



Designing the “Perfect” Filter - Revolutionary New Pleat Shape Optimizes Filter Performance

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Hydraulic and lubrication oil filtration are critical in today’s highly competitive marketplace, where equipment durability and reliability are of increasing concern. A filter is expected to perform consistently, under a wide variety of operating conditions, over the course of its service life. Hydraulic filter manufacturers have been continually working to improve existing filters. The first major step toward upgrading hydraulic filters took place over 30 years ago, when cellulose was replaced by glass fiber media. Since then, improvements have been slight and difficult to achieve. The challenge has been to formulate a fine media that removes smaller size particles, but does not significantly reduce flow capacity (higher pressure drop) or shorten filter service life.

Recently, Pall Corporation used an innovative design approach and developed a filter that has the potential to significantly improve hydraulic filtration. Instead of directing efforts toward improving traditional element structure, Pall filter designers thought outside the box. To overcome the limitations of traditional filter design, they investigated innovative alternatives. The result is a filter with a revolutionary new design — a *curved* pleat shape — that takes hydraulic and lube filtration to the next level. Figure 1 shows one of the Ultipleat® SRT curved pleat filters developed by Pall Corporation.

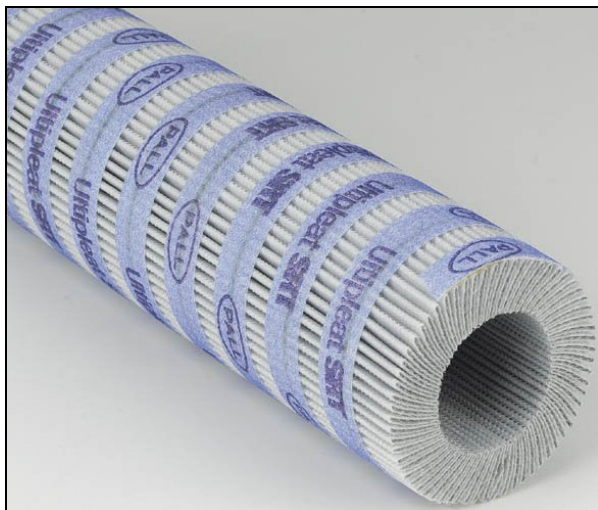


Figure 1: Pall Ultipleat® SRT filter with curved pleat construction

Shape is the Determining Factor

Filter elements used in hydraulic and lube systems typically have a *fan* pleat shape. During the manufacturing process, the pleats are formed on a corrugator. The pack is then wrapped around a core, and the pleats fan out around the circumference, perpendicular to the core. (See Figure 2.).

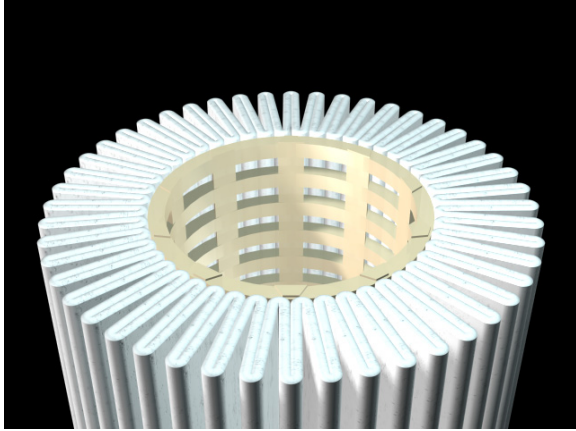


Figure 2: Filter with a traditional fan pleat construction

In Pall's new concept, the pleats are arranged in a curved configuration, as illustrated in Figure 3. The primary purpose of the curved pleat design is to maximize filtration area (filter media) for a given filter element size. This advanced design has numerous benefits, which will be discussed later in the article.

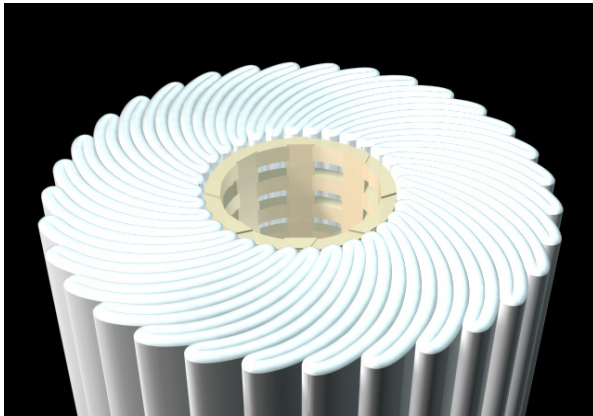


Figure 3: Filter with an innovative curved pleat construction

Development of an Alternative Filter Design

The space available for media within a filter is the annulus between the filter element outer diameter (OD) and the filter pack inner diameter (ID), represented by the OD of the internal core. (See Figure 4.) In fan pleat filters, the unused space between the pleats is lost potential filtration area. The original purpose of investigating alternative designs was to find a configuration in which all of the available space would be used.

Optimization studies were conducted to determine the best pleat configuration for a given element, and equations were derived for ideal pleat shape and length. These studies revealed that the ideal shape is that of the involute of a circle. An involute is the curve traced by the end of a taut string unwound from the

circumference of a fixed circle. It is the most common shape for gear-tooth profiles. Using an involute shape ensures that filtration area is maximized since there are no voids or gaps between the pleats throughout the depth of the filter. Figure 4 shows the involute shape and provides the equation for determining an effective pleat height.

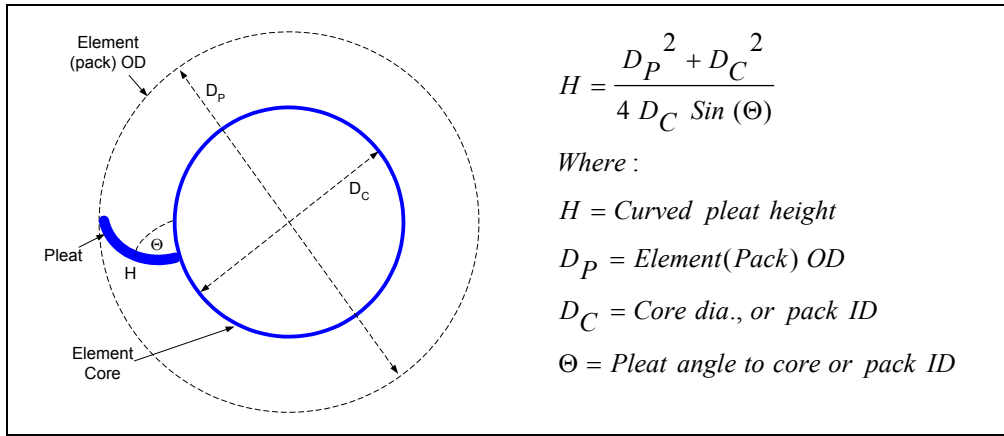


Figure 4: Determination of effective pleat height for involute pleat shape filters

Benefits of the Curved Pleat Design

With its increased filtration area, the curved pleat design provides a number of significant benefits for hydraulic and lube oil filtration. Among them are maximum service life, minimum filter size, uniform flow distribution, improved stress resistance, and element design flexibility.

Maximum Service Life

The involute pleat design can increase filter service life by as much as 100 %. (See Figure 5.) Greater filtration area (typically 30-60 % higher than with conventional designs), lower flow density (flow per unit area), and uniform flow distribution (see below) contribute to this outstanding improvement in filter service life. Longer service life can save on maintenance costs, system downtime for filter changes, and the purchase of additional filter elements.

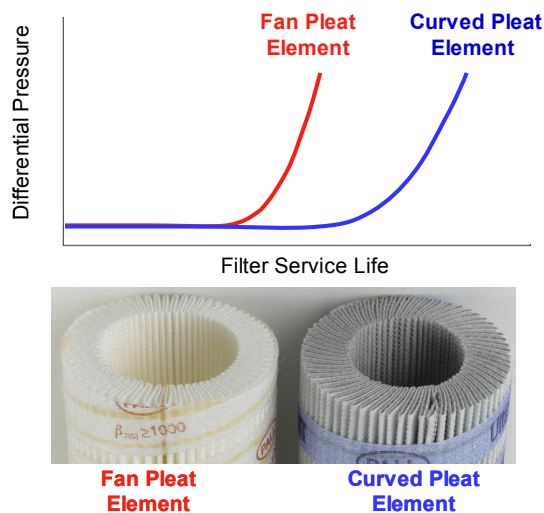


Figure 5: Same size curved pleat and fan pleat designs compared for length of service life

Minimum Filter Size

The greater filtration area of the curved pleat design results in a lower flow density, and consequently, a higher flow capacity. As a result, filter size can be reduced substantially, sometimes by as much as 50%. (See Figure 6.) A smaller size curved pleat filter has the potential to provide the same length of service life as a larger size fan pleat filter. The decrease in element and housing size can result in reduction of cost, weight, and the space required for installation and filter element change out.

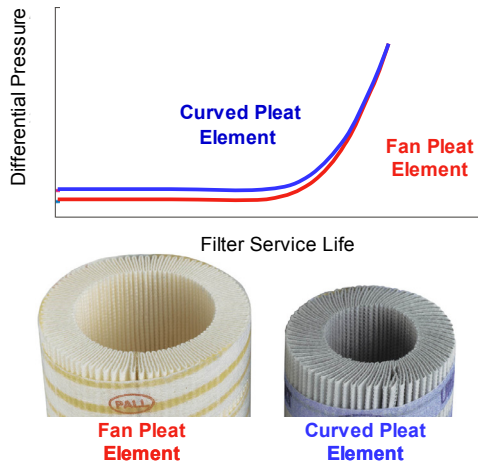


Figure 6: Different size curved pleat and fan pleat designs compared for length of service life

Uniform Flow Distribution

Another advantage of the curved pleat design is uniform distribution of fluid flow. The involute pleat shape facilitates a uniform flow distribution throughout the pleat structure, which results in uniform velocity and dirt loading. (See Figure 7.)

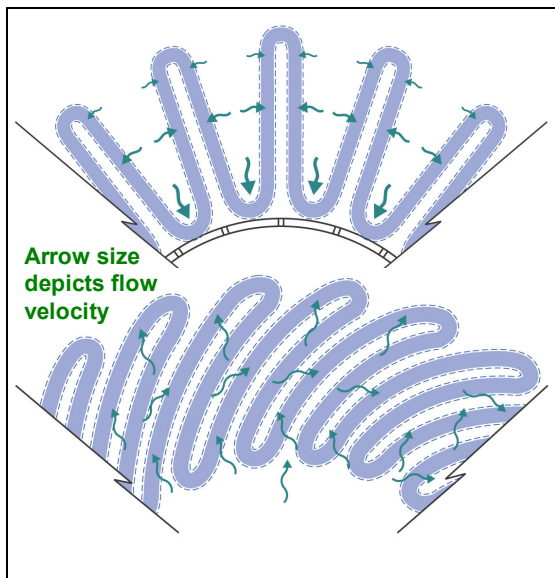


Figure 7: Flow distribution in fan pleat and curved pleat designs

A fan pleat element has the least resistance to flow at the base of the pleat, near the core. The resistance to flow at this point is equal to that of the media pack. When flow passes through the media at the top of the pleats (at the element OD), the total resistance is equal to that of the media pack plus that of the flow channel between the pleats. As a result, velocity is higher at the base of the pleat and lower at the pleat tips. The result is uneven dirt loading of the media, which can potentially shorten filter service life and reduce filtration efficiency over the life of the filter.

The flow resistance of an element with an involute pleat shape is equal at all points within the pleat. When flow passes through the media at the base of the pleat, the total resistance is equal to that of the media pack plus a full flow channel. When flow passes through the media at the top of the pleat, the total resistance is equal to that of a full flow channel plus the media pack. When flow enters the media at the middle of the pleat, the total resistance is equal to one-half flow channel plus the resistance of the media pack plus one-half flow channel. The total resistance is the same regardless of where along the length of the pleat the fluid passes through the media (i.e., the flow velocity is uniform throughout). This results in uniform dirt loading in the media and contributes to longer filter service life and consistent particle control.

Since the involute pleat shape has flow channel resistance upstream and downstream, it produces a slightly higher clean pressure drop than a fan pleat element with equivalent filtration area. The increased pressure can be reduced if the support and drainage material between the pleats that forms the flow channel is properly selected. More importantly, the increased filtration area of an element with the involute pleat design usually more than offsets the higher clean pressure drop. In most cases, a curved pleat element has a lower differential pressure compared with a fan pleat element of the same size and particle removal efficiency.

Improved Stress Resistance

As illustrated in Figure 7, the pleats of an involute pleat element fully support each other on both the upstream and downstream sides. In contrast, the pleats of a fan pleat element only support each other on the downstream side. During operation, the tight structure of the curved pleat element provides excellent resistance to the stresses encountered from cyclic flow, cold start up, and vibration. The result is better and more consistent fluid cleanliness as well as resistance to flow fatigue.

Element Design Flexibility

In the involute pleat shape design, each pleat supports adjacent pleats. This design can be used for the conventional outside-to-inside flow configuration or the preferred inside-to-outside flow configuration. With inside-to-outside flow, there is less chance of the system getting contaminated during an element change because the dirt is captured on the inside of the element.

Pall Ultipleat® SRT Curved Pleat Filters

Pall Corporation has recently introduced a new line of filters for hydraulic and lubrication systems that incorporates the involute pleat shape. Ultipleat SRT (Stress Resistant Technology) filters combine an involute pleat shape design with an innovative, high-performance filtration media that has been specifically designed to resist system stresses such as cyclic flow and dirt loading. The compact, high performance filter improves fluid cleanliness, which increases the reliability and longevity of hydraulic and lube systems.

For more information on Pall Ultipleat SRT filters, call 1-888-333-PALL, or visit us on the Web at <http://www.pall.com/ultipleat>.



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