy efficiency and ease of dryer management and maintenance.

The drying process consists of four fundamental components temperature *(or heat source),* airflow, mechanical action *(or tumbling),* and time. All four must exist in order for the dryer to function efficiently.

When we covered the science behind the washing process, a simple model was used to depict the four major components of the wash process. The same can be done for the dry process. This model is called the *"Dry Pie℠"* and is shown below in **Figure 5.**

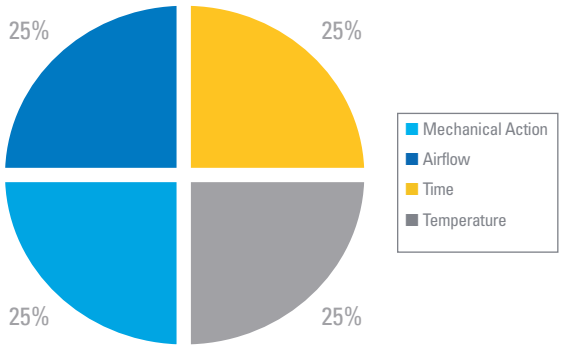


Figure 5 Dry Pie℠

This publication will explain the science behind each element of the Dry Pie℠ so that the reader can understand how technology is used in the drying process. These four elements of the Dry Pie℠ allow the dryer to evaporate moisture from textiles in an efficient manner.

After a thorough review of these fundamentals, we'll dive deeper into the actual science behind each component to provide a solid understanding of how this science has helped technology evolve. The end user can benefit by understanding this science and applying it to track key performance metrics for the drying process.

Before we get into the science behind each of the fundamentals of drying, **Figure 6** provides a summary on the relationship of energy usage in today's industrial dryers.

Where does the heat go?

1. It takes 970 BTUs/lb of H_20 @ 212° to evaporate water
2. It takes 1 BTU/lb to raise the temperature of water 1° F
3. It takes 0.02 BTU to raise each Cubic Foot of air 1° F
4. Heat absorbed by the dryer itself and not transferred to the textiles
5. Unburned gas (burner efficiency)
6. Losses from the lack of good sealing design and/or lack of preventative maintenance

Figure 6 Energy Facts

So given the facts presented in Figure 6 why is it that your industrial dryer consumes much more than 970 BTUs per pound of water removed?

This next section takes a look at the science behind drying technology and helps answer this question.

The Science

Temperature (Heat Source)

First, a dryer must have a heat source to generate temperature. Temperature is the first component of the Dry Pie℠. This heat source is typically one of three types:

Natural Gas, Liquid Propane Gas, or Steam.

Let's briefly examine each source.

1) **Natural Gas (NG)** is by far the most common source of heat used in commercial dryers today. It is a very economical source of fuel for the dryer given today's pricing and the abundance of this resource domestically. However, pricing can fluctuate and having metrics to ensure your dryer is performing at peak efficiency is vital to long-term cost management.

2) **Liquid Propane Gas (LPG)** is another fuel source commonly used in commercial dryers. Propane prices can also fluctuate, so metrics are equally important to track. The main difference between NG and LPG is that LPG contains over twice the BTUs per cubic foot as NG *(2,516 BTUs per cubic foot for LPG versus 1,030 BTUs per cubic foot for NG)*. So LPG will burn at a much higher heat rate per cubic foot consumed to the point that if the dryer gas train isn't compensated for LPG, serious damage can occur to the dryer and structures housing them. Users must ensure the dryer gas trains are properly adjusted for the type of fuel (NG or LPG) and that the dryer gas train is certified for both. Adjustments to the gas train are something the end user should have their dryer manufacturer perform if possible. Remember that misadjustments can lead to serious consequences up to and including a fire.

3) **The third source is steam.** Steam is not commonly used in North America because of the availability of either NG or LPG. Also, steam is much less efficient than the other two fuel sources. This is because of the BTU content of steam and the ability to convert that BTU content to usable energy to evaporate water. One pound of steam has 1,000 BTUs at 125psi. The usual method to dry with steam is to pass air through steam coils heating the air to ~300 – 330° F. Unlike NG or LPG, this is the maximum inlet temperature obtainable. NG and LPG can generate inlet temperatures exceeding 600° F thus starting the evaporation process sooner and reducing cycle time.

Temperature is usually monitored in at least two locations during the drying process. These two areas are the inlet temperature, or temperature of the air entering the dryer basket containing the textiles, and the exhaust temperature, or the air temperature exiting the dryer basket. Inlet and exhaust temperatures are both very important and drive the efficiency of today's modern dryers.

Inlet temperature is normally the higher of the two, and is a direct measure of the temperature of the air entering the drying vessel *(or basket)*. It is typical to set the inlet temperature to a point where evaporation will take place as fast as possible without causing damage to the textiles being processed. The inlet temperature is a key setpoint when creating a dry formula.

The exhaust temperature is typically monitored by all industrial dryer controls. This temperature is set to a value representing the temperature of the air stream exiting the dryer will stabilize at when the textiles are fully dry or reach a set percentage of moisture remaining *(2% – 5%)*. It is almost always much lower than the inlet temperature, and is a key variable in the proportional-integral-derivative *(PID)* controllers used in today's modern dryers.

The importance of determining the correct values for these two temperatures cannot be overstated. They are the drivers behind getting the most efficient cycle possible for each type of product dried in the industrial dryer.

So how does the end user determine these temperatures?

Each textile product has a suggested dry temperature setting shown on the product tag that is attached to it. Most textile manufacturers publish these dry settings on their websites and in their literature. **The most important take away from this discussion is that one setting will not work for all goods types.** Cotton for example can handle fairly high inlet and exhaust temperatures. As an example, 100% cotton terry towels could handle a 600° F inlet and 190° F exhaust *(this may vary depending on the specific OEM's solution utilized).* Scorching won't be seen on cotton terry until approximately 700° F. On the other hand, microfiber towels that have become very common in the industry must not be exposed to a temperature above 160° F or damage to the fibers will occur. The last example is walk-off mats. The mat manufacturers have conducted many studies, and their recommendation for maximum temperature is that the mats should see no more than 180° F. This recommendation is to ensure the rubber backing and the mat fibers themselves do not break down due to thermal stress. These three extremely different temperature settings show the importance of doing the homework up front on products that will be run in the dryer before creating the dry formulas for them.

One "size" just won't fit all!

So how do these two temperatures interact with each other during a typical dry cycle?

Figure 7 shows the inlet and exhaust temperatures charted during a typical cycle running 100% cotton terry towels.

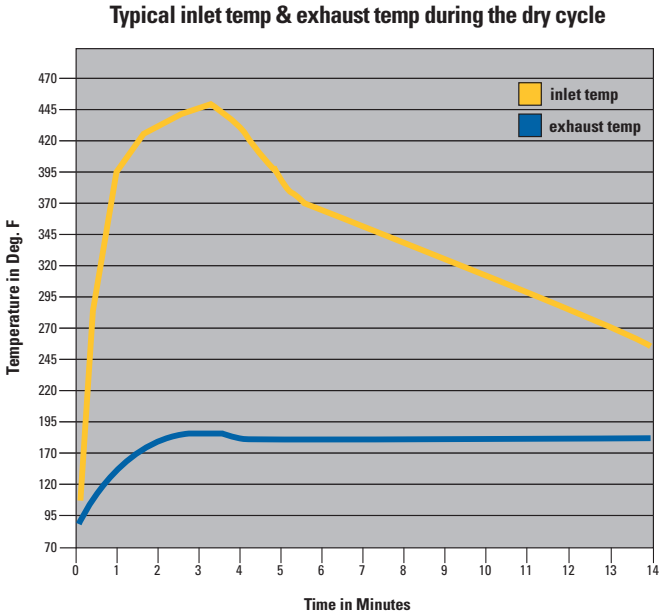


Figure 7 Inlet and exhaust temperatures

The first few minutes are consumed performing a number of different functions unrelated to the actual drying process. Typically during this time, a lint blowdown cycle may be conducted prior to burner ignition. A purge cycle is performed to ensure no combustible gases remain in the combustion area prior to igniting the burner. Lastly, time is needed to heat the goods and dryer to get the temperature inside the basket to the evaporation point.

The example above is from a dryer using a modulating gas valve controller. This allows the dryer, using a predefined PID control, to automatically adjust the burner output precisely around the user's programmed formula setpoints for inlet and exhaust temperatures. When the inlet setpoint temperature is reached, the maximum amount of energy is being input into the dryer for that dry cycle, and the highest moisture removal takes place as water begins to evaporate at an increasing rate. In fact, 40% - 60% of the moisture in the textiles is evaporated and removed in the first five minutes of a typical dry cycle.

As the goods continue to dry, the reader can **see in Figure 7** the inlet temperature curve decreases as less and less energy is needed to continue the evaporation *(drying)* process. While the inlet temperature decreases over time, the exhaust temperature is stabilizing around the setpoint. The exhaust temperature is an indication of the actual temperature of the goods as they begin to dry. This will stabilize at the setpoint exhaust temperature once the textiles have reached a full dry condition. One very important factor to understand from this graph is the term **"Differential Temperature."**

Differential temperature is simply the temperature difference between the inlet and the exhaust. Looking at the left side of **Figure 7** at approximately one minute the differential temperature starts at 265° F *(395 – 130)*. At the end of the dry cycle, this differential temperature has reduced to approximately 80° F *(260 - 180)*. Differential temperature is extremely important in that it allows the user to program the temperature when a load of goods becomes dry or has 2% - 5% moisture remaining. It is best to allow some moisture *(2% - 5%)* to remain in the textiles to allow for slight evaporation during time spent in the laundry. If the user finds that the goods are still a bit damp at the end of the cycle, a slight reduction in the differential temperature will allow the inlet and exhaust temperatures to become closer allowing for more drying to occur. On the other hand, if the goods are over dry, increasing the differential temperature will allow the dry cycle to end before overdrying takes place. Differential temperature is one of the most accurate ways to run each product formula. It is a much more efficient way to run the dry cycle versus using *"Time,"* which will be looked at in more detail later in this section.

Airflow

The second component of the Dry Pie[SM] is airflow. If we look at how textiles used to be dried; by being hung outdoors and allowing natural conditions to dry the goods, the importance of airflow becomes very clear.

Textiles can be hung in an open environment and exposed to natural or mechanically induced air currents. These air currents passing through the fibers coupled with natural temperatures above freezing allow water to evaporate and be carried out of the fibers allowing the goods to begin to dry. Without any airflow, goods hung outside on a calm day will take much longer to become dry than they will on a windy day.

This same principle is at work in an industrial dryer. A dryer must have a source to pull the heated air through the goods and a means to remove that moisture-laden air. This is typically done with a blower motor and wheel, which pulls air through the heat source into the vessel containing the textiles and then discharges that air out through ductwork outside the building. Much more detail on airflow will be presented in the next section.

Like temperature, ideal airflow will be different for different size dryers, load sizes and goods types, and a balance must be established between the variables to get the fastest drying times at the most efficient energy use rate.

Figure 8 shows the relationship between high and low airflow and the impacts each have on dryer efficiency. Namely, each has an impact on the BTU/lb of water removed rate and on the pounds of water removed/minute rate. Remember that these are a measure of a dryer's efficiency and productivity.

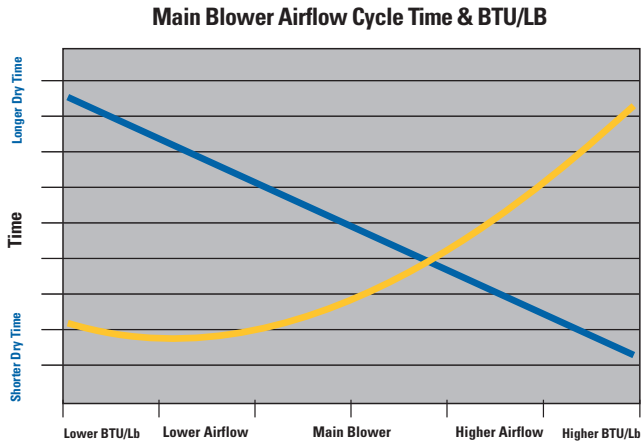


Figure 8. Main blower airflow cycle time & BTU/LB

Let's take a minute to understand what this graph is trying to tell us. The horizontal axis denotes blower speed or air velocity. As you go farther to the right on the horizontal axis, you see an increase in blower speed and thus airflow. On the left vertical axis, total dryer cycle time is included. Now we can dive into what these numbers are trying to tell us.

First, it is evident that high airflow volume results in faster dry times *(as denoted by the blue line)* but at the sacrifice of lower energy efficiency *(as denoted by the yellow line).* Thus having a dryer with maximum airflow will theoretically increase your productivity, but it will also increase your energy bill.

On the other hand, reducing the airflow will certainly reduce your energy bill *(as denoted by the yellow line)*, but your productivity rate from this dryer will not be very good *(as denoted by the blue line).* Now as a dryer manufacturer, we want to give you the best of both.

Sounds easy right?

Just pick the point where both lines cross each other! We all wish it were that easy. In theory, this might work, but in practice there is much more to determining the optimal airflow.

One of the first considerations when designing a dryer's airflow is to determine how to optimally mix the heated air by determining the type of burner or steam coil to use and where to position that burner or coil in the incoming air stream. This important first step will ultimately determine how that heated air is brought into the dryer vessel to perform the function of evaporation. There are a number of methods to include bringing air in from the top, sides, front and rear, or combinations of all four. Today's modern design tools allow engineers to model airflow and the application of heat throughout the system before they actually build the first prototype. Remember these tenants of airflow:

Air is compressible, air expands when heated, and air velocity helps convey away moisture.

Figures 9 & 10 show examples of how 3-D modeling can help engineers determine the optimal point to get both efficiency and productivity from their dryer.

Velocity **Flow Trajectory Plot**

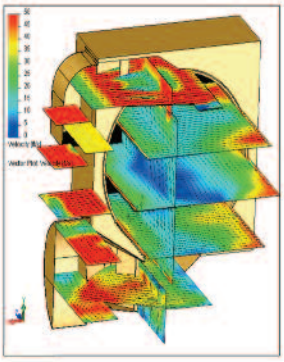


Figure 9

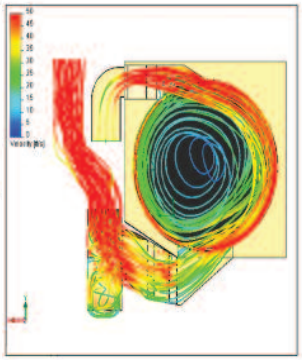


Figure 10

Now the purpose of this previous discussion is not to make dryer design engineers out of the reader, but to help them understand that there are many factors that govern how airflow is applied to a dryer and no single way (*like the crossover point on the curve)* will work best for all types of designs.

A general rule of thumb can be derived from looking at the graph in **Figure 8**. A higher rate of airflow, in general, is going to produce reduced efficiency and better productivity than a generally low airflow, which will produce an increased efficiency and reduced productivity. To obtain high airflows in an industrial dryer requires that the dryer be constructed of rigid weldments, as the forces applied to industrial dryers with high airflow can be quite considerable. As an example, the average vacuum generated in today's dryers can exceed 12 inches of water column. When this type of force is applied to many square inches of surface within the dryer, significant structure is required. For example, in a 300-pound dryer, this force can be over 2,000 pounds. This is one reason why a dryer must be made with a heavy-duty superstructure. Dryers manufactured with light gauge material are not going to hold up to the rigors of industrial drying and remain reliable and air tight for many years of use.

In order to make the best use of optimal airflow and the heated air that it brings, the dryer must have a means of

moving the goods through this heated airflow for the most efficient drying possible. To do this, the third piece of the Dry Pie℠ is needed.

Mechanical Action (Tumbling)

The mechanical action as defined within the Dry Pie℠ is used for a much different reason than it was used for in the Wash Pie. If you remember, mechanical action needed for washing allows the goods to release soil so it can be suspended and removed by the surfactants used in the wash process.

Mechanical action in an industrial dryer is needed to ensure uniformly heated airflow is distributed on the goods during the drying process. Without any mechanical action, the goods would simply sit on the bottom of the dryer basket, impeding airflow, and thus impeding the removal of moisture. However, in a dryer, the mechanical action is not needed to drive moisture out of the goods, but to tumble the goods through the heated airstream allowing that air to pass through the fibers and take away the evaporated water.

So how is the optimal mechanical action determined within an industrial dryer, and should it be the same for all goods types?

This section will attempt to answer these questions and present the science behind the answer.

There are four design considerations used when determining the correct mechanical action for a given dryer size. First, the specific speed or RPM must be determined, which may be different for various goods types. Second, the basket diameter will play a key role, as will the third factor, basket volume relative to the rated load size to be used in the dryer. The fourth factor is rib design and how those ribs are able to produce a smooth tumbling action in the airstream. Let's start this discussion by looking at the most important factor as it relates to efficiency, and that is volume as related to load size. **Figure 11** depicts what load size variation does to dryer efficiency based on a 500 – 600 pound rated dryer.

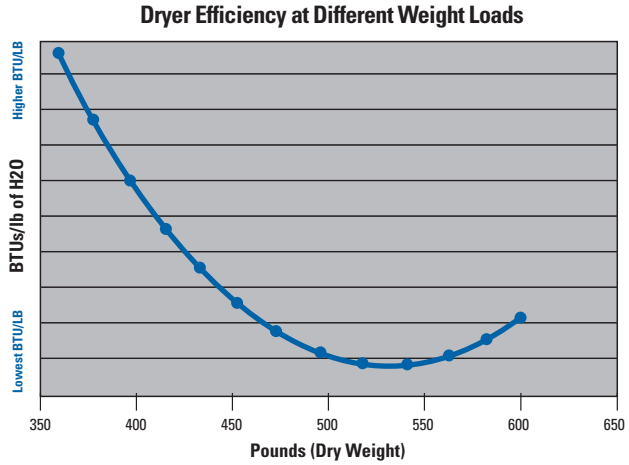


Figure 11. Dryer Efficiency at different weight loads

This graph represents probably the most misunderstood parameter of modern dryers today. In a world where bigger is better, and discussion of load factor reins, science can help us understand how to get the best energy efficiency possible given the volume of your dryer basket. As can be seen in **Figure 11,** as load weight increases toward rated load size for this dryer, efficiency steadily improves. As rated load size is exceeded, efficiency begins to fall off. This relationship holds for any type of dryer, no matter what the heat source or airflow. It represents the one single parameter that is the easiest to control in a laundry, yet the one parameter most overlooked or misunderstood. The key to getting the most efficiency out of your dryers begins in your soil sort area. If 525 lbs clean dry weight happens to be your dryer's "sweet spot" as shown in **Figure 11,** then you must determine what the correct soil weight is for each type of product going to your washers so that 525lb clean dry weight will be dried in your dryer. You also must ensure that your washers, whether they be conventional or batch tunnel washers, are sized correctly to give proper cleanliness at these load weights. Running undersized loads because the rated load capacity of your washer is less than your dryer is a recipe for inefficiency and a guarantee that your energy bill will be much higher than necessary.

So how can you use this information to benchmark your dryers?

Remember, dryer basket volume is directly proportional to the energy efficiency of the dryer. Bigger isn't always better.

Benchmarking the **"sweet spot"** of your existing dryers is really quite easy, although some time must be dedicated to collecting the data. Benchmarking will help tell you if the dryer manufacturer did their homework when developing the clean dry weight rating for the dryer. If they rated it too low or too high, you aren't getting optimal efficiency or productivity from your purchase.

First, let's cover the terminology used when discussing performance related to dryers. Here is a list of two very important items:

* BTUs per pound of water removed **(Energy Efficiency)**
** Pounds of water removed per minute **(Productivity)**

These terms will be used extensively throughout the remaining dryer section and are terms that are key to developing sound measurements for any laundry to benchmark its dryer's efficiency and performance.

First, you must determine the rated load weight of your dryer. This is always shown in clean dry weight. Next, weigh a load of clean dry goods to this rated load weight. Run this load through your normal wash process to include the extraction step. Next, weigh the load after extraction and note the weight. This will give you the moisture content of that load, and thus, the extraction efficiency of your washer, batch press extractor, or centrifugal extractor.

Remember that it is always more efficient to remove moisture in your extraction process than in an industrial dryer!

Now, to complete this benchmarking exercise, you must have a meter on your dryer to measure the energy consumption needed to dry this test load. Once you have that installed, note the beginning reading on the meter before you put the load in the dryer. Load the dryer with this test load. The next critical data needed is the actual dry time. This is measured from when the burner ignites or the air and/or steam starts flowing through the steam coils and stops when the burner is extinguished or the air and/or steam stops flowing through the steam coils. It does not include the lint blowdown time, purge time, cool down time, or other "non-dry" events that may occur in your dryer before or after the actual dry cycle. Make sure you do not under dry or over dry this load as this will throw off your measurements. Dial in your dry formula before starting this exercise. Record the meter reading at the end of the dry cycle.

When the load is done, remove it from the dryer and weigh it one more time. This should equal the same clean dry weight you recorded prior to putting it into your wash process.

Now it is a simple matter of performing some calculations to determine the two key benchmarks of your dryer. First, convert your meter readings into BTUs. Typically gas meter readings are measured in cubic feet. Remember that 1 cubic foot = 1,000 BTUs unless you're using LPG, then use 1 cubic foot = 2,500 BTUs.

Subtract the clean dry weight of your load from the wet weight *(recorded after the extraction process).* This is the weight of the water that was removed during the drying process. Take the total BTUs consumed in your dry cycle *(from your gas meter reading)* and divide it by this total water weight. You now have the first of the key benchmark numbers. (BTU/LB)*

Next, take the total weight of the water in the load and divide it by the total dry time (in minutes). You now have the second benchmark number. (LB of H_2O/MIN)**

You can perform this exercise for a few loads under the rated load weight of your dryer and a few above the rated load weight to generate a curve similar to the one shown in **Figure 11.** Now you have a metric to monitor to ensure your dryer remains running at its peak performance characteristics.

We've spent some time discussing load weight and benchmarking, as this is an extremely important exercise the end user should perform to develop metrics for their dryers. However, it is not the only piece of the mechanical action puzzle.

The type of tumbling action that occurs inside the dryer basket is also very important to the efficiency numbers obtained in your benchmarking. The diameter of the basket in relation to the length *(or depth)* of the basket plays a key role. Long slender basket designs tend to reduce tumbling action as do short baskets with large diameters. These types of designs can also lead to tangled *(roped)* goods. The right ratio is a key design element used by today's engineers to get the most efficient tumbling action possible.

Basket ribs also play a significant role in tumbling action as they do in a washer. They are mainly used to lift the wet goods into the air stream at the beginning stage of the dry cycle. Ribs that are too large will compartmentalize the goods and reduce tumbling action, while ribs that are too small will not lift the wet goods into the air stream. As the goods become dryer, the ribs play less of a role and centrifugal force comes more into play.

Experimentation with different goods types shows that optimal airflow, and thus optimal drying happens when an almost perfect cylinder of goods tumbling around a hollow center occurs. To obtain this condition for various goods types with various moisture contents, variable basket speed can be employed. Having the optimum basket speed for each goods type can also help with efficiency. This is typically done using an inverter drive on the basket motor in conjunction with programmable speed within the dry formula or by automating this process for the user within the dryer controller.

In summary, like its cousin on the washer side, mechanical action plays a critical role in the efficiency of today's modern industrial dryers. It is an important component of the Dry Pie^{SM}. That leaves only one piece left, and that is time.

Time

Last, but certainly not least, is time. Unfortunately, time is the one component that can cost the user both money *(in fuel usage)* and productivity *(turns per hour).* The shorter time needed to dry a load of goods, the less fuel used and the higher the turn ratio. However, time ties all the components together, as different types of textiles require different temperatures and mechanical action. These different requirements will dictate how much time it takes to complete the drying process for each particular textile type. Time also plays a key role in airflow as water must be allowed to begin to evaporate, and airflow must be given a chance to carry that moisture away from the processing environment.

Time seems to be the easiest of the pieces to use and understand, but it can also be the most costly in terms of your dryer's efficiency. Lets take a look at why that might be.

In order to get a given size load of goods dry, we've already seen that a heat source or temperature is needed to heat the airflow that is passed through the goods by means of mechanical action. The reader has also seen how benchmarking a dryer can provide key metrics when attempting to control costs generated while running the dryers. Remember that one important data point needed to calculate the BTU/lb of water removed and lbs of water removed/minute was the dry time. This is pretty straight forward as time is needed so the goods can interact with the other three elements of the Dry Pie^{SM} and allow water to evaporate.

Unfortunately, time is also the one piece of the Dry Pie^{SM} that is most abused at the sacrifice of using other types of technology available in modern dryers today. For the end user, it is easy to just add another couple minutes onto the dry time if they get a damp load, then to actually identify the root cause for that damp load and resolve it. It is also a good bet that the additional time added would not be removed once that root cause is determined or conditions change that no longer require the additional time anymore. That additional time means more fuel is being consumed and fewer goods per hour are being sent to the finishing department. This lowers the overall efficiency and

productivity of the dryer. Overdrying can also lead to damaged textiles and shortened textile service life.

Many variables can impact dry time to include inside and outside temperature and humidity, temperature of the goods when they go into the dryer, moisture content of the goods from load to load, and many other variables that can change the dry time needed with almost every load. Remember that for optimal drying, the user should target a moisture remaining number of between 2% - 5%. Doing this consistently with time alone is almost impossible.

So why do most users rely on time?

Simple…it's easy to understand the relationship that more time equals more drying.

But is it really the best method to use?....NO!

The following discussion looks at other methods that modern industrial dryers employ to provide a more economical means of drying goods without using a timer like the old dryers of the past.

Emerging Technologies

During the discussion regarding the science behind temperature, a short overview was presented on the use of differential temperature. Most modern industrial dryers today offer differential temperature setpoints as an alternative to using time in the dry formula. The science behind using differential temperature as an alternative can be seen in **Figure 12** .

Differential Temperature

Differential temperature technology use can be explained by examining how the wet bulb/dry bulb thermometer works. In this analogy, the dry bulb is the inlet temperature and the wet bulb temperature represents the exhaust temperature in the dryer. The measured exhaust temperature will always be lower than the inlet temperature because of the evaporative cooling effect on the exhaust air stream. As the load gets closer to having the ideal moisture content (between 2% - 5%), the two temperatures become closer to each other. **Figure 12** graphs humidity readings in the exhaust of the dryer and the differential temperature. Comparing the slope of the humidity curve with the slope of the differential temperature curve during the drying portion of the cycle shows that both measurements track a very similar profile. Similar to clock timers, some adjustments must be made for large swings in outside conditions, especially during seasonal changes.

The important note is that differential temperature is a much closer representation of the actual moisture content being removed at a given time and will always produce more consistent results than the use of time alone.

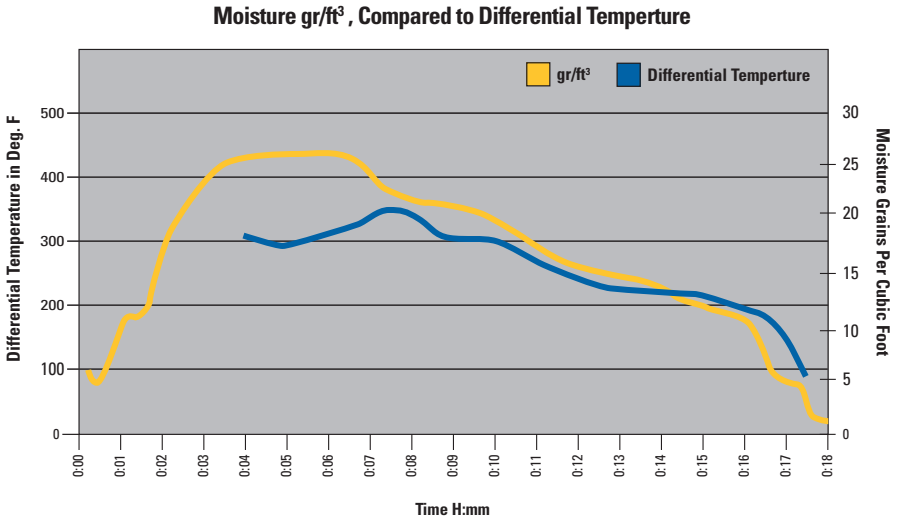


Figure 12. Moisture gr/ft³, compared to differential temperture

As we examine differential temperature and the close correlation to moisture removal, it may become apparent to the reader that using a moisture sensor would be the best of all possible methods to guarantee that 2% - 5% moisture content in the finished load of goods. Sounds good, but there are some pitfalls in moisture sensing technology that the reader should be aware of.

Moisture Sensors

Moisture sensing technology has been in use for a number of years, especially in residential dryers. It has been introduced in large industrial dryers, but has not been generally adopted. There are a number of reasons, and those will be described in this discussion.

First, a short understanding of the different types of moisture sensors is in order. Moisture sensors can be obtained in several different types. The two most common are resistive and capacitive. There are also some manufacturers that have attempted to use conductivity sensors to measure moisture inside the industrial dryers. To study the viability of moisture sensors, an experiment was conducted using a moisture sensor *(capacitive type)* mounted in the exhaust air stream. This generated the graph shown in **Figure 13**. Multiple loads with different load weights were washed, extracted, weighed and then dried until the moisture sensor determined the moisture level was 10 grains per cubic foot. The load was then weighed again to determine the actual moisture remaining in the load.

The results of this experiment were fairly conclusive. As load weight varied, so did the moisture content of the actual load. Most readers may have experience using moisture sensors on their residential dryers and had damp loads as a result. The same principle holds true for large industrial dryers using just moisture sensing for dryness determination. As load weight varies from load to load, so will moisture content and thus, the potential for a damp load to be produced increases. Obviously, this is disruptive to the process as this load must either be dried again, or processed outside the normal methods for that laundry adding unanticipated cost for the user.

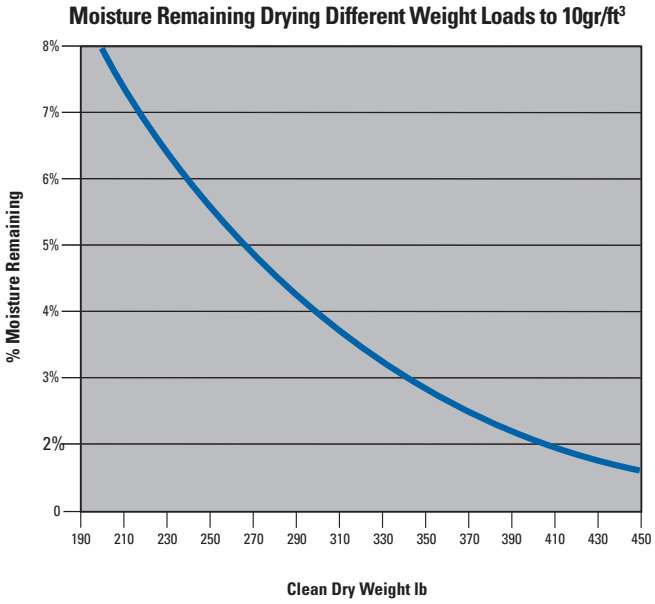


Figure 13. Moisture remaining drying different weight loads to 10 gr/ft³

So why does this variance happen with load size variation?

Let's look at a simple example:

Imagine a dryer with 1,000 hand towels with each towel having one drop of water in it. Compare that to 10 hand towels with each towel having 100 drops of water in them. As heat is applied to each load, the moisture-sensing device will read a similar value. However, when you weigh the goods at the end of identical length dry cycles, the percent of the water remaining in the goods will be different. The reason is that the moisture sensor is measuring the moisture in the air stream versus the actual moisture remaining in the goods.

The other main downside of moisture sensors is the contamination that dryer air streams typically carry. Lint, sand, and other particulate can have devastating consequences on the life span of moisture sensors in an industrial dryer application.

Infrared Technology

Another method used in many industrial dryers today is infrared technology. Infrared technology is a very viable means to detect temperature *(actually emissivity)* and thus calculate the moisture remaining using the dryer controller. The limitation on the application of infrared sensors is the locations available to sense the goods inside the dryer basket as the dry cycle progresses. As the temperature of the tumbling goods changes, the infrared sensor can read those changes. The key to successful implementation and repeatable performance is that the entire load must be

sampled to ensure it is completely dry *(or has the 2% - 5% moisture remaining in it)*. This limitation has proven somewhat challenging to dryer manufacturers as looking at a large enough sample to represent the condition of the entire load is very difficult to do. The sensor may be able to tell the outer portion of the load is dry or tell the inner portion is dry, but the beam spread and interpolation of that spread is not presently reliable enough to detect dry conditions repeatedly load after load. Varying emissivity levels of different material inside the dryer also presents a challenge for infrared sensors. However, as technology changes and sensors become smaller and easier to locate within the dryer basket itself, the technology holds promise.

Heat Recovery Technology

The previous sections have focused on the science behind drying and the Dry Pie[SM]. As the reader can see, many factors contribute to each piece of that pie. One factor becoming more commonly used is heat recovery. It is certainly not difficult science to understand. Waste energy in the form of heated air is being discharged to the outside. If that energy can be captured and reused to heat the incoming air, efficiency should be gained.

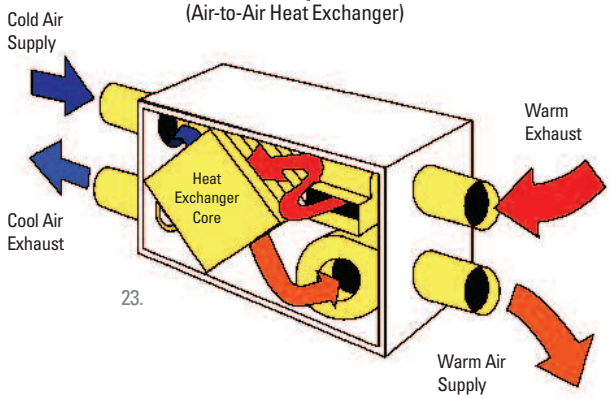
Heat exchange technology is certainly not new, but as energy costs continue to rise, new designs are being promoted with new savings claims being made. There really are two distinct types of heat exchange technology. The first is heat recirculation. The science here is to take the waste air stream and reroute some or all of it back into the intake air stream.

Sounds like a winner right?

Well think about this for a moment and go back to the fundamentals of drying. The purpose of a dryer is to remove *(or evaporate)* moisture from a load of textiles. The air stream exiting the dryer during this process contains that moisture. It seems intuitive that putting this high moisture content air back into the dryer would be somewhat counter to the stated objective. If you're thinking this, you're partially right.

However, remember that *40% - 60%* of the moisture is evaporated off during the first five minutes or so of the dry cycle, and recirculation begins to make more sense. What if we can predict the moisture content of the air stream and, using automatically controlled dampers redirect that hot air back into the inlet air stream after the moisture content has reduced to an acceptable level where it benefits the efficiency instead of hurting it? This is exactly what some manufacturers have done and modest gains in efficiency have been seen. These gains range from *3% - 10%* depending on the temperature of the incoming air and the moisture content of the recirculated air when it is redirected back into the intake.

Heat Recovery Ventilator
(Air-to-Air Heat Exchanger)



23.

The other method is true heat exchange technology. This involves passing the heated waste air stream over a median that then is used to pass the incoming air through to pre-heat it. Again, the effectiveness of this depends on the temperature of the incoming air to begin with. The gains with this type of technology are slightly higher than recirculation and range from 10%-15%. Claims of significantly higher efficiency gains have been made; however, when tested using the benchmarking procedures described earlier, these claims have not materialized. Also, this technology brings with it some hidden costs that often aren't fully explained to the end user. These costs come in the form of increased preventative maintenance.

Remember from the previous discussions that the waste air stream of an industrial dryer contains significant contamination in the form of lint, sand, and other types of debris. When this air stream is passed through a perforated plate, coil, or other median, that debris is trapped. If not maintained, this debris will ultimately block the flow of air, leading to significant problems with the dryer to include excessive high temperature alarms and possibly, in severe cases, fire. This is not to say there isn't a benefit to the technology, but it is important for this discussion that the reader understand the added maintenance and capital acquistion costs that come with it.

So is that heat reclamation system really saving you money?

To calculate this, we'll run the numbers for a 500-lb. clean dry weight rated dryer. We'll also assume a 10% energy savings from the heat reclamation system. Assume that the dryer is consuming 1,800 BTU/lb of H_2O removed, must dry goods with 50% moisture retention *(or 250 lbs. of H_2O),* and is being turned over three times an hour. Last, we'll assume the plant operates one shift/day, five days per week or 2,080 hours/year and the cost of NG per therm is $0.50/therm.

Here's the calculation of the savings per dryer:

10% x 1,800 BTU/lbs H2O x 250lbs H2O/load x 3 loads/hour x 2,080 hours/year x 1 therm/100,000 BTUs x $0.50/therm = $1,404/year or ~$0.68/hour

The readers must ask themselves if this savings per year is worth the additional maintenance that is inherent in the heat reclamation system to begin with. **How many hours per year will you dedicate to maintaining this system? How much downtime or lost productivity will you experience due to exhaust temperature alarms due to lint build up? How much did it cost to add this recovery system and what is my added depreciation impact to the profit and loss statement every year?** The homework needs to be done before buying into the stated claims.

There is one additional type of heat exchange technology that is fairly common. That technology is the use of **coaxial ductwork.** Again, from the previous discussion on fundamentals, a dryer must have air supplied to it and that air is then discharged from it to the outside. If the duct bringing the hot air out surrounded the duct bringing fresh air in, the incoming air will be heated by that waste air discharge at a rate of approximately 1° F per linear foot of duct run. So a 20-foot coaxial duct run from the dryer to the outside would increase the temperature of the incoming air approximately 20° F.

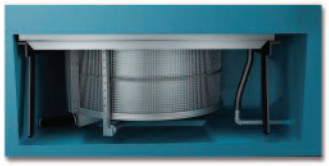
What would this mean in energy savings?

Like the caveat noted in the other types of reclamation, the temperature of the incoming air would play a major role. On average, coaxial duct runs greater than 20 feet with an average inlet air temperature of 50 degrees, would see a 2%-3% increase in efficiency increasing as the length of duct run increases. Coaxial duct also eliminates the maintenance problem with debris in the exhaust air stream, as there are no perforated plates, coils or other heat exchange media to catch it.

Lint Collection

The last portion of this section is a brief look at the various types of lint collection systems available in today's industrial dryers. There are basically three types: internal, external dry, and external wet. Lint collection is very important, as discharging lint into the environment is not desired. One point to remember with dry-type lint collection systems, whether internal or external, is that they are only approximately 90% effective in stopping lint. A wet-type lint collector will stop up to 100% of the lint, but at a significantly higher cost. Lets take a look at each and the fundamentals of how they work.

Internal Lint Collection



24.

This type of lint collector is built into the dryer and the exhaust air stream is passed through screens to filter out lint. Some internal lint collectors have automatic blowdown after each dry cycle and some are completely manual requiring operators to clean them out throughout the production shift. Some automated internal lint collectors also have an external vacuum unit connected to remove the lint for easy disposal removing the requirement to clean the internal collector periodically. Internal lint collectors will protect components downstream like the dryer blower wheel from debris, which could cause damage or at minimum, add a preventative maintenance step to clean the lint from the wheel so it doesn't become unbalanced. Internal lint collectors are typically less expensive than both dry and wet external collectors.

External Lint Collection

This type of lint collector is typically mounted downstream of the exhaust air stream past the dryer's blower motor. It can be mounted to the dryer itself or mounted separately from the dryer. The external lint collector is most often automated and conducts a blowdown either during the dry cycle or when static pressure increases beyond a specified threshold. External lint collectors typically add footprint to the installation of the dryer and require a fire protection system separate from the dryer's. They are usually sized so that cleanout can be conducted once or twice a day. External collectors are more expensive both in initial cost and in some cases add cost for installation. *Note: External collectors typically increase the cost of the duct work and can consume a great deal of floor space.*

25.

Wet Lint Collectors

As the name implies, wet-type lint collectors use water to capture lint from the air stream. They are always mounted externally to the dryer, usually on the roof. Water is sprayed into a chamber that the exhaust air stream is passing through. Lint becomes quickly saturated by the water and falls out of the air stream. Wet collectors are very effective in removing lint (up to 100%), but also are extremely costly both in the up front cost and installation cost. They are also not really suited for cold climate installs unless they are installed inside the facility.

26.

The last section of this discussion on dryers will focus on some common preventative maintenance that needs to be done to keep your dryer running as efficiently as possible.

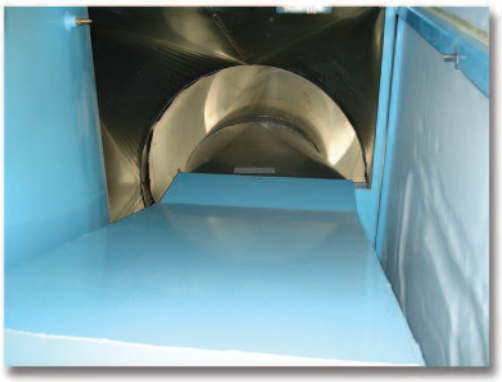
Preventative Maintenance

The first area to focus on is the airflow. As this document has shown, airflow is one of the four critical elements of the Dry Pie[SM] and any restrictions that impede airflow need to be dealt with quickly or the efficiency of the dryer will be compromised. Also, if airflow restrictions are neglected and become serious enough, a dryer fire can occur from overheating.

So where do you start when it comes to ensuring good airflow?

Let's start with installation and discuss the dryer's ductwork.

First, before looking at the dryer itself, check the ductwork connected to the dryer starting from the roof. If you find screens attached to the entrance of the inlet or exhaust duct *(usually installed to keep animals/birds out),* remove them. Screens act as a lint trap on the exhaust duct and will quickly become clogged and restrict airflow. If you can't remove them, ensure that you setup a daily cleaning routine.



27.

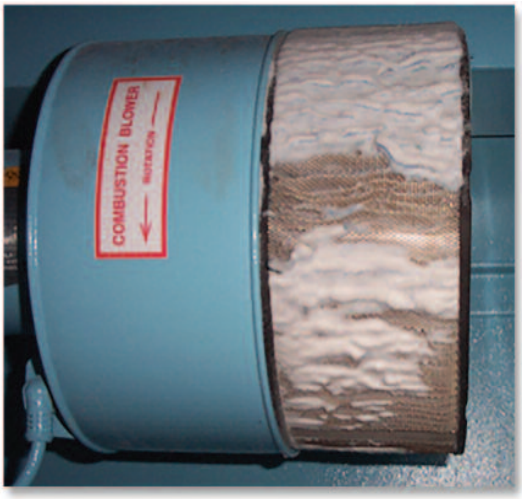
Unfortunately, if your ductwork is already installed, your airflow may be restricted because it was undersized or contains too many bends in the run to the dryer. This creates high static pressure and makes it difficult to pull air through the dryer. High static pressure can cause structural damage to the dryer, overheating problems, and if serious enough, even a dryer fire. If you're experiencing these types of problems and believe they are coming from poor ductwork, consult either the manufacturer or the company that installed the ductwork for recommendations on how to improve it.

The next area to check is the combustion airflow assuming the dryer is using NG or LPG as a fuel source *(this section would not apply to a dryer using steam as a fuel source)*. NG and LPG burn very cleanly, but if the airflow to the burner is restricted, serious overheating problems up to and including a dryer fire can occur. Most dryers have a combustion air filter. Check the operations/maintenance manual that came with the dryer. This air filter must be checked on a daily basis as lint will easily clog it and cause poor combustion. This is an easy PM to do and one of the most critical in terms of efficiency of the dryer. Another way to check for poor combustion airflow is to watch the flame during the dry cycle. The flame should be bluish white and uniform under normal conditions. If the flame is ragged and yellowish, there is a combustion airflow problem and it should be dealt with as soon as practical.

Remember the discussion on airflow from the beginning of the dryer section. Air is pulled through the dryer using a blower fan. The key to good airflow is to ensure there are no restrictions in its path through the dryer. The next area to check after the ductwork is the basket. Industrial dryer baskets are typically made up of panels.

28.

Some manufacturers provide removable panels. These panels are perforated to allow the air to exit the basket. Because many laundries have poor soil sort practices, items such as plastic bags, plastic soda bottles, heart monitor stickers, and everything in between end up in wash loads. Ultimately this contamination ends up in the



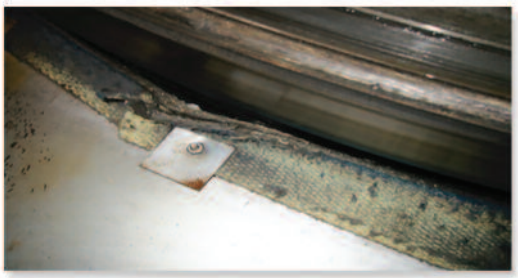
29.

dryer where it melts and becomes embedded in the dryer basket perforations. If not removed, it will significantly impact airflow and lead to poor dryer performance. As mentioned earlier, many manufacturers supply removable panels. Purchasing a couple extras will allow for a rotation schedule giving maintenance personnel the opportunity to clean the panels offline without interrupting production. The clean panels can be put back in at the next scheduled PM. Most manufacturers also provide either a Teflon or Ceramic coated panel that helps prevent plastic debris from sticking to begin with. A better solution to this problem is to attack it at the source – *Soil Sort.*

Another impediment to airflow as it exits the dryer is the lint screens. Whether the dryer has an internal or external lint collector, dirty, clogged lint screens are a common source of airflow restriction. Ensure proper PMs are established to check the lint screens daily to ensure they are blowing down *(if automated)* or being cleaned *(if manual)* correctly and as specified.

30.

The last item to check that can really impact dryer efficiency is air leaks. All dryers use different types of seals to prevent hot air from leaking from the basket area and to prevent ambient air from being pulled into the baskets. These seals may be located on the inside of doors, faceplates, inside the shell up against the outside of the basket, and many other places depending on make. Consult the operations and maintenance manual to locate all seals for your particular dryer and be sure that seals are checked on a routine basis and replaced as needed. A few dollars spent on seals will go a long way in keeping your dryer running at peak efficiency.



31.

As a wrap up to the drying process discussion, the following section is a brief overview on the most common types of industrial dryers used in laundry industry and how they are loaded and unloaded in both manual and automated situations.

Dryer Types

32.

This document has spent a fair amount of time describing the drying process and the science behind it. What the document hasn't done to this point is describe the types of dryers that are commonly used in today's laundries.

In general, there are really two types of industrial dryers. The first type can be used in both a manual and automated situation. These are referred to as pass-thru (PT) dryers, although some models used in a manual operation may not actually allow pass-thru processing. Lets start with the manual operation.

In a manual operation, washers are typically used to process laundry and when that operation is completed, the clean, wet laundry is either loaded into a cart or loaded into a sling bag hoisted up to a rail. The load is brought to the dryer and hand-loaded either from the cart directly, or by emptying the sling bag into the dryer. The type of dryer utilized in this scenario is usually badged as a two-way tilt dryer. This functionality allows the dryer to be tilted back for loading and when the cycle is complete, tilted forward to unload back into a cart. In some cases where pass-thru dryers are used, they may be configured as one-way tilt dryers and are tilted back to load and when the cycle is complete, open a second rear door, tilt to the rear and unload either to a cart or onto a conveyor.

These manually operated dryers, sometimes pass-thru dryers, are typically sized for the appropriate rated washer size and usually come in 200 – 800 pound clean dry weight ratings. These dryers are also used in an automated or semi-automated laundry as described in the next paragraph.

Automated or semi-automated operation typically takes advantage of the pass-thru dryer. We'll focus on a washer operation first and look at a batch tunnel operation in the next section. In a washer operation *(whether semi-automated or fully automated)*, goods are automatically unloaded to a conveyance device, usually called a Loose Goods Shuttle. We'll cover much more detail on material handling equipment in the last portion of this document.

Once the goods are automatically unloaded on to a Loose Goods Shuttle, or other means of conveyance from the washer/extractor, they are typically transported to the dryer where they are automatically loaded and the dryer is automatically given the appropriate formula and started.

There is some demand for systems without a shuttle where goods are automatically unloaded from the washer/extractor and conveyed into a sling bag and put into a clean

33.

storage area. Some manufacturers have developed methods to use vacuum to load the dryers. This method does have some limitations on the type of goods vacuumed to the dryers. Another manufacturer has developed a patent-pending chute loading system. In this system, the sling bags are released and positioned over the chute on the dryer and dropped into the dryer for processing. There is no limitation on goods type in this type of system.

This is only a brief examination on types of dryers and methods for loading them. As the reader can see, in semi-automated and fully automated washer/extractor and batch tunnel systems, conveyance devices or clean storage systems are extremely important to transport the goods from the wet side to the dryers. The next section of this publication will examine the different types of material handling options available for both washer/extractor and batch tunnel systems.

In conclusion, dryers are an integral part of today's laundries, but they are one of the largest consumers of energy costs and can be a limitation on production rates. Understanding the fundamentals and science behind the drying process coupled with good preventative maintenance will ensure your dryer performs efficiently and effectively for many years of service.

Material Handling for the Open Pocket Wash Alley

In the last section of this publication, we discussed the dry process and ended with a short discussion on dryer types and ways of conveying material from the washer/extractors and batch tunnel washers to the dryers. This section will cover this in more detail. The discussion here will not attempt to cover every conveyance device used in laundries, but focus primarily on conveyance devices used in the wash alley.

Today's laundries have come a long way from their past when it comes to conveying textiles. Automation has gained acceptance worldwide, especially as economies have tightened in an effort to reduce operating costs and increase operational productivity. There are certainly still many manually run laundries operating today, but in the larger operations, automation has taken a solid foothold. Automation has also removed the operator(s) from exposure to the potential hazards associated with the washers and dryers when loading and unloading them manually. This section of this educational publication will address the material handling solutions that exist for the manual, semi-automated and fully automated wash alley.

Manual Open Pocket Wash Alley

Before we look at the Open Pocket wash alley, a short discussion on manual wash alleys in general is warranted. All three types of washers, Open Pockets, Top Side Loaders, and End Loaders are used in a manual setting. There are a number of methods used by various plant operators to mitigate safety, ergonomic and productivity exposure. A number of different types of loading devices have been devised to facilitate mitigation of one or more of these factors. From a simple hoist on wheels that can take a sling bag and lift it sufficiently to facilitate loading the washer, to the use of jib cranes for the same purpose, plant operators have utilized what they could create to help this sometimes difficult process. Top Side Loaders and End Loaders present a unique challenge as they do not tilt back and must be loaded into a typically smaller opening than an Open Pocket. Small chute devices, again mounted to a frame on wheels, have been employed to help load these machines. Some Top Side Loaders and Tilting Side Loaders allow the load pocket to be positioned in an upward direction allowing slings to be easily loaded. The main point of this discussion is that if you are operating in a manual environment and loading an Open Pocket, Top Side Loader, Tilting Side Loader, or End Loader by hand, there are some ingenious alternatives that can help reduce ergonomic and other concerns.

34.

35.

As mentioned, there are still many manual wash alleys in operation and some manufacturers have designed devices specifically geared toward the Open Pockets to help keep operators safer during the loading operation. There are two solutions commonly used and we'll take a look at each one next.

The first is really not a conveyance device, but a semi-circular attachment that is affixed to the front faceplate of the washer/extractor. When the operator is ready to load the washer, the frame of this device automatically extends upward and creates a pocket protruding in front of the open washer door. This pocket is made of canvas attached to the frame on top. Goods are either loaded from a cart by hand or by using a sling. To facilitate the loading operation, the washer basket is normally spun during the loading operation. This spinning basket can expose the operator to potential injury if they become tangled in the sling or

goods as the goods and/or sling bags are pulled into the washer. This device allows the operator to drop the goods while maintaining some level of separation from the washer's spinning basket. However, when sling loading, the potential still exists for the bag and/or draw string to become tangled with the operator. Proper training and adherence to loading procedure is important to ensure the device is used correctly. One other concern is the potential for cross contamination from the canvas portion of the device that could contaminate clean goods as they are unloaded from the front of the washer.

The second solution is a mobile conveyance device. This device is made up of a short conveyor sitting atop a battery powered primary mover. The battery pack provides power to move the device around the wash alley and also provides power for the conveyor functions. The device can be pre-loaded in another area, or loaded at the washer using a sling or by taking goods directly from a cart. Once positioned at the washer, the device provides a physical barrier between the operator and the spinning basket. Goods are loaded on the front of the conveyor and conveyed into the washer/extractor by pushing a pedal on the rear of the device. The operator can activate both the spin and spray functions from the loading position. Once the device is moved away from the washer, the spin and spray functions are automatically deactivated to prevent exposure to the hazardous motion. This device completely eliminates the exposure to the hazard of manually loading the washer; however, it does require training in order to efficiently maneuver it within the operating environment of the wash alley.

But is there a way to at least remove part of the manual operation?

36.

Semi-Automated Open Pocket Wash Alley

Although much more costly than the first two options, in many cases a return on investment (ROI) can be generated by the reduction in labor and the potential for injury in a completely manual operation by at least semi-automating the process. Using an automated conveyance device removes many of the ergonomic issues associated with manually unloading the washers and loading the dryers, providing a better overall environment for the operators. The automation can also improve the wash alley productivity, as it won't be called upon to do other tasks unrelated to the wash alley operation. Last but certainly not least, it provides a safer overall environment for the operators depending on how the system is implemented.

So, assuming raising the rail height is not an option, what other possibilities exist to automate some of the process?

37.

The solution is the use of a track-mounted conveyor, commonly referred to as a loose goods shuttle. To install this type of system, sufficient space must exist in front of the washers to allow the shuttle to travel up and down the alley, which is usually created with the washers on one side and the dryers on the other. Another requirement that helps on the other side of the wash alley is the use of this shuttle to unload the washers and load the dryers. It is normally not cost effective to install an automated shuttle only to load washers. Again, assuming the rail height cannot be raised, there are typically only two shuttle systems used in this semi-automated solution.

The first type of loose goods shuttle is simply an angled conveyor bed mounted on a frame with wheels. This shuttle rides on a parallel set of tracks and is controlled by either a program logic controller (PLC) or a computer system. When a washer becomes ready to unload, it communicates through the PLC or computer system to the shuttle. The shuttle responds by positioning itself in front of the washer and in some cases, telescoping the bed just in front of the washer faceplate to facilitate the unloading process. Once in position, it communicates back through the PLC or computer system, which in turn communicates to the washer and commands it to unload. Once the washer is done unloading, the shuttle is then commanded to travel to an available dryer and automatically load it. Once complete, the sequence repeats itself. The only real downside of this type of a shuttle is that it is solely dependent on the software in the PLC or computer system running it. It can't *"think"* for itself and make decisions that might facilitate better productivity on the fly. For that task, another option to the loose goods shuttle could be employed.

A number of manufacturers offer a *"Ride-On"* version of their normal loose goods shuttles. Some provide only rudimentary manual controls that probably won't improve productivity over the standard automated version. However, there is at least one manufacturer that provides a completely integrated solution, which maintains the automation, yet provides the ability for the operator to interact with the shuttle controls providing improved productivity over the standard loose goods shuttle or the completely manual ride-on version.

38.

This ride-on shuttle provides a full cockpit with an integrated touchscreen control that allows the operator to interact with the main computer system controlling the automation. The operator can either allow the shuttle to operate in an automated manner like the unmanned version, or can interact to override certain functions to give the shuttle more flexibility to respond to varying conditions. For example, if two washers are ready to unload at the same time, the operator may need the goods from one sooner because of route timing or other reasons. They can easily select which washer to go to first, versus allowing the system to select, which might not be the one needed. The cockpit also offers up to three cameras providing 360-degree visibility around the shuttle. It comes equipped with three safety-monitored devices to ensure the operator is present in the cockpit and that no one is attempting to hitch a ride on the shuttle. If the operator takes their foot off the foot pedal or leaves the cockpit, all hazardous motion on the washers and dryers can be halted depending on the needs of the wash alley. The downside in a semi-automated wash alley is that it does require a person to operate the shuttle and typically another to load the washers.

So how can you eliminate as much of the labor as possible and still maintain or improve productivity?

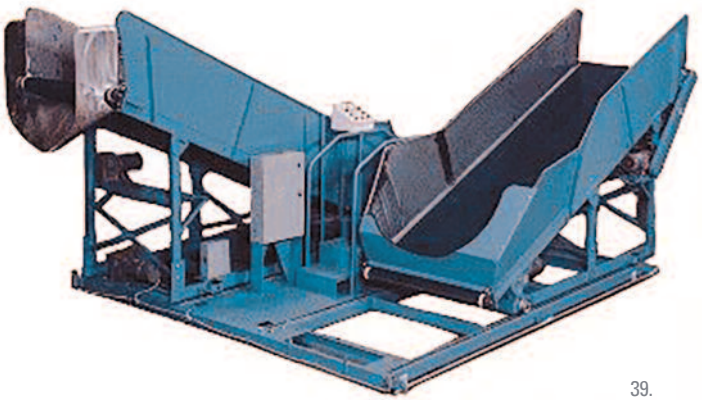
Fully Automated Open Pocket Wash Alley

There are typically six possibilities to automate the loading process for the washers. The first is by use of sling bags dropped into a chute mounted to the front faceplate of the washer, or as in the case of one manufacturer, dropped directly into the washer without use of a chute. For laundries to configure an automated sling loading system from their current manual loading operations, the rail height typically must be raised significantly. This can be fairly costly, and in many laundries, impossible due to ceiling height restrictions. However, if this is an option, the fully automated system can provide reduced labor costs and improved productivity. Different solutions for varying operations are provided in the following section.

The second solution, which is an adaptation of the first, is loading the washer via a vacuum system. In this system, soiled goods are brought to a weigh station and the weight is recorded into the tracking system. The goods are then vacuumed up and travel to a holding hopper located above the washer to be loaded. When the washer becomes available, a chute is lowered in place (similar to a sling loading chute) and the hopper opens a door dropping the load into the washer. This type of system is specialized, but like a sling system, loads can be pre-staged thus facilitating productivity. The downside to this system is that it carries a large price tag and can require significant maintenance to keep it operating at peak efficiency.

The next solution offered by one of the major manufacturers is a variation of the automated loose goods shuttle. This shuttle offers all the automation for unloading the washers and loading the dryers, but also adds a feature to load the washers as well. It has a patented option that utilizes a hydraulically actuated chute. This eliminates the need for mounting chutes on all the washers, saving significant capital. This shuttle can be configured in either a ride-on version (with identical features as described in the semi-automated section) or non-ride-on version (completely automated) with or without the chute. Another advantage of the ride-on version as described in the semi-automated section is the operator can control the flow of laundry from the soil sort rail to staging at the washers, prioritize unloading washers, and prioritize loading the dryers. The downside in a fully automated system is that multiple washers cannot be loaded simultaneously when utilizing the chute model. This may impact productivity over machines that incorporate chutes on each washer.

The fourth solution is the use of a shuttle system commonly referred to as an "X" Shuttle. This is a shuttle with two separate conveyors *(or beds)* mounted on a frame that rides on a fixed track. This provides a solution if the rail cannot be raised. One bed is used to load the washers with soiled goods and the other is used to unload the washer



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and load the clean goods into the dryer or bring them to a bypass station. There is typically labor required to load the soiled goods on the shuttle, but these shuttles can work well for this type of operation. However, they do have space restrictions. The wash alley must have sufficient space at each end so the shuttle can both load and unload the end washers. This becomes important, as the bed not in use will protrude beyond the washer. If there is a wall or other fixed object next to these end washers, the object will interfere with the second bed thus negating this option. The other downside to the "X" Shuttle is productivity. Since both the load and unload operations are taking place using one device, it becomes obvious that the shuttle can't perform both operations simultaneously. Therefore, a washer may be ready to unload, but must wait until it is done with the load operation, creating unproductive time for the washer. Or the opposite may occur, where a washer

is unloading clean goods and another washer is ready to load but again, must wait thus creating unproductive time. This must be taken into account when analyzing this type of system against the existing system. As mentioned earlier, there is also another option that carries some of these same restrictions. This second system utilizes two shuttles running on the same track.

Another solution is the use of two shuttles on the same track. This may sound like a very productive system; however, when analyzed, isn't as productive as it might first appear. First, the rail system will need to be modified (raised) or installed to provide a washer loading option. Like its counterpart, the "X" Shuttle, productivity can be impacted. In this scenario, one shuttle is used to load soiled goods into the washer and the second is used to unload the washer and bring the clean laundry to either a dryer or bypass station. The productivity impact comes from the interference each shuttle creates with each other. If one shuttle needs to get to a washer to unload it, in many cases, the other shuttle can't get to the washer needing to be loaded and vice versa. Also, the ends of the wash alley must also be free of interference restrictions as each shuttle will need to move past the end washers to allow the other shuttle to service those end washers. So as the reader can see, if raising an existing rail system or installing a new rail system isn't an option, careful analysis must be done before investing in either of these alternatives to a manual operation.

The last machine used in a load and unload operation is the scissor shuttle. This shuttle is a single-bed shuttle with a flat conveyor mounted to a scissor mechanism, which sits on a frame with wheels. This shuttle serves the dual purpose of loading the washer and also unloading it and bringing goods to the dryers. Typically the bed is loaded via slings at one end of the wash alley and travels to an available washer to load. This travel is done either manually or automatically depending on the configuration of the wash alley. This eliminates the manual loading step of pushing sling bags into the spinning basket by the operator. The scissor shuttle also telescopes to the machine for loading or unloading. Unlike dropping loads via sling, loading with a flat bed can lead to a few items being dropped on the floor because the opening of the washer is not completely enclosed like it is with chute loading. However, the main disadvantage of using a scissor shuttle for both loading and unloading washers is the cross contamination problem. By loading soiled goods on the same bed as the clean goods are unloading to presents a real problem of contamination and should be considered carefully before employing this type of solution. Even if the scissor shuttle isn't used to load, there is another downside as compared to a standard loose goods shuttle. Since the scissor shuttle's conveyor bed is flat, to incorporate the same surface area as an inclined bed on a loose goods shuttle means the wash alley width will be greater. This means more floor space will be necessary, which may be an impact depending on availability of square footage.


40.

But what if you can raise the height of the existing rail or have plenty of height to install a new rail?

With this consideration, the ROI might look even a bit more attractive and productivity may actual increase over the semi-automated or fully automated low ceiling height restricted solutions discussed above. It certainly will remove the exposure to the hazards of manually loading washers. However, fully automated systems bring hazards that must also be addressed. Let's take a look at the options available.

The first option was alluded to earlier, and that is mounting chutes on the washers, or utilizing the 90-degree tilt feature of one of the manufacturer's washers. The beauty of this type of loading system is that soiled sling bags are pre-positioned at the washer and are loaded almost immediately when the washer becomes ready to load. The non-productive wait to load time is almost completely removed, giving the user a boost in productive wash time. Second, it removes exposure to the hazards of manually loading washers that was discussed earlier. All these

factors should be taken into consideration when looking at the overall ROI. However, to take full advantage of the automated loading process and the investment in the rail modifications or installation, you must also address the unloading process.

We've already discussed how washers can be unloaded to a degree. They can be unloaded automatically to a loose goods shuttle system or to a conveyor. We'll start by discussing the loose goods shuttle systems.

Most of the major industrial washer manufacturers provide complete automated conventional wash systems to include loose goods shuttles. Since we've already covered the general concept of the loose goods shuttle, let's look at options to the standard unmanned version.

The "X" Shuttle concept with two beds was discussed in the previous section. It is a viable solution for loading and unloading when you don't have the ceiling height for rail, but really isn't an option if you do.

The loose goods shuttle with the *"ride-on"* features has its merits, although controls, functionality and ergonomics vary among the manufacturers. A number of these were discussed (pros and cons) in the semi-automated section, but there are some additional considerations to be discussed here in relation to the fully automated wash alley.

Having human eyes inside the automated wash alley gives an extra layer of defense against inadvertent human interaction with the hazardous motion associated with washers, dryers and conveyance systems. A manned shuttle also allows the operator to *"think"* and possibly improve productivity decisions over the *"computerized"* version as alluded to in the semi-automated discussion. The downsides are capital cost, although the added cost of the *"Ride-on"* option will be far less than the capital cost of a safety interlocked gated system. The other downside is the labor requirement created, but in most cases the operator is needed to manage the overall automated wash alley anyway, so this may remain neutral as far as a labor cost addition. Also, if the wash alley is being converted from a manual wash alley, the labor was already in place and may be able to be reduced with this option to one operator.

One manufacturer has taken this *"Ride-on"* concept a step further. They offer a *"Ride-on"* (and non-ride-on – computer-controlled) with a load chute attached to the loose goods shuttle. This patented device allows the operator to load the washers from the controls on the shuttle without the need for chutes mounted on the washer themselves. Obviously this saves initial capital cost for the chutes on the washers. The rail controls are also located inside the cockpit allowing the operator to call off and pre-stage sling bags for upcoming washer loads. If you are upgrading from a manual or semi-automated system, benchmarks have shown a 10% – 15% gain in productivity. However, when benchmarked against a fully automated system with chutes on the washers, a slight productivity decrease occurs. This is solely due to the fact that only one washer can be loaded simultaneously, where a fully automated system with chutes on the washers can load multiple washers at the same time. However, it is not often that multiple washers become ready to load at the same time, so benchmarking your operation is always the place to start when making a decision on the type of loading system to deploy.

As the reader can see, the function of any of these loose goods shuttles is to move laundry from the washers to the dryers or bypass station. However, there are a couple other methods used as alternatives to the loose goods shuttle, and we'll take a look at them in the next section.

41.

Fully Automated – Shuttleless Open Pocket Wash Alley

The first solution to consider is a vacuum loading system. In this system, the washer/extractors unload to a conveyor, which then brings the goods to a vacuum station. An operator facilitates the station using the vacuum created by the dryer blower motor to vacuum up the goods from the load into a round duct that carries the load to each of the dryers. This system is an efficient use of the dryer's blower motor and removes the need for an automated shuttle system. It does need an operator to man the loading station, but again, that operator would most likely be monitoring a fully automated wash alley anyway. Another advantage is that the dryers can be located above the station on a second floor, mezzanine, or another area of the plant. The dryers don't have to be located across from the washer/extractors, as they must in a typical shuttle-feed wash alley.

The downsides to a vacuum system are two fold. First, the type of goods the system can handle is limited. Heavy walk off mats for instance are not going to work with a vacuum system. Second, large thermal blankets or other very heavy long items can become clogged and create significant downtime to clean the system out. Again, the system is efficient for some operations, and you must weigh all factors involved in your particular operation when deciding on this type of system.

The second non-shuttle system makes use of conveyors and a patent-pending chute loading system on the dryers. In this type of system, goods from the washer/extractors are unloaded to a conveyor, which brings them to a sling loading station. An operator is also needed in this type of system to ensure bags aren't overloaded as the conveyor drops goods into the waiting slings. Once the slings are loaded, they are automatically moved into a storage cue and called off by the dryer as the dryer becomes ready to load. The bags can also be pre-staged at the dryer and when the signal to load is given, automatically drop the contents into the attached chute mounted to the face of the dryer. This is also a very efficient system providing a storage buffer for goods. In a typical shuttle system, if the dryers are all in use, a backup can occur causing unproductive time with the washers as they wait to unload. In this system, there is no backup at the washers as goods are stored in the clean cue and staged at the dryer as soon as it is about to become ready to load, eliminating non-productive time. The other advantage, like the vacuum system, is that the dryers can be located almost anywhere in the plant and don't need to be located directly across from the washer/extractors. The downside of this system is the need for an operator to manage the weight each bag is loaded with. However, as in the vacuum system, the operator would most likely be needed to manage a fully automated system, so this probably would not impact the ROI calculation.

Both of these systems are used to eliminate the shuttle and some of the downsides associated with a shuttle system. They both have advantages and disadvantages, so the user must do their homework to determine if there is a ROI, how the added flexibility of dryer location plays into that ROI, and if the gains in efficiency outweigh the higher capital cost over a standard loose goods shuttle system.

Dryer Unloading Options

The last area this section will take a look at is the dryer unload process. Most dryers used in a conventional wash alley unload in one of two ways. They are either manually unloaded to a cart, which is fairly inefficient and labor intensive, or they are unloaded to a conveyor, which is a much more efficient way to unload the dryers. Let's focus on the unload conveyor as there are a couple different scenarios that can be used.

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In a typical automated *(or semi-automated)* wash alley, a conveyor is run behind the dryers. In this type of a system, pass-through dryers are utilized *(see previous section on dryer types).* When the

dryer has completed the cool down cycle and becomes ready to unload, a rear door opens; the dryer tilts back, and goods are deposited onto the conveyor. This is now a good spot to discuss the types of configurations that can be employed on these unload conveyors.There are four typical types of configurations used for an unload conveyor. The first is pretty straightforward. The flat unload conveyor is configured with one additional incline conveyor on one end. The goods are transported to the top of this incline conveyor and stop. When an operator has a cart in position, the goods are manually jogged off the incline and into a waiting cart. Again, this is fairly labor intensive, but in many plants, space and/or height restrictions prevent a more automated solution.

The second configuration is a simple variation of the first. A second incline conveyor is attached to the opposite end from the first. The system can be programmed to send goods in either direction. This can be particularly useful when the finishing area of the plant on one end handles a specific type of goods and the finishing area on the other handles a different type. Again, if goods are manually unloaded into carts, this type of operation can be extremely inefficient. If goods are not unloaded in a timely manner, the unload conveyor can become backed up and not allow waiting dryers to unload. This will then cause backup on the front end of the process causing a lot of wasted productive time for the entire wash system.

A better option if the facility design will allow it, is the use of automated (or manual) take-away slings. In this type of system, the goods travel up the incline conveyor and are dropped into a sling bag. The sling bag is then raised and put into a finishing cue to be processed as needed by the finishing department. The limitation to this type of system is similar to the washer sling system. An operator must be present to ensure the sling bags are not overloaded *(for system load weights over ~ 300 lbs).* This type of system can be utilized with a dual incline system as well.

A third option for an unload conveyor system is use of a vertical drop to either a waiting cart or sling bag. In this situation, the goods are conveyed to one end of the flat conveyor and drop through an opening into a cart or sling bag. This type of system would also most likely need an operator to monitor it to ensure carts are in place or that bags are not overloaded *(for system load weights over ~ 300 lbs).* However, it is a very viable option, especially for dryers that are located on a second floor or mezzanine. This may be a good option for systems utilizing a vacuum or chute loading system for the dryers when they are located above the wash alley.

This section has hopefully given you an overview of the different types of conveyance devices that are available for a conventional wash alley. There are many variations of these types of devices that were not covered here, but all involve use of conveyors, shuttles, and/or sling systems. Moving goods from one process to the next is often an area overlooked in plant design and layout. Make sure you take the time to study how your goods will travel from one process to the next as a poor design can cause significant productivity impacts on your overall wash and dry processes.

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