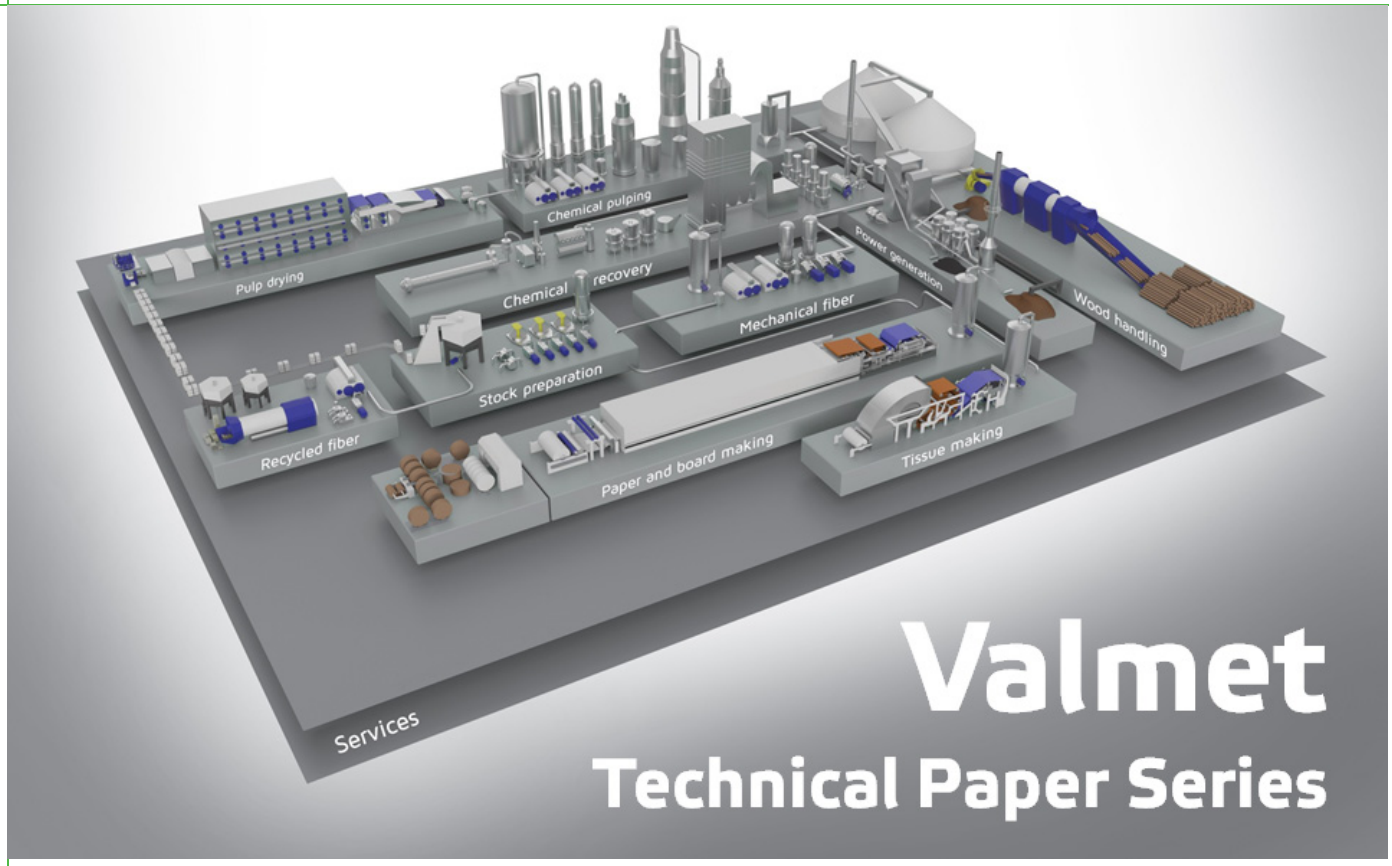


Doctor Blades

Executive Summary

Doctor blades, their materials and use in the paper machine, are complex issues to comprehend. In this white paper, the special needs of doctoring systems in each paper machine section will be addressed. Specialty equipment designed to increase operator safety and improve doctoring productivity is listed. Methods for doctor blade measurement and setup are provided, as well as basic doctor blade troubleshooting information.

The appendix is a blade troubleshooting chart based on recognizing blade wear patterns.

(The scope of this paper does not include creping or coating blades. Additionally, the paper uses as examples only those Valmet products available in Canada and the United States.)

Doctoring in papermaking

Almost all rolls and cylinders need doctoring. The primary functions of doctors are simple: shed the sheet at sheet breaks or sheet threading and remove excess water and contaminants from the doctored roll surface. The keys to an optimal doctoring process are state-of-the-art blade materials, modern roll covers, suitable doctoring equipment and optimal doctoring parameters.

Valmet has taken big steps forward in recent years both in terms of materials technology and innovations dealing with roll covers, doctor blade composition and doctoring equipment. This paper will discuss doctor blades, blade materials, troubleshooting recommendations, blade setup and safe handling, choices of blades for different machine sections, and blade choices by roll cover type. (Doctoring equipment is discussed in a separate white paper "*Doctoring 101*".)

Figure 1. Valmet doctoring R&D includes new blade material design and equipment testing on pilot machines and in the field.

Doctor blades

There are only three basic types of doctor blade:

- Metal (steel, stainless, bronze, Monel® and thermal coated, i.e. ceramic and carbide metal blades)
- Plastic (polyethylene)
- Composites (laminated resin structures which include a binding material)

Until the late 1950s, all doctor blades were of the metal type. In the late 1950s a phenol formaldehyde resin called Bakelite was taken into use as a doctor blade material. It took many years for this material to become accepted for doctor blades since its cost in those early days was relatively high compared to metal. But as the resin structures were improved and new resins and binders formulated, the advantages of reduced roll wear and better runnability became apparent to the mills and the materials started to gain popularity.

High density polyethylene doctor blades

From the early 1980s, paper machines became considerably faster and wider, and soft rolls were introduced. The soft roll covers were easily damaged by both metal and composite blades and a new blade material had to be found. The result of that search was high density polyethylene.

Poly blades are best used on soft covers, as these blades also have the disadvantages of aquaplaning on wire rolls and trapping of abrasive particles which scratch the covers of felt rolls. However, since an aquaplaning blade does not touch the roll face, it will last for a very long time. This led to misuse for economic reasons.

In the early 1990s it became apparent that although composite materials would damage soft roll covers (e.g. softer than about 12 P&J) and poly was the only acceptable alternative for these rolls, poly was not a good choice of blade material for hard roll covers. The blades are usually 0.200 - 0.250 inches (5.0 - 6.5 mm) thick and can be in different colors.

Many suppliers still use high-density polyethylene (HDPE) or polyethylene high-density (PEHD) which has shorter polymer strings.

Valmet provides Valmet Doctor Blade Poly, an ultra-high-molecular-weight polyethylene (UHMWPE) which has longer polymer strings than HDPE for extra durability. It is more stable than HDPE with a higher melting point. Valmet Doctor Blade Poly is a good blade for soft covers that are not too demanding.

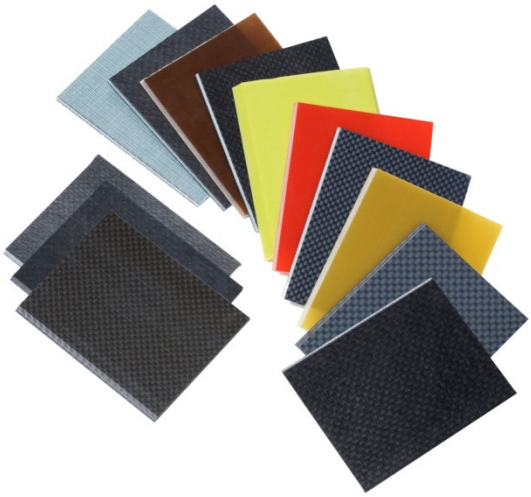


Figure 2. Valmet doctor blades range from high-quality, wear resistant composite blades, reinforced with carbon fiber and/or glass fiber, to more traditional plastic and metal blades.

Additionally, Valmet offers the Valmet Doctor Blade Poly B, also UHMWPE. It features additional cross-linking alloyed with molybdenum disulphide which has long polymer strings, is dense and has high durability. The blade has more stable melting properties and will last at least twice as long as a regular polyethylene blade. Valmet Doctor Blade Poly B is a good option for soft press rolls, grooved or drilled rolls.

Composite doctor blades

Composite blades consist of a resin structure (polymer matrices). These polymer matrices are different resins of epoxy resins, vinyl ester resins or special resin systems for high temperature conditions (e.g. Valmet Ecoresin) reinforced with numerous layers of a binding material (reinforcing materials). The reinforcing materials are layers of fabric mat comprised of glass fiber, carbon fiber, Armide or other fibers in combination. Special raw materials used include: polymer matrix resins and reinforcements with exceptional wear resistance and heat resistance.

The layers of binders and resin can be laminated under very high pressure and temperature for a specific time period or with a pultrusion method. The pultrusion method is continuous and automatic, producing blades with a consistent shape. From 2 to 50 layers of fabric are used.

The resin basic structures are usually enhanced by manipulating their formula to produce resins which are suitable for a specific application. The resin formula used by one manufacturer may vary considerably from that used by another for the same material, which varies the characteristics of the finished blade. A good resin reduces the chance for the resin to melt before the binder wears out; this in turn decreases the risk for a saw-toothed doctor blade edge to develop which would result in poor doctoring.

By combining different resin structures, and their virtually unlimited variations in formula, with various combinations of binders, a large variety of blade materials can be produced, each with its own individual characteristics, and each being suited to a specific application. However, blades produced by different manufacturers will have different characteristics, even if they appear to have the same component materials.

Woven linen (cotton) doctor blades

The blades are usually 0.117 inches (2.8 mm) thick and have a brown color. The different suppliers' blades look very similar. But the properties such as wear rate, water absorption and friction can differ considerably. Valmet provides two types of woven cotton blades – Valmet Doctor Blade Cotton and Valmet Doctor Blade Cotton M.

Valmet Doctor Blade Cotton comprises layers of finely woven long fiber cotton, impregnated and bonded with phenolic resin. It's appropriate for low wear demanding felt rolls.

Valmet Doctor Blade Cotton M is composed of laminated fine weave cotton, with molybdenum added for lubricity. This blade is more durable and has a lower coefficient of friction. Valmet Doctor Blade Cotton M is good for soft breast rolls, breast roll shaker positions and felt rolls. It can also be a good option for soft press rolls depending on the process and roll doctoring recommendations.

Glass fiber (usually woven) doctor blades

Typical glass composite blade thicknesses are 0.060, 0.079 and 0.117 inches (1.5, 2 and 3 mm). The blades are produced in many different colors and wearing properties vary significantly due to the use of different resin types. Glass fiber blades have a high friction factor against most rolls. This can sometimes be a benefit because high friction provides an extra cleaning effect on the roll surface. Experienced paper makers use glass fiber blades as the secondary blade on composite press rolls. This blade can be used for most doctoring positions. It grants superior doctoring for wire and felt rolls when used in combination with lubrication showers and oscillation. The blade is the preferred solution for dryer cylinders, which require good quality blades that can take the extreme heat. Additionally, some fiber glass blades have abrasive particles added which increase the cleaning effect.

Carbon fiber (the raw material for carbon blades)

The commercial production of carbon fibers started in the late 1960s. The main raw materials for carbon fibers are viscose (wood cellulose acetate) and polyacrylonitrile (PAN) a semi-crystalline organic polymer resin. Also used are natural asphalt and pitch natural asphalt.

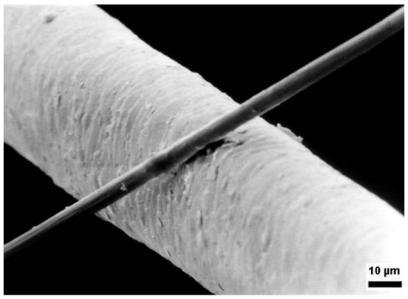


Figure 3. Carbon fiber vs. human hair (black fiber is carbon fiber)

Carbon fibers are manufactured as a continuous bundle of fibers, called "tow". Tows are produced in a wide variety of sizes, 1K, 3K, 6K, etc. with the "k" valuing indicating the number of individual filaments within the tow, i.e. a 3K tow has 3000 filaments. The best type of carbon ropes for doctor blades are flat ropes because they provide an even coverage of carbon at the doctor blade tip.

Traditionally carbon fibers are divided into four groups according to stiffness and strength properties: high strength (HS) is the most widely used and manufactured, but also intermediate modulus (IM), high modulus (HM) and ultra-high modulus (UHM) are produced.

Carbon fiber fabrics

Fabrics are the most common reinforcements used to reinforce plastics. Conventionally, they are biaxial plain structures which are formed from two orthogonal thread systems in which threads run above and below each other depending of the binding being used.

Threads which run in the longitudinal direction are called warps, threads running in the cross direction are wefts. Fabrics can be either even-sided or directed. The most common fabric weaves are plain, basket, twill, satin and leno (**Figure 4**).

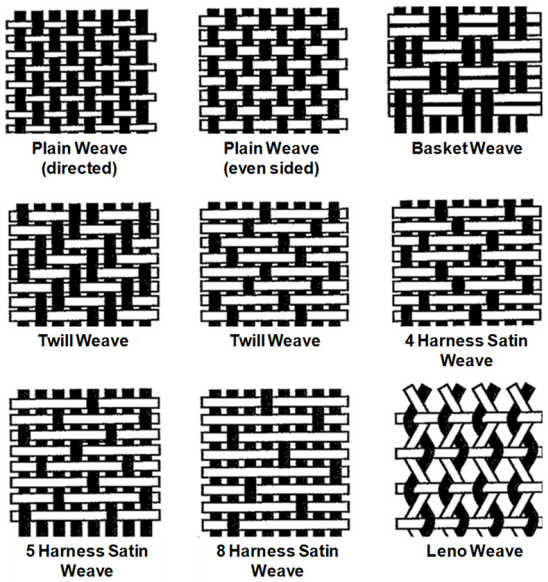


Figure 4. The most common fabric binding structures

Carbon fiber doctor blades

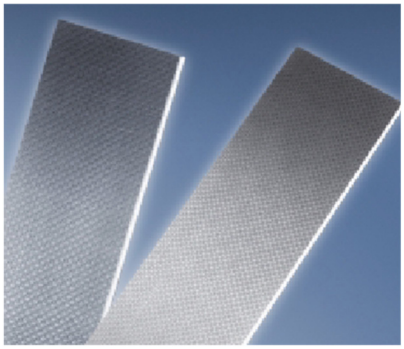


Figure 5. Carbon fiber doctor blades

Common carbon fiber blade thicknesses are 0.060, 0.079 and 0.117 inches (1.5, 2 and 3 mm). Most blades are black in color. From blade to blade there is a big difference in the amount of carbon in the blade composition, and similarly to fiber glass blades there is a wide variety of resins used. For example, Valmet manufactures four types of carbon blades, and each type can be made with varying carbon amounts. So there are about 20 different carbon blades from which to choose – and that's just from Valmet.

The cost of carbon blades varies a lot from manufacturer to manufacturer, and even within a producer's product range. However the benefits can be huge comparing cost to runtime of the blade.

Thus, it's very challenging and important for mills to determine which specific type and formulation of carbon fiber blade to use. Most mills require a doctor blade expert to assist with recommendations, trials and follow-ups.

The main benefit of using a carbon blade is the very low friction coefficient. Stated another way, carbon blades transport heat from the blade edge very effectively. If it were possible to achieve 100% heat transfer, it would effectively be frictionless and the doctor would not wear at all. Water lubrication of the rolls is a powerful means of decreasing friction and reducing blade wear.

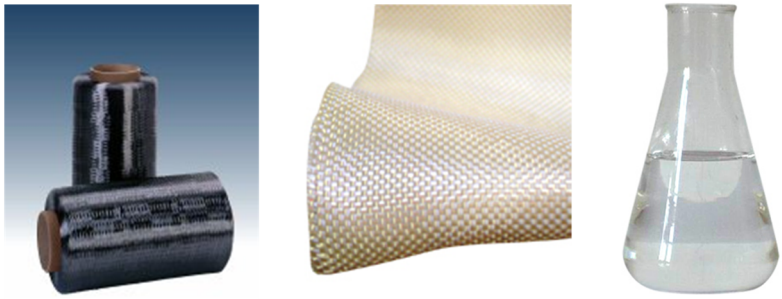


Figure 6. Elements of carbon fiber blade material include: carbon fiber (left), fabric mat composed of glass fibers (center), and polymer matrices (right).

There are different carbon fiber types and resins that effect how the blade wears. The amount of carbon per square inch in a doctor blade is a very good indicator of how good the blade wear properties will be. A simple way to determine relative carbon content is to take a torch and burn one end of multiple suppliers' blades. You will be surprised how different they are. (Naturally, this should be done in a safe and well-ventilated area with appropriate welding protective gear.)

The blade with the most carbon may have the best wear properties; however this does not mean that it will give the best doctoring result. A high carbon content blade will work best for the most wear demanding position. For example, in a center roll position (extreme wear) a high carbon content blade will wear about 1/2 inch in about 1-2 weeks. Valmet Doctor Blade Carbon VT10 blades are very suitable for this type of position

If, however, the position has high but not extreme wear, a blade such as Valmet Doctor Blade Carbon VT4 would be the preferred

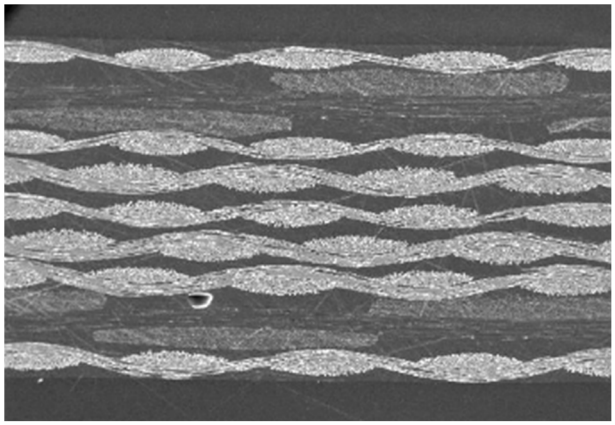


Figure 7. Cross section of carbon fiber blade, 2 layers of carbon and 5 layers of glass fiber

option. This blade can be run for 2-6 weeks before showing 1/2-inch blade wear. For a normal blade wear position, Valmet Doctor Blade Carbon VT2 is appropriate.

Many mills with low actual blade wear use blades with carbon contents that are too high, and therefore they can only use them for a matter of days. If they were to change to a good quality 20-40 % carbon content blade, the running time for the blade can often be increased to 2-6 weeks. There are also many mills that use blades with too low carbon content and have to stop the machine only to change blades because they are worn out.

Metal blades

Many mills don't allow metal blades to be used on their machine lines, and most mills are working to decrease usage of metal blades. The main reason for this is the safety concern. Metal blades are heavy when compared with composite blades and a sharp heavy blade creates a serious personnel safety hazard during blade handling. Still there may be temporary situations where there is a need to use metal doctor blades.

The main metals available for use as doctor blades are carbon steel, stainless steel, Monel and bronze.

Carbon steel is an excellent material for sheet removal, but its normal hardness is about 54 Rockwell C. Most metal rolls used for sheet removal applications are only about 58 Rockwell C. Therefore carbon steel blades are not as compatible with the rolls as we would wish, and massive roll wear can result over a period of time if these blades are regularly used.

Stainless steel, an alloy of carbon steel and chrome, is significantly softer and therefore will result in reduced roll wear as compared to carbon steel. However, stainless has a high friction factor on the majority of metal rolls. So it is normally reserved for use on granite or man-made hard synthetic rolls. Depending on the chrome percentage the hardness varies between about 42 and 48 Rockwell C - a higher chrome percentage is best for high corrosion applications while lower chrome percentage gives better blade life on low corrosion applications.

Monel is an alloy of nickel and copper with a very small percentage of iron and manganese and has a hardness of about 39 Rockwell C. The material is compatible with the majority of metal and granite rolls and some man-made ceramic rolls, and is an excellent sheet removal blade. It has a low friction factor, retains a very sharp edge, has a low coefficient of thermal expansion, and conducts heat away from the cutting edge rapidly. On the downside, the material is expensive.

Bronze (usually phosphor bronze) is an alloy of copper and tin. It conducts heat readily and retains a sharp cutting edge. Its hardness (normally measured on the Brinell scale, but converted to the Rockwell C scale for comparison purposes) is about 16 Rockwell C.

Bronze is generally regarded not as a sheet removal blade, but more as a conditioning blade for new or reground metal rolls. The exposed surface of new and reground rolls is usually quite porous and does not release the sheet cleanly. Bronze is an excellent sheet release agent, and will readily transfer itself into the pores of a steel roll to give a smooth surface which will offer good paper making qualities. It is therefore normal practice to run bronze blades on new (or reground) rolls for 15 to 60 minutes at crawl speed to develop this conditioned surface. If the dryer cylinder was reground within the last year or so and a bronze blade was not used to seal the surface, it can still be done with a good result. Using bronze blades during paper production can result in bronze migrating from the roll to the sheet causing sheet marking. Bronze pieces can also break loose from the blades and end up in fabrics creating sheet breaks – so care should be exercised.

Thermal coated metal blades (ceramic and carbide) are mainly used for ceramic press rolls, very dirty dryer cylinders and after dryer cylinders after coating stations with coating rings on the cylinder surface. Some mills use tungsten blades for their ceramic press rolls. Many have switched to the next generation of carbon blades, blades that today have no problem competing with tungsten blade durability.

There are many benefits in switching from tungsten to carbon fiber blades. These include the previously mentioned safety reasons and also the ability to maximize use of the new surface properties of modern ceramic covers. Also tungsten doctor blades need very efficient lubrication showers to decrease the amount of steel contamination of the ceramic cover that otherwise always occurs.

Still there can be situations such as seasonal process problems with stickies that can only be solved with a tungsten blade. That is why Valmet provides a tungsten blade manufactured by latest methods. This secures even density carbide and less risk to scratch the roll surface of a ceramic roll cover.

Some mills use steel/bronze tungsten carbide blades for demanding dryer positions. Valmet's experience is that bronze with aluminum oxide works best for demanding dryer cylinders. This is due to the varying nature of dryer cylinder surface properties. Rolls that have been used with steam and later are used cold may have a softer surface. Therefore is it important to perform follow-up of dryer cylinder surfaces when using carbide blades. If possible, composite abrasive blades should be used.

Valmet Doctor Blade	Composition and Properties
Poly	Ultra-high-molecular-weight, high density polyethylene.
Poly B	Ultra-high-molecular-weight polyethylene with additional cross linking. More durable than Valmet Doctor Blade Poly.
Cotton	Layers of finely woven long fiber cotton, impregnated and bonded with phenolic resin.
Cotton M	Laminated fine weave cotton with molybdenum added for lubricity.
Glass	Ultra-fine weave glass fiber laminations bonded with special epoxy resin.
Glass ABR	High strength abrasive epoxy glass laminate. Can be used during production. For dryer cylinders.
Carbon VT	Highly wear resistant carbon fibers bonded in special epoxy resin.
Carbon VC T2	Gentle cleaning layer laminated to a conventional Valmet Doctor Blade Carbon VC blade.
Steel	Hardened and tempered 0.75% carbon steel, specially treated.
Brite HT	Wear resistant hardened and tempered martensitic stainless steel (13 % Cr).
Brite nC	Wear resistant hardened and tempered stainless steel blade with carbide edge coating.
Monel	Hard rolled and aged K-Monel 500 (a nickel based copper alloy).
Bronze	Extra-hard rolled phosphor bronze, free from zinc and ferrous impurities.
Bronze A	Extra-hard rolled phosphor bronze with an aluminum oxide edge coating. Ideal for after coater dryers.
Dual	Designed especially for difficult dewatering positions such as grooved rolls and suction rolls with soft covers. Can be used as foil blade or doctor blade, replaces air blades and foil blades.

Table 1. Valmet basic doctor blade family

Identifying doctoring problems

There are three basic steps in the investigation of doctoring issues:

1. Inspect while in operation
2. Gather information
   - From operators, millwrights, supervisors, etc.
3. Inspect during shutdown
   - Check for broken or worn parts
   - Inspect blade wear pattern
   - Check for proper assembly
   - Activate cylinders or DST

There are several characteristic wear patterns that can be remedied after simple visual examination of the blade. These are listed in **Appendix 1** (Blade Troubleshooting Chart).

When changing blades, use caution due to the extremely sharp tip of the used and new blades. Check the blade for wear pattern when changing the blade. Maximum acceptable blade wear is 1/2 inch (15 mm). Protect the tip of the new blade.

It can sometimes be hard to see how unevenly the doctor blade is wearing. One easy method is to put the worn blade on the floor and then put a second blade on the floor with the back (holder) edge very close to the worn blade's blade edge. Then you can easily see how the blade is wearing. For a double doctor, use the lead blade and secondary blade and see if the different blades have the same wear pattern. Saving blades from the same positions and comparing their wearing patterns over time is also recommended.

Valmet doctoring experts use a special Valmet Doctor Blade Analyzer tool that helps document doctor blade wear and optimize doctoring positions.

Alignment & settings for doctoring

In addition to doctor condition, holder and blade type, the doctor settings and alignment are the key to doctoring performance. (Additional information on doctor holders and adjustment may be found in another Valmet white paper entitled "*Doctoring 101*".) The following setup items are particularly important and will be addressed one-by-one:

- Doctor alignment parallel to roll axis
- Blade angle
- Even blade contact across the roll surface (profiling)
- Blade pressure

Cross-machine alignment

A single, imaginary line drawn through the center of the two doctor journals must be made parallel to a single, imaginary line drawn through the two roll journals. This ensures that the blade is parallel to the roll face.

NOTE: Before aligning a doctor, make sure to perform prework. Start by cleaning the roll surface and blade holder. Also check the holder integrity, i.e. check the hoses, top plate, etc. Install the new blade and

then center the doctor on the roll. And most importantly verify the doctor beam bearings are in good condition - most holder misalignment is caused by worn out bearings.

Aligning a rigid holder

To align a rigid holder such as the ValGap or KF35A, perform the following steps:

1. Complete the prework.
2. Adjust so the blade contacts the roll with equal pressure (use .005 inch shim gauge).
3. Level and square the blade contact point (may need to raise or lower and move the doctor bearing in or out).
4. Set the blade angle.
5. Profile the blade holder (only one person should do this part, for a 200 inch holder plan on 1-2 hours).

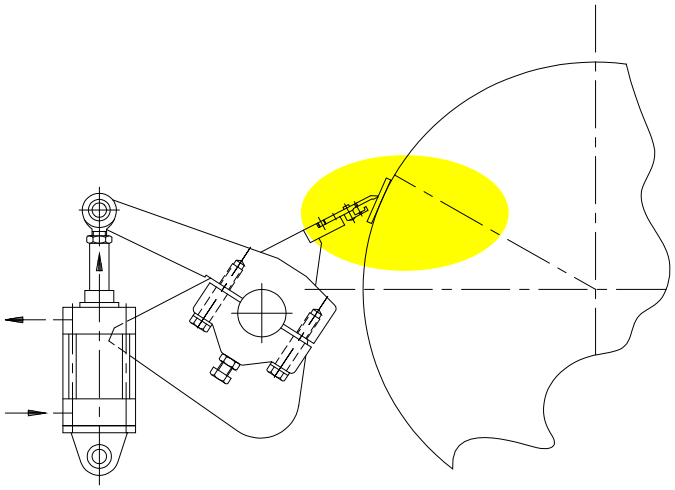


Figure 8. Adjusting safety distance KF-Holder and roll surface

6. Load the holder without a blade and verify there is a 1/8 to 1/4 inch safety distance between the holder and the roll surface. If needed, adjust the mechanical stop.

Aligning a self-profiling holder

To align a self-profiling holder such as a ValFlex or DST, perform these steps:

1. Complete the prework.
2. Disconnect one turnbuckle.
3. Apply equal pressure to both air tubes (up to 30 psi).
4. Adjust so the blade contacts the roll with equal pressure (use .005 inch shim gauge).
5. Level and square the blade contact point.
6. Set the blade angle.
7. Recheck the blade angle with air in the loading hose only.
8. Reconnect the turnbuckle.
9. Load the holder without a blade and verify there is a 1/8 to 1/4 inch safety distance between the holder and the roll surface. Adjust the cylinder stroke length if needed.

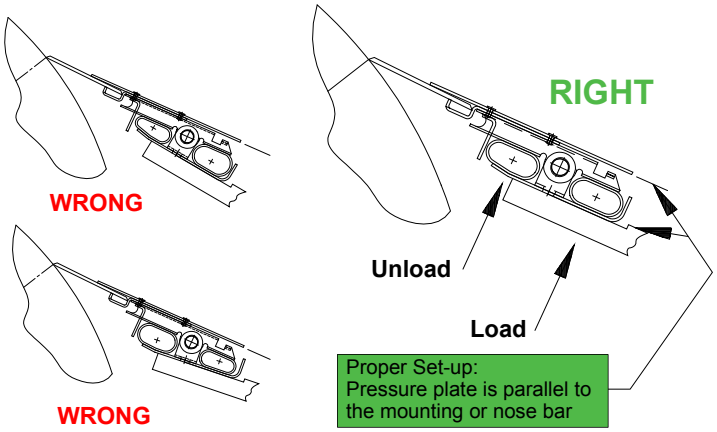


Figure 9. When setup correctly the pressure plate is parallel to the mounting or nose bar.

Examples of alignment methods

There are many ways to align the doctor in practice. The simplest way is to use the Valmet Doctor Angle Meter. Another simple method uses a bubble gauge.

To align using the Valmet Doctor Angle Meter (**Figure 10**) follow these steps:

1. Clean roll surface.
2. Clean holder.
3. Install new blade.
4. Center doctor on roll.
5. Adjust so that blade contacts roll with equal pressure.
6. Use the Valmet Doctor Angle Meter inclinometer to check blade angle reading at both front (TS) and back (DS) sides.

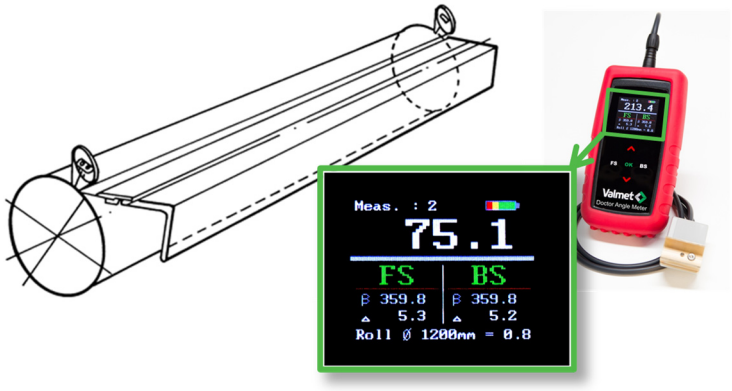


Figure 10. Aligning a doctor using the Valmet BladeAngle tool.

To align using a bubble gauge:

1. After fitting a new blade, the gauge is first applied to the contact point between roll face and blade cutting edge at the tending side of the machine, and the bubble set level.
2. Without disturbing the gauge setting, it is then transferred to the drive side of the machine and applied to the roll face.
3. Next, move the gauge circumferentially around the roll face until the bubble again reads level.
4. The drive side of the doctor must then be moved until the blade cutting edge contacts the gauge foot.

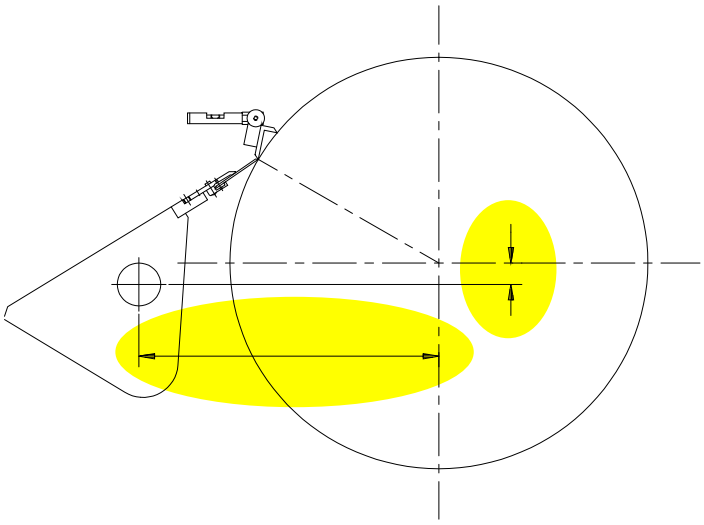


Figure 11. Aligning a doctor using a bubble gauge

Blade angle measurement

The angle at which the blade approaches the roll face should be within +/-1.0 degree of the recommended angle when measured with a new blade under operating conditions. (Note: Measurements should never be carried out with a worn blade.)

Years of experience have shown that the most effective blade angles are in the range of 20° - 30°. As a rule of thumb, soft roll covers require less aggressive angles than hard covers. Draw a tangent to the roll at the point of blade contact, and measure the angle between that tangent line and the blade.

There are a number of ways to measure the blade angle; the best methods use an electronic digital readout device such as Valmet Doctor Angle Meter. These are very accurate and relatively easy to use. These units require two operations for each reading. First, the blade angle relative to vertical is measured, and then the roll face angle at the point of blade contact relative to vertical is measured. By subtracting one reading from the other, the blade approach angle is obtained (i.e. the doctor blade angle). Valmet Doctor Angle Meter will also display the doctor blade contact point. When using a digital blade angle measurement tool it is very important to correct the angle reading according to the roll size. With the Valmet Doctor Angle

Meter this is done easily by adding the roll's dimensions before taking the measurements. Moving the doctor to obtain the desired angle is exactly the same regardless of the measuring device used.

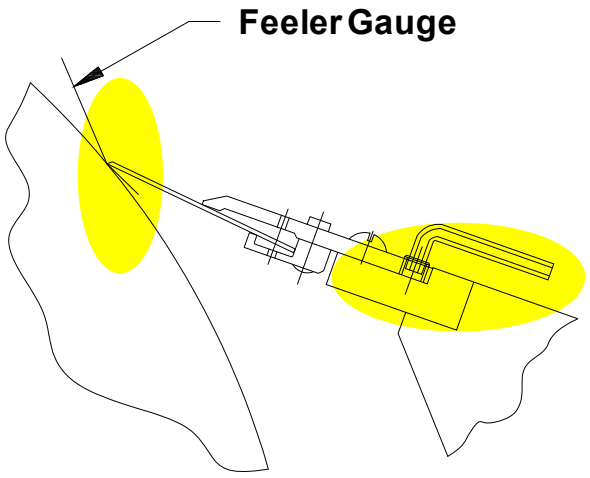


Figure 12. A feeler gauge can be used to profile a holder.

Several other devices and methods are available for measuring and setting alignment and angle but the limitations of this paper do not allow for a description of them all.

Profiling

Very few rolls on the machine have a face which is truly flat over the machine width, especially during operation. Regardless of the straightness tolerance to which the doctor beam is made, it is almost certain that it will be a slightly different shape than the roll face to which it is to be married. This can result in sheet skipping or other doctoring problems. To eliminate all gaps when using a rigid metal blade holder, the blade holder must be profiled. (Note: Valmet composite rigid holders do not need to be profiled due to the self-profiling properties inherent in their design.)

The part of the holder which attaches to the nose bar of the beam is called the "tang". In addition to the holes which contain the bolts for attaching the tang to the nose bar, the holder also contains a row of small screws. These screws are usually on about 3 inch (75 mm) centers and immediately behind each attaching bolt. These are called "micro-adjusting screws".

After aligning the doctor across the machine, and achieving the correct blade angle as described above, the micro-adjusting screws are then used to profile the holder to the roll face.

There are several ways to determine how much profiling is required, some methods being more accurate than others. This paper will describe one method only.

First, install a new doctor blade. Allow the holder to rest against the roll face under gravity load only (i.e. disconnect any other loading device).

Insert a lead light or flashlight behind the holder and, viewing from the opposite side to the light source, look for light penetrating between the holder and roll face. Where light is seen, turn the micro-screws at that location to slightly bend the holder toward the roll until the light disappears.

Start in the center of the doctor and work gradually toward the drive and tend sides uniformly, adjusting one micro-screw at a time. Repeat this procedure down the entire length of the holder. For best results, the exercise will need to be repeated about three times over the entire length of the holder.

The task is very time-consuming, requiring a reasonable amount of skill and a great deal of patience. It can only be done by one person (with a second person handling the light), if more than one person is allowed to adjust the micro-screws, they will inadvertently cause interference with each other's settings. As a rule of thumb, at least three hours should be allowed for the profiling procedure, and it should not be rushed.

The marriage achieved by the above procedure is between the holder and the roll which is to be doctored. Once the profiling is achieved, it need never be repeated unless that marriage is broken. In other words, if

a new holder or a new (or reground) roll is fitted, the procedure would need to be repeated. But otherwise the profiling will remain good, even if the doctor is removed and then re-installed (on the same roll). Often it's more efficient to change the old holder for a new composite holder due to the large amount of time needed to adjust an older damaged holder.

Blade pressure

The optimal blade loading pressure (**Figure 13**) depends on the application. Factors such as blade material, roll surface, machine speed and furnish provide a good starting point for the optimization, but the final load pressure must be tuned to the process requirement.

Recommended blade pressures are based on empirical data from paper mills and theoretical calculations. Settings should always be made with a new doctor blade. As blades wear, the angle changes and so does the loading pressure. The golden rule of blade pressure is to always use the lowest safe load. A blade load that is too high will bend the doctor blade and decrease the blade's profiling properties. Valmet's composite holder support blades move the blade pressure point out closer to the blade edge, thus decreasing the risk for the blade to bend.

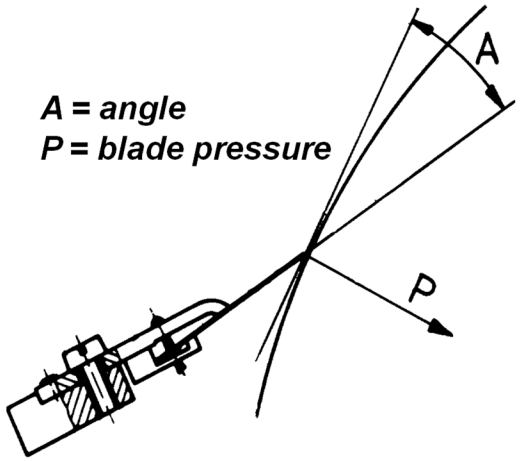


***Figure 13. Blade angle and** pressure*

It is important to remember that the blade angle directly affects the blade load, due to roll rotation speed. If the blade angle is too low, the roll's rotation speed will push the doctor blade away from the roll, thus decreasing the actual blade pressure. If the blade angle is too high, the roll speed will cause the blade to dig into the roll, increasing the effective blade pressure.

NOTE: Never increase load with a used blade! The blade tip will open up and there is a big risk for paper wrap.

Blade storage, handling and adjustment equipment

There are many ways to store and handle doctor blades. Most mills can significantly improve their existing blade storage and handling capabilities. The following sections review alternative state-of-the-art blade handling, setup and adjustment equipment that will maximize operator safety and efficiency on the machine line.

Equipment for doctor blade storage

Technology is available to accurately, conveniently and safely store doctor blades while making very efficient use of space.

Valmet Doctor Blade Cabinet, the easy way of storing doctor blades

Valmet Doctor Blade Cabinet helps store doctor blades next to the machine without the need for storeroom inventory. This doctor blade storage container is capable of holding 10, 15, or 20 doctor blade boxes, depending on the model. Doctor blades are supplied direct to a Valmet Doctor Blade Cabinet located in the machine room. Each blade box is clearly marked indicating the blade position, blade material and blade dimensions, which makes blade changes simpler and safer.

Valmet Doctor Blade Cabinet can be located close to the production line in the machine room, and can also function with consignment inventory. In this case, Valmet Doctor Blade Service assumes responsibility for the supply and storage of all blades.

Valmet Doctor Blade Trolley, for safe and efficient blade handling

Valmet Doctor Blade Trolley is a mobile storage container on wheels located next to the production line. The trolley allows the blades to be installed directly in the machine. Valmet Doctor Blade Trolley includes 5 or 7 blade boxes with 5 to 10 blades packed in each box. The blades are cut to correct lengths and ready for use. Each Valmet Doctor Blade Trolley and blade box is clearly marked similar to the Valmet Doctor Blade Cabinet.

The mobile nature of the Valmet Doctor Blade Trolley allows the operator to move blades close to the machine prior to installing the blade. The blade is then pulled out of the box and inserted directly into the blade holder, eliminating installation damage.

BladeCoiler
blade recycling

Valmet Doctor Blade Puller
safe extraction

Valmet Doctor Angle Meter
angle measurement

Valmet Doctor Blade Cabinet & Trolley
storage/transport

Figure 14. Doctor blade auxiliary equipment for safer blade setup and handling

Valmet blade box, for blade handling and transportation

A Valmet blade box provides easy and safe handling of doctor blades, and is labeled for each position. BladeBox holds up to 10 blades. Blades are pulled from the box like a hose off a reel for easy installation into the holder.

Equipment for doctor blade handling

After safe and efficient storage of doctor blades is achieved, there are several options available to facilitate insertion, extraction, reuse and recycling of the blades.

Valmet Doctor Blade Puller firmly grips the surface of a blade

Valmet Doctor Blade Puller is a handy slide hammer that firmly grips the surface of a blade, and quickly removes even the most obstinate blade from the holder. Changing doctor blades is quick, easy and safe. The angle of blade extraction is always appropriate due to the design of BladePuller's grappling jaw, which can rotate a full 360 degrees. Thanks to its compact size, the device will fit even the narrowest blade gaps and the tightest spaces. The puller's grip is sure to hold; it releases the blade only when pulled sideways. Valmet Doctor Blade Puller uniformly compresses the surface of a blade, without damaging the important blade fibers. The puller's arm is long enough to reach most locations. For jobs requiring more reach, such

as center roll blade replacements, an extension arm is available to stretch Valmet Doctor Blade Puller total length to 6 feet (1.8 meters).

BladeCoiler enables blade reuse

BladeCoiler collects and coils used blades into recycling containers at the mill, which are then sent to the closest Valmet blade shop facility. The blade shop sorts blades into those that can be resharpened and those that will be scrapped and sent to a waste treatment facility. Blades selected for reuse are sharpened at the blade shop and returned to the mill inside recycling containers. This recycling substantially reduces waste treatment costs and helps to protect the environment.

Valmet Doctor Blade Cutter shreds used doctor blades

Valmet Doctor Blade Cutter is designed to minimize used blade handling. It cuts used doctor blades into 3 inch (90 mm) pieces. Design features include improved safety and reduction of waste bulk.

Equipment for doctor blade setup and adjustment

Efficient and accurate operation of a doctor requires careful setup and monitoring of blade angle and wear.

Valmet Doctor Angle Meter, for quick and easy blade angle measurements

The Valmet Doctor Angle Meter inclinometer permits measuring rapidly and exactly absolute angles and angle differences. It functions electronically and instantly provides the correct angle reading, angle difference and angle change. Valmet Doctor Angle Meter is applicable to all doctor and holder types, also to the second blade of double doctor.

Figure 15. Blade angle measurement is easily performed with Valmet Doctor Angle Meter.

Measuring with Valmet Doctor Angle Meter is easy. Its ergonomic design permits quick and reliable measurement. A clear spotlit liquid crystal display shows the angle reading, the angle difference and the angle alteration. The advanced measuring program allows taking into account the deviations caused by the most common roll diameters. The accuracy of the meter is ± 0.1° and the measuring range is 360°. Valmet Doctor Angle Meter is designed for heavy use and comes in a transport case.

Blade choice by paper machine section

The correct choice of blade material is critical for problem-free operation of the paper machine and for a high-quality end product. When selecting blades, many different factors must be taken into consideration. Different paper machine sections have different requirements. There is a lot of empirical data available to aid in selection. When selecting a blade there are four questions which must be answered:

1. Is the blade intended for sheet removal only?
2. Is the blade intended for cleaning purposes only?
3. Is the blade required to both clean and remove the sheet?
4. Is the preferred blade material compatible with the roll cover material?

A basic rule for the blade material is that under set doctoring parameters the blade must wear in order to maintain blade tip sharpness. Of course, for economic reasons the wear rate should be minimized.

Factors affecting the doctor blade material selection on paper machine include: safety; paper grade; machine speed; machine section; roll cover material, surface finish, hardness and general condition; application (shedding, cleaning, etc.); surface temperature; doctoring parameters (blade loading, angle); environment and cost.

Doctoring in forming sections

The forming section of the paper machine can be considered a "break generator". Circulating water and a wet, weak paper web allow a lot of fiber, filler and other papermaking raw materials to accumulate on the roll surfaces. Preventing excess water and contaminates from weakening or breaking the web makes doctoring a very important process in the forming section.

High-density polyethylene (HDPE) doctor blades are widely used in the paper machine wet end. HDPE, however, needs a lot of lubrication water to keep the blade tip from melting.

A good alternative to HDPE blades is to use glass fiber blades which provide better doctoring compared to poly blades - however glass fiber blades also require good showering. The best option is to use carbon fiber composite blades. The lubrication shower volume can be significantly reduced without fear of damaging the blade or cover.

For driven rolls that have softer roll covers modern poly blades or Micarta blade may be used, for example Valmet Doctor Blade Poly Black or Valmet Doctor Blade Cotton M. Oscillation is preferred for all wire roll doctors with the exception of grooved or drilled covers.

For couch rolls is it very important to have a blade holder that is easy to keep clean, such as Valmet Doctor Holder Compact. This holder in combination with a well-designed save-all allows the use of a special foil blade, Valmet Doctor Blade Dual, which provides the same increase in dry content of older more expensive air blades.

Wash roll doctoring is very important because poor doctoring on this position results in sheet breaks. It's important to use a good holder such as Valmet Doctor Holder Compact and to have both adequate showering and an appropriate doctor blade. The best time to make doctoring changes in this area is when new wire roll covers are installed, at which time all doctor settings should be checked.

Doctoring in press sections

There have been many innovations to increase the production capability of paper machine press sections. One development that directly impacted doctoring practices was the addition of a steam box to the press section. Many presses that used granite center rolls had to be modified because the thermal load from the steam box caused expansion of the granite that made it structurally unsound. Granite, as a roll surface, is excellent due to its smoothness and release factor but the structural limitations forced paper machine

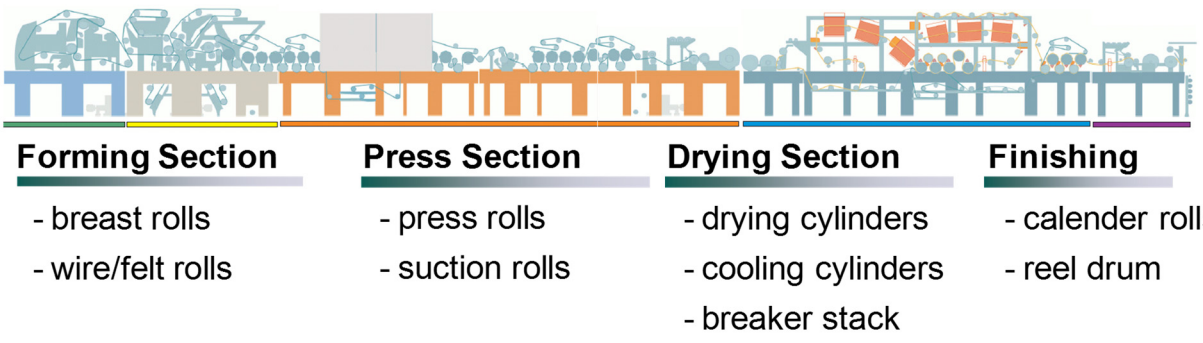


Figure 16. Doctoring positions on the machine

builders to develop new ceramic covered roll replacements. Modern ceramic covers are very sophisticated and allow both the steam boxes and the high linear pressures required to achieve high paper machine speeds.

The press section is the most critical position in the paper machine for doctoring. The doctor must clean the press roll surface without affecting its release properties. It must also be able to shed the full sheet for long periods during the threading process. Failure to excel at either of these functions will reduce the efficiency of the machine.

Many mills are not satisfied with their current press doctoring method. An investment in a well-designed double doctor with good showers and the latest technology doctor blade holders together with a suitable roll cover and good doctor blades is frequently recommended. This almost always solves press section doctoring problems. And in those cases where doctoring problems are not completely solved, this investment provides the mill with the best tools to use for continuing optimization efforts together with the doctor, roll and process specialist(s).

For press felt rolls, glass fiber blades can only be used when there is good shower lubrication. The best option is to use carbon fiber composite blades. Lubrication shower volume can be significantly reduced without fear of damaging the blade or cover.

For rolls without lubrication, modern poly or Micarta blades may be used (Valmet Doctor Blade Poly B or Valmet Doctor Blade Cotton M). Oscillation is recommended on all felt roll doctors except for grooved or drilled roll covers. For suction rolls, grooved or drilled roll covers, the blade holder must stay clean. Similar to the forming section, using Valmet Doctor Holder Compact, a good save-all and the Valmet Doctor Blade Dual blade is the optimal solution for high dryness.

It can be very difficult to select the best press roll doctoring method on a specific machine. The main reason is that most machines don't have optimal doctoring equipment installed. In those cases it's not possible to use intermediate showering, easily removable blade holders, and special doctoring concepts such as non-oscillation and reversed bevel blades. While reading this paper should improve your understanding of the different blade materials and doctoring, there's nothing like talking to a doctoring expert for the particularly complex issue of press doctoring.

Doctoring in dryer sections

The dryer section often has the highest number of doctors installed in the paper machine. The purpose of the doctors is to clean the cylinder surfaces and direct the web down to the pulper on take-off positions.

Stickies and fiber accumulate on the drying cylinder surface. These impurities form an uneven insulating layer which impacts the sheet moisture profile. Additional drying energy must be used at some point to even out the profile. Stickies and other impurities may also cause web breaks in the dryers and subsequent sections.

With sufficient doctoring, dryer cylinders can be kept clean. As machine speeds have increased, composite blades have replaced metal on dryer sections. This has also led to fewer fires on paper machines.

The composite materials used for doctoring in dryer sections are usually a glass fiber or a carbon fiber composite, with or without abrasive additives. Glass fiber doctor blades are traditionally used in slower machines. For higher speeds, more carbon is required due to the wear factor.

As stated earlier, some mills use steel/bronze tungsten carbide blades for demanding dryer positions. Valmet's experience is that bronze with aluminum oxide works best for demanding dryer cylinder positions. This is due to the varying nature of dryer cylinder surface properties. Rolls that have been used

with steam and later are used cold may have softer surfaces. Therefore it is important to perform follow-up of dryer cylinder surfaces when using carbide blades. If possible composite abrasive blades should be used.

Summary

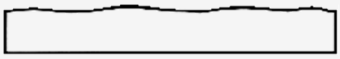
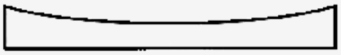
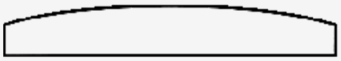
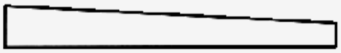
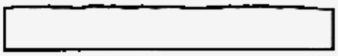
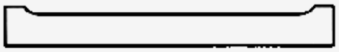
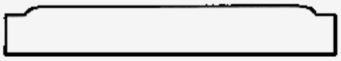
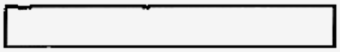
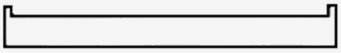
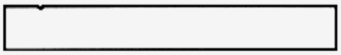
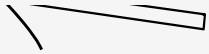
In conclusion, doctoring in paper machines is often considered to be a simple ancillary process and, as such, is often overlooked. However, use of good doctoring practices and the best available materials can result in better machine runnability and reduced water and power consumption.

This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers' performance forward.

Appendix – Blade Troubleshooting Chart

Blade Wear Pattern	Probable Cause	Suggested Remedy
 **Uneven wear**	Holder not profiled to roll	Re-profile holder
 **Center wear**	Beam deflecting	Replace doctor
 **Bow wear pattern**	Beam bent	Replace doctor
 **One end wear**	Doctor misaligned	Realign doctor
 **Rough blade edge**	A. Wrong blade material B. Excess blade load	A. Change blade material B. Check blade load
 **Wear within trim**	Abrasive furnish	Apply water lubrication to the face of the roll
 **Wear outside trim**	Sheet lubricates roll	Apply water lubrication to the face of the roll
 **Localized pitting**	A. Excess heat B. Static discharge	Use nonmetallic blades
 **Horns both ends**	Blade is too long	Reduce blade length to match roll face length
 **Score on blade edge**	Damaged roll face	Repair roll face
 **Feathered blade edge**	A. Low blade angle B. Excess blade load C. Incorrect blade material	A. Check alignment B. Decrease blade load C. Use harder blade material
 **"Bird's mouth"**	Blade load increased after startup, may result in sheet pass.	Never increase the load on a worn blade. Decreasing load is OK.

Always inspect your worn blades – they will give you valuable indications of any doctoring problems.