Effect of printer roll-quality requirements on winding technology

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ABSTRACT: Before we can meet printer requirements for consistently high-quality rolls, we must first identify all roll defects in the pressroom. Only when we completely understand these deficiencies and their causes will equipment engineers be able to design the proper equipment to meet these requirements. There was a time, not very long ago, when the solution was to use a single-drum winder. However, other problems surfaced. Today we can modify the two-drum winder to meet production requirements by producing a higher quality and larger roll. This paper explains methods of extending the range of the two-drum winder into applications that had previously been satisfied only by single-drum winders.

KEYWORDS: Defects, printing machines, quality, rolls, specifications, technology, winding.

Through a very extensive study of more than 360,000 rolls at a printer that operates 19 presses, over 85 different defects and their causes have been identified. This database includes more than eight different paper grades from 24 major paper suppliers. These defect categories include core bursts, edge bursts, edge cracks, crepe wrinkles, tension-related defects, and many more. Only by analyzing the percentage of total breaks caused by individual defects can we begin to address the defects causing the most breaks (**Table I**).

We also found that the paper mill and the pressroom share the blame for breaks in the pressroom. Presses tend to be run with very high tension levels to maintain register control. Therefore, what is perceived by the mill to be a small and insignificant defect can potentially cause a break on the press. To prevent this, it was necessary to reduce tension levels on the press while still maintaining register control. The paper mills supplying paper to these presses must understand the paper characteristics that affect printability and runnability and how to manufacture rolls that will perform best in this application.

By addressing each major defect category in this manner, the total breaks in this pressroom were reduced by over 50% (**Fig. 1**). Working as true partners to resolve problems both in the mills and the pressrooms, break levels of less than one per 100 rolls are attainable.

Roll quality requirements

When hidden defects are introduced during the winding process, often they are not found until a break occurs in the pressroom. Pressmen have no idea what the structure is of a particular roll when it is being run on their press. Therefore, rolls that are not wound consistently at the mill from set to set and from machine to machine will cause breaks to occur in the pressroom even though no visual defect can be seen. Operators in the pressroom will attempt to run a minimum of 10 rolls from one supplier and from one deckle position. However, the wound-in tension as it relates to deckle position (**Fig. 2**) shows that roll quality and structure are very different because of cross-machine profile variations and paper characteristics.

This problem is amplified when the same grade from different machines is run (**Fig. 3**). When this is attempted, the operators may have to make up to nine adjustments to

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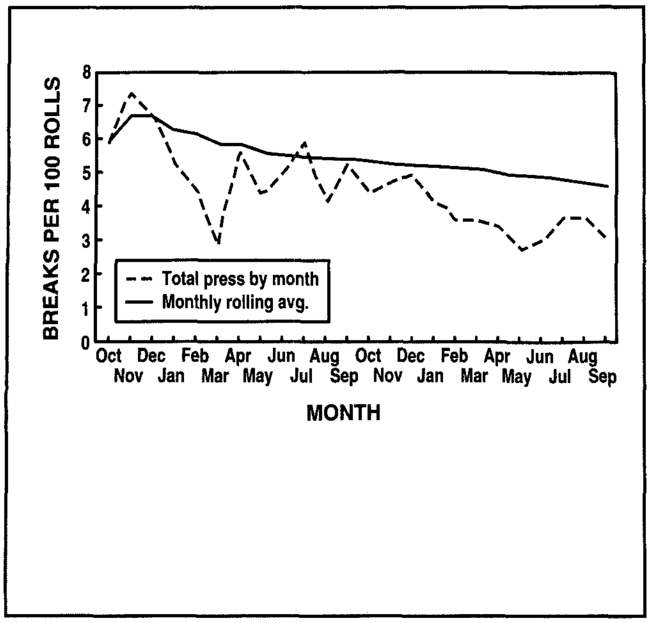
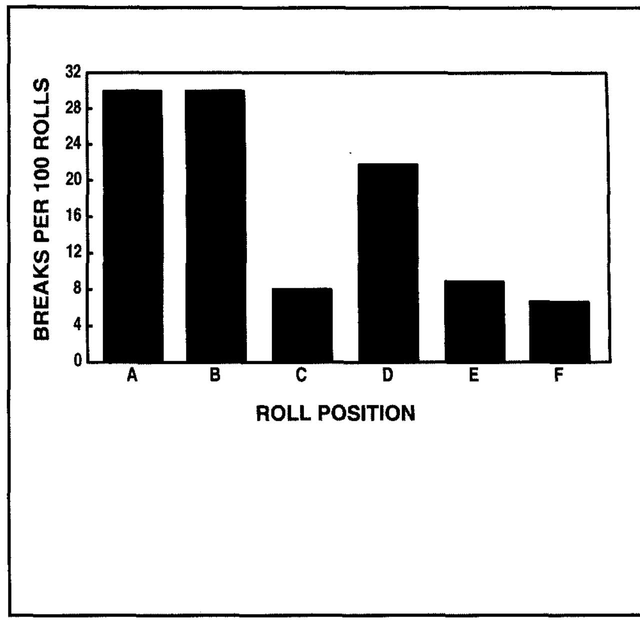
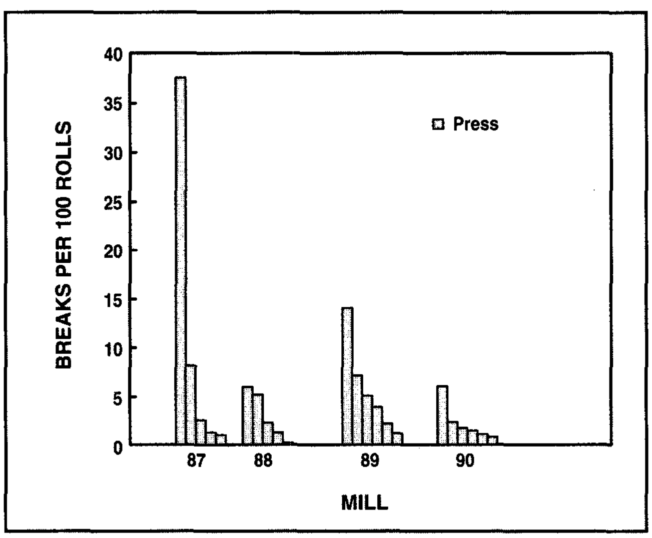
1. Defects reduced in Pressroom A



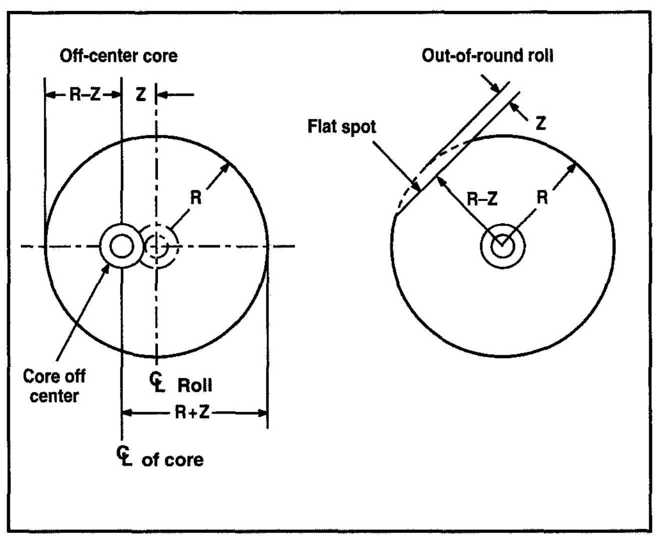
2. Roll position



3. Breaks per 100 rolls by mill and press



4. Improper roll structure



keep the proper register control. All these adjustments take time, cause waste, and increase the cost of printing.

The two most often identified problems evident from improper roll structure are off-centered cores and out-of-round rolls (**Fig.** 4). When a core is off center or a roll with a flat spot on the outside is run on the printing press, it will have large variations in tension, causing the web to break or the press to be slowed down. Again, these variations in roll structure result in lost time and increased paper waste.

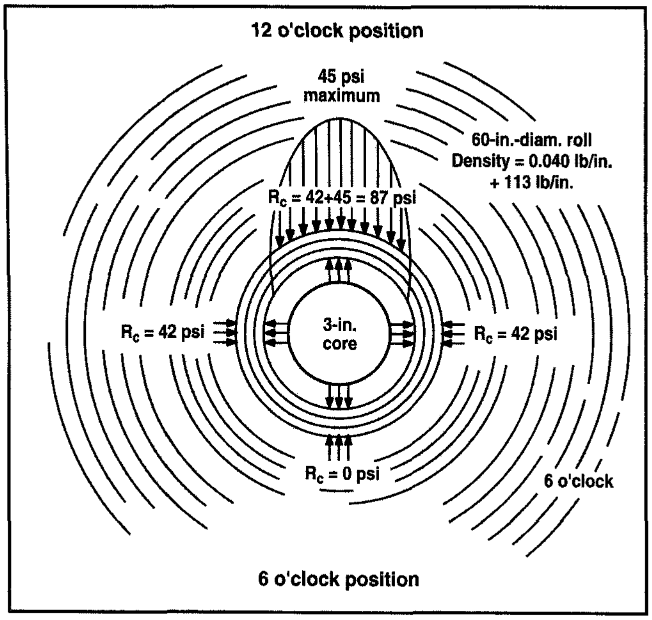
From the data that have been collected from customers, equipment builders are able to provide enhancements to two-drum winders that allow mills to provide consistent roll structure for all rolls.

Winding equipment

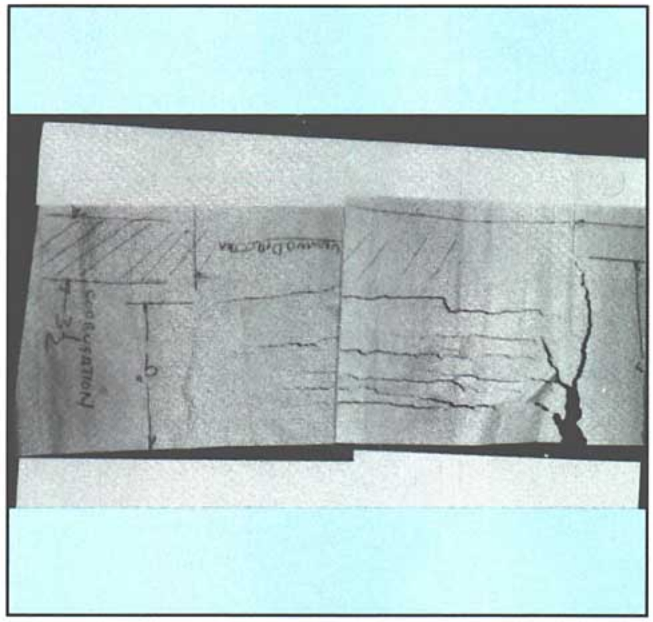
In the last three years the two-drum winder has been making a comeback due to new technology aimed at extending its performance.

The fundamental technology behind all products offered is reduction of the drum nip at large diameters. Beloit also offers an Articulating Rider Roll™, which im-

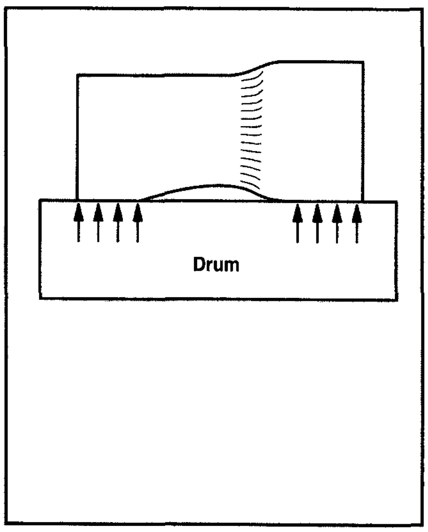
5. Compressive pressure (P_c) about core



6. Crepe wrinkles



7. Large-roll corrugations



proves roll structure at the start for paper with cross-machine profile variation. The problem with conventional two-drum winders is their inability to compensate for cross-machine profile variation and high drum nip at large diameters.

A roll of paper is a succession of tension bands being wrapped around each other, with the outer layers of paper compressing the inner layers. As the roll is unwound, the compressed paper in the inner layers regains its initial tension to be presented to the next process.

When a roll of paper is put into the unwind of the printing press, it is supported by the core. Pressure at the 12 o'clock position between the paper and the core increases, while it decreases at the 6 o'clock position. As the paper sags, it compresses the paper at the 12 o'clock position and loosens the paper at the 6 o'clock position (**Fig. 5**). This causes the paper at the 3 and 9 o'clock positions to stretch. If the tension in the 3 and 9 o'clock positions exceeds the pretension put in during the winding process, a complete loss of tension results. The core and a small amount of paper acts as a sun gear and the roll as the ring gear. This results in the core traveling a shorter distance, eventually causing either a crepe wrinkle or a burst near the core (**Fig. 6**).

One of the main contributors to controlling wound-in tension is nip pressure. There are three nip points in a two-drum winder—one on each drum and on the rider roll. The profile variation in a web of paper makes it difficult to use nip pressure to its full advantage on a conventional two-drum winder. At a large diameter the drum nip cannot be controlled.

With the conventional steel drum, the winding roll surface deflects. When the nip moves, it rotates about a point in the roll called the instant center.

This center is not the center of the roll. This gives rise to layer-to-layer shear that moves the paper. This shearing action causes slip between the layers and results in an accumulation of paper which eventually forms a crepe wrinkle. Here, too, one may find a burst in the vicinity of the crepe.

Also, with the conventional drum, as the web of paper winds on the drum the high-caliper areas build on each other as well as on the low-caliper areas. This results in diameter variation across the roll of paper, with the large-diameter areas, usually two, supporting the majority of the roll weight (**Fig. 7**). The variation in nip pressure causes the wound-in tension of the roll to vary across the width, making it impossible to build consistent and repeatable roll structure.

Early two-drum winders had the rider roll installed level and maintained level throughout the building

Table I. Defect classification

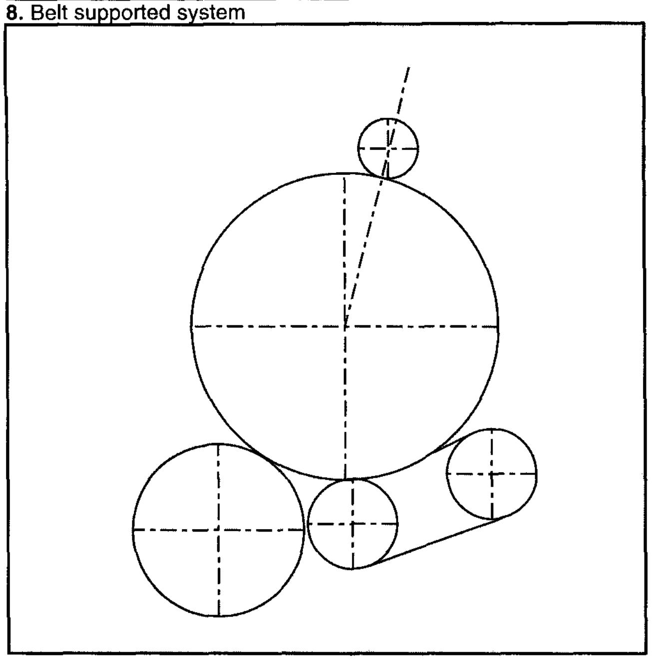
Primary Definition	Secondary	Definition	Primary	Secondary	
UK	UK	All unknowns	SP	UK	Splice unknown
UK	PR	Unknown press	SP	S<D	Splice break below splice diam.
UK	PP	Unknown paper	SP	WB	Splice wrinkle blow
PR	UK	Press unknown	SP	TP	Splice tape problem
PR	EL	Press electrical	SP	WR	Splice wrinkle
PR	ME	Press mechanical	SP	BK	Break near splice
PR	HE	Press human error	SP	Cu	Cut near splice
PR	IG	Press ink glob	SP	TB	Splice table too long
PR	TW	Press trolley wheel	SP	WC	Splice wrinkle crepe
PR	ST	Press slitter	SP	WK	Splice workmanship
PR	GR	Press grease	SP	SLT	Splice slit
PR	OT	Press misc	SP	EG	Splice exposed glue
BU	UK	Burst unknown	ST	MI	Slitter mill
BU	BTP	Burst tension partial	ST	PR	Slitter press
BU	BTR	Burst tear	RC	UK	Roll condition unknown
BU	BT	Burst tension	RC	RCT	Roll condition transit
BU	BC	Burst core	RC	CO	Roll condition handling core
BU	BSAA	Burst shear A/R	RC	ED	Roll condition handling edge damage
BU	BSC	Burst shear caliper	RC	TL	Roll condition mill telescoping roll
BU	BE	Burst edge	RC	CG	Roll conditions corrugations
BU	BS	Burst shear	RC	BG	Roll condition mill baggy roll
WR	UK	Wrinkle unknown	RC	H2	Roll condition water damage
WR	WS	Wrinkle soft	RC	RD	Roll condition out of round
WR	WP	Wrinkle pucker	SL	UK	Slime unknown
WR	WG	Wrinkle glassined	SL	H2	Slime water spot
WR	WM	Wrinkle hard	SL	SCB	Slime scab
WR	WE	Wrinkle edge	SL	SL	Slime stock lump
WR	WB	Wrinkle blow	SL	PT	Slime pitch
WR	WC	Wrinkle crepe	SL	HL	Slime hole
CT	UK	Coating unknown	SL	CB	Slime crumbs
CT	SL	Coating slur	SL	TB	Slime tab turn back
CT	TB	Coating tab turn back	SL	GL	Slime glassined
CT	SK	Coating streak	SL	SP	Slime spot
CT	SCB	Coating scab	SL	FZ	Slime fuzzy hole
CU	UK	Cut unknown	SL	HE	Slime line hard edge
CF	CF	Cut fiber	HO	HO	Hole unknown
CH	CH	Cut hair	PA	MS	Paster unknown
CC	DW	Cut calender dryer wrinkle	ME	MI	Misc
CC	PW	Cut calender press wrinkle	MI	TB	Misc tab turn over
CC	HC	Cut calender head box cockle	MI	SS	Misc stuck sheets
CC	RW	Cut calender reel wrinkle	MI	SC	Misc scrap in roll
CE	CE	Crack edge	MI	PAT	Misc. patch
			TR	TR	Tear edge

of the roll. This arrangement is actually worse than with steel drums because now the theoretically desired nip for the full roll is supported at only one point.

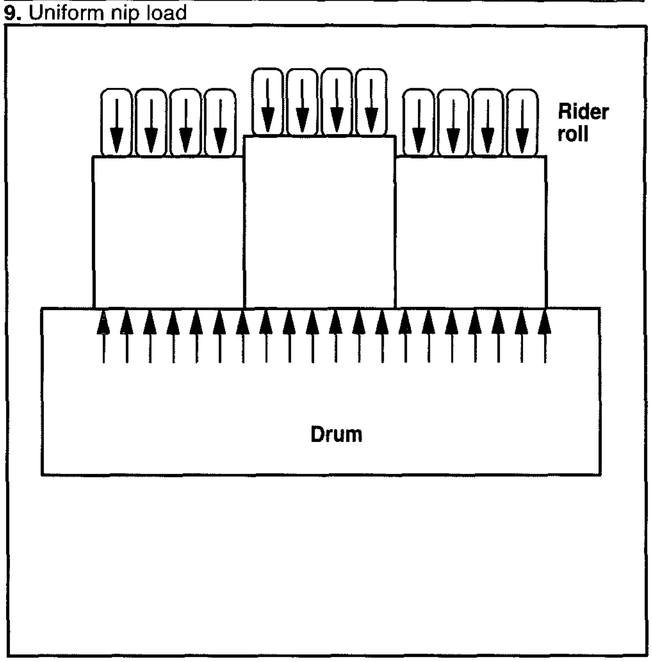
Newer and rebuilt steel rider rolls allow the rider roll to vary in level while building the roll of paper. This is a slight improvement because now the theoretical nip is supported on two points. As you might expect, the higher points usually coincide with the drum points, increasing the problem.

Now let's review the new technology being offered. As mentioned earlier, all of these products address the ability to control nip at large diameters. The ability to control the nip means that as the roll increases in weight, the nip load can be main-

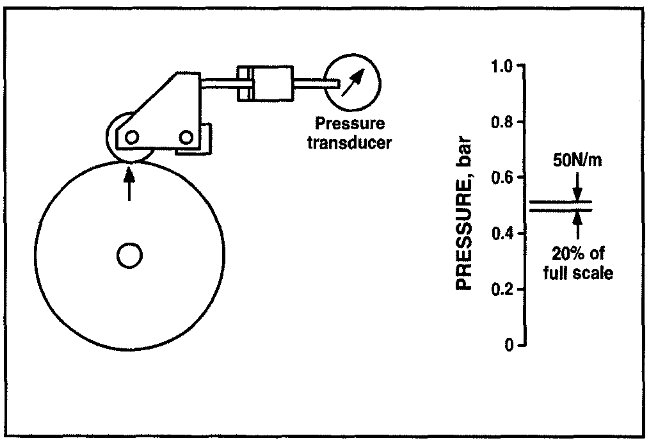
8. Belt supported system



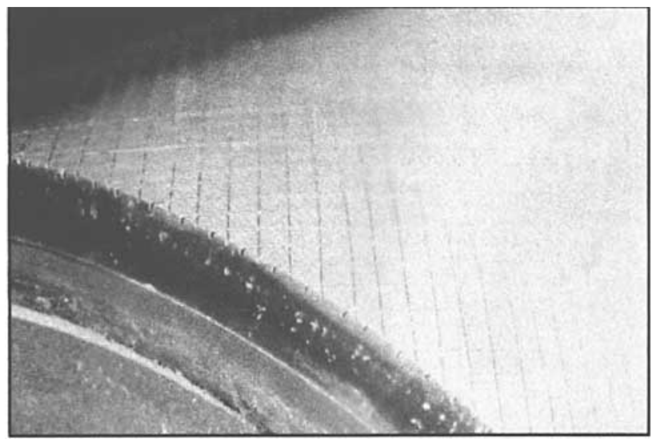
9. Uniform nip load



10. Load feedback



11. Compliant drum



tained at a level that does not deflect the roll surface. By not deflecting the roll surface, the layer-to-layer slippage is reduced so that crepe wrinkles or bursts are not found in the roll.

Belt supported system

The belt supported winder consists of a conventional back drum and a belt bed in place of the front drum to support the roll during winding (**Fig.** 8). The belt bed consists of two pulley drums with a series of individual belts across the width of the winder.

As winding begins, the core is supported by the back drum and one of the drum pulleys. The roll builds up with a conventional rider roll (thus providing nip) the same way a conventional two-drum winder does. At a diameter of 400–700 mm, the winding roll starts to be supported by both the back drum and the belts. As the roll diameter increases, more of the weight is supported by the belts. The belts distribute the nip load over a larger area, reducing roll-surface deflection. The geometry is such that the nip on the back drum only increases a small amount throughout the winding cycle. The high friction between belts and paper helps facilitate the use of torque.

Since the start of the roll is similar to a conventional winder, we do not compensate for profile variations and core tolerance variations.

It requires extensive work to rebuild an existing winder with a belt supported system. In most cases, the entire wind-up and discharge section of the machine must be replaced.

Articulating Rider Roll and compliant drum system *soft-nip winding*

The Articulating Rider Roll is a series of separate, narrow-width wheels that replace the conventional rider roll. The wheels are mounted to a common beam and pivot independently to maintain a uniform nip load under every wheel segment (**Fig. 9**).

The Articulating Rider Roll starts improving roll consistency at the core. This uniform nip compensates for variations in core diameter and profile variation, which the conventional rider roll cannot. Without a proper and solid foundation for the roll, it is common to have off-center cores and tension within the inner layers that is unable to support the roll for unwinding without causing crepe wrinkling or core bursts.

The Articulating Rider Roll nip load is controlled by a closed-loop feedback system through a pressure transducer in the manifold for the wheels (**Fig. 10**). Now the rider roll load is uniformly distributed on all wound rolls. It is possible to increase or decrease the rider roll load to improve the roll structure and maintain consistency.

The wheels for the Articulating Rider Roll system are made of a compliant material, which allows the wheels to conform to the diameter of the rewinding roll. The compliancy also allows for higher nip loads and more consistent roll structure.

The compliant drums are the other part of this soft-nip package. A compliant drum is a steel drum covered with compliant material (**Fig. 11**). The compliant cover deflects from the nip load just like the conventional drum roll-surface deflects, but the high-caliper points are now supported on a wider and more forgiving nip. The wider nip will have a much lower pressure because the compliant cover deforms from the nip and more of the low-profile areas of the roll are in contact with the drum. This reduces the total nip pressure on the high-caliper areas of the roll. Another benefit of the compliant cover is that it allows more front-drum torque to be applied to the roll of paper because more of the roll is in contact with the drum to transmit the torque. On conventional steel drums, the torque is transmitted mainly at the high-caliper points of the roll of paper, making it less effective and possibly damaging the roll.

The combination of the Articulating Rider Roll and compliant drum provides consistent products to the printer. The Articulating Rider Roll improves roll structure at the core by building a good foundation. This, in combination with the compliant drum(s), builds consistent and repeatable roll structures for the large shipping diameter required by printers.

The Articulating Rider Roll and compliant drum is an easy rebuild for most two-drum winders. The rebuild is the equivalent of replacing the rider roll and drum.