HEXPOL COMPOUNDING

PAPER MILLS ROLLER COVERINGS

Overview

The paper industry utilizes rubber covered rolls throughout the paper making process. These rolls are primarily used in the dewatering, sizing, drying and calendering processes. A wide range of elastomeric materials, in a full range of hardness's, are used to meet chemistry, temperatures, coefficient of friction and abrasion resistance requirements of the process. Common elastomers used include NBR, EPDM, CSM, CR, NR, SBR, HNBR as well as polyurethane and the hardness range from extremely hard plastic like material to very soft material (1PJ - 300PJ). These compounds offer the necessary versatility required to develop the proper NIP settings under the broad spectrum of operating conditions of the paper industry.

Essential Properties

Chemical Resistance

First, the rubber covering must be resistant to the various chemicals that are being used in the paper making process. Normally a caustic or acidic media is used depending on the specific mill chemistry. A common application involving a caustic solution are the sizing applications. As changes are made toward a more caustic media, operating temperatures have tended to increase as well. Typically, most wet applications today operate in temperature range from 170° - 180 ° F in the caustic environment. Another chemical to be aware of in the paper industry is Kerosene, this is used to clean the felt. If proper handling techniques are not followed during the cleaning process Kerosene can chemically attack the rubber.

Hardness Stability

Another essential property to be concerned with in the paper industry is hardness stability, all compounds must maintain hardness's at elevated temperatures (see Table below). In general there are three compounding variables that will have a direct impact on the overall hardness stability of a given compound (choice of the elastomer, state of cure of the compound, and the filler system used. We cannot totally change the hardness stability of a given elastomer, in general for paper mill applications NR will never have as good hardness stability as NBR compounds as evidenced below. That is why NBR is the material of choice today since paper mill temperatures today are in the 170° - 180° F range. The importance of hardness stability should not be underrated since paper applications must have a constant nip setting over a range of temperatures. This means coverings must not change appreciably with exposure to heat.

Dynamic Properties

Also, compounds for use in the paper industry must exhibit excellent dynamic characteristics since press rollers operate under high pressure and speeds. A closer look specifically at the nip or contact region of rubber rollers may help one to understand some of the problems and challenges involved. If the rubber used to cover the rollers has good hysteresis properties, the energy, or work, expended to pass the rubber into and through the nip is essentially completely recovered as the rubber comes out of the nip. However, many roll coverings have only fair to poor hysteresis properties, and the energy expended is not totally recovered as the rubber comes out of the nip, but instead is lost to heat build-up. In other words the roller gets hot. This phenomenon may help explain why some rollers develop hot spots near one end, and sometimes even blow out on the press. If the rollers are not set evenly, to a straight stripe, the region where the roller is set tighter, where the stripe is heaviest, tends to heat up. However if the rollers are set straight, they will heat up evenly, if at all. The problem complicates itself, because as the rubber heats up, it grows due to thermal expansion, which in turn causes the roller to run even hotter.

Heat Stability

Pulp and paper roll coverings must be able to withstand elevated temperatures and must not degrade from long term exposure. Pulp and paper coverings must be able to withstand elevated temperatures in the wet and dry ends of the process and must not degrade from long term exposure. Since most applications minimally operate at 170° F, a peroxide cured compound is beneficial. As is the case with all elastomers, heat resistance is an inherent aspect of a given polymer chemistry, most elastomers can be compounded with a peroxide cure system to enhance overall heat stability. This cure system is essential to insure coverings are not attacked by the higher temperatures. This tends to increase the state of cure of the given elastomer and is desirable since the state of cure will also reduce softening phenomenon (heat Stability) as well as the overall heat aging.

Essential Properties — Cont.

Low Coefficient of Thermal Expansion

Another essential property for high hardness (0-5 P&J) pulp and paper roll coverings is resistance to thermal expansion. It is a generally recognized principal that shrinkage is thermal contraction resulting from cooling from the temperatures of vulcanization to room temperatures. This property has a direct impact on a high hardness coverings during vulcanization processes since ebonite rubber inherently has a high coefficient of thermal expansion as compared to steel. Compounds must exhibit low shrinkage characteristics to be able to withstand the wide range of temperature differences from vulcanization to ambient temperatures. If high hardness compounds do not exhibit low shrinkage properties the roll covering will crack during cooling since the rubber will not contract as quickly as themetal cores. Low shrinkage compounds will reduce the potential for stress cracks since the rubber will not change as much during the cooling process. We completed a series of tests in conjunction with one of our customers with our BNJ0101 covering material. These tests involved the fabrication of a large roll, then subsequently taking that roller outside in temperature to 18 degrees below 0, then bringing the roll back indoors to ambient temperatures to see if stress cracks occurred. This was done continuously for a period of 60 days, each day the roll was placed outdoors for a day then subsequently brought back indoors the following day. These tests found that BNJ0101 did not exhibit any form of stress cracking during this period. This is evidence of the fact this compound exhibits excellent thermal expansion properties.

Abrasion Resistance

Abrasion resistance is an important property for pulp and paper coverings. This property relates directly to roll wear on the press associated with exposure to abrasive substrates like the wire and felt materials that are used in these applications. Many abrasion tests have been devised, but nothing measures abrasion resistance better than actual field results. It is extremely difficult to correlate laboratory results with real world experience. Roll coverings must have enough abrasion resistance to not exhibit wear, but not too abrasionresistant since this can potentially abrade the felt and wire. The cost of replacing a wire or felt is higher than replacing the cost of the roll, so it is better for the roll to exhibit wear than for the wire or felt to. It should be noted that abrasive fillers should not be used in these applications to insure the roll covering do not abrade the surface of the wire or felt being used.

Thermal Conductivity

Many roll coverings are internally cooled to reduce the overall temperature of the covering. To assist in cooling thermal conductivity in certain roll's are important. This is to keep the bond line cooled, since as a general rule the bond line should not exceed 150° F to maximize roll performance. This can be a challenge since rubber is inherently a good insulator. Thermal conductivity enables a compound not only to transfer heat during use in an application but also contributes to faster curing in the vulcanization process during roll manufacturing. Certain fillers such as zinc oxide can be used as a filler to enhance thermal conductivity.

Coefficient of Friction

Coefficient of friction of the roll covering is an important property for pulp and paper roll coverings. By definition "friction is independent of the area of sliding solids and is directly proportional to the load". As it relates to the paper industry there are many factors which may influence friction in the system. A wide variety of variables including load, speed, lubricant viscosity, surface finish, presence or absence of chemical deposits, hardness, temperature are involved. Certain applications in the paper industry require the roll covering to drive the wire or felt, this means the roll covering must exhibit a higher coefficient of friction. Conversely certain applications such as a hard top press roll must have good release or a low coefficient of friction. The roll covering will have a direct impact on release or traction depending how the compounds are formulated. This property cannot be ignored since the compound can have a direct impact on the performance in use as is the case when a drive roll experiences slippage in use and the energy required to drive the rolls increases.

Roll Construction, Bonding, Vulcanization

Rubber roll coverings are manufactured differently for the pulp & paper applications in many instances to enhance overall performance in the end use application. Typically rollers are stripped, sand blasted, bonding systems applied, rubber is applied with a strip builder, wrapped with nylon tape or polypropylene tape then vulcanized, ground to size including crowns, and packed in crates for shipping. It is our opinion there are several areas where special handling precautions must be made in the manufacturing process different from those traditionally used to produce rollers for other market segments.

Metal Prep

In order to remove any contamination from the old covering and to prepare the metal for bonding, metal preparation is essential. It is recommended metal prep for pulp & paper applications be accomplished by sand blasting. It should be noted that grit blasted surfaces are superior in dynamic applications because this method creates a mechanical bond in addition to the traditional chemical bond. This is essential for high pressure applications & will insure the greatest bond strength.

Bonding Systems

Once the core has been blasted the selection of the bonding system to be used must take into account the function of the covering.

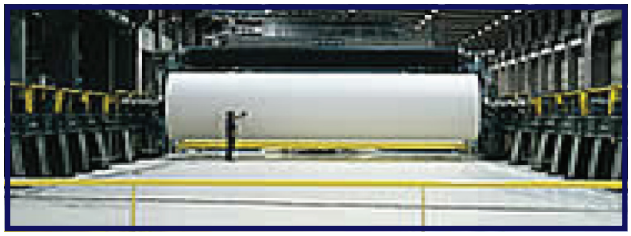
BONDING — 3 CATEGORIES
LOAD BELOW 400 PLI
LOAD BELOW 400-800 PLI
LOAD ABOVE 800 PLI

Vulcanization

The curing process is as fundamental to the manufacturing of rubber rollers as is the rubber itself. Once fabricated, the rubber must be cured/ vulcanized, to transform the covering to produce its desired properties. The topic of curing is a complex subject. We take cure time into consideration at compound development, and we strive to achieve consistent characteristics in each formulation, but many factors must be taken into consideration in determining the best cure cycle. Vulcanization cycles are even more complex when you consider that typical rolls used in the paper industry are generally larger. This means that the larger mass of steel much be heated up slower to allow the compounds and metal mass to heat up evenly.

Crowns

Roll coverings for paper machines have a variety of functions. In order to maintain even pressure from one end of a roll to the other & compensate for such factors as cores bending crowns are used extensively in paper industry. Pressure in paper applications causes the roll body itself to bend. The paper maker wants absolute uniformity in the nip across the machine and putting crowns on these rollers help obtain that uniformity.



GENERAL CURE CYCLES

Ebonite Cure Cycle Large Rolls

	Standard	Solid Core
Step 1	2 hr at 180°F	6 hr at 180°F
Step 2	1/2 hr.rise to 200°F	1 hr.rise to 200°F
Step 3	2 hr. at 200°F	3 hr. at 200°F
Step 4	1/2 hr. rise to 220°F	1/2 hr. rise to 220°F
Step 5	2 hr. at 220°F	3 hr. at 220°F
Step 6	1/2 hr.rise to 262°F	1 hr.rise to 262°F
Step 7	10 hr. at 262°F	10 hr. at 262°F

Peroxide Cure Cycle Large Rolls

Step 1	2 hr. at 220°F
Step 2	½ rise at 240°F
Step 3	2 hr at 240°F
Step 4	1/2 hr rise to 260°F
Step 5	5 hr. at 260°F
Step 6	1/2 hr rise to 280°F
Step 7	9 hr. at 280°F

*1st 10,000 lbs. Add 1 hr for each add. 10,000 lb

NOTE: Cooling Cycle in general should approximate to reverse of cure-cycle.

Product Offering

BNJ0101

Hardness: 0 - 1 P&J **Thickness:** ¼" to 5/8"
Temperature Resistance: 250 °F

This compound is a universal 0 – 1 P&J paper compound. It exhibits excellent abrasion resistance, low hysteresis and superior chemical resistance. The compounds outstanding hardness stability enables it to outperform typical ebonite compounds even at higher operating temperatures.

Applications: Form fabrics/ Wire Rolls, Table Rolls, Felt Rolls, Breast Rolls, Felt Carrying, Suction Couch, Plain Couch, Dandy Roll, First Return Roll, Hard Press Roll, Breaker Stack, Top Center Press, L/ P Rolls, Smooth Size Press, Hard Size Press, Dryer Felt, Lead In / Lead Out Rolls

BNJ0521 – BNJ9921

Hardness: 5 - 99 P&J **Thickness:** ¼" to 1"
Temperature Resistance: 275 °F

This family of compounds exhibits excellent abrasion resistance, low hysteresis & superior chemical resistance. The compounds are formulated to exhibit outstanding hardness stability that enables them to outperform typical nitrile compounds. They will out perform most other compounds in high pH chemistry even at higher operating temperatures. They will provide positive drive where wire slippage may be of concern.

Applications: Suction Couch Rolls, Breast Rolls, Fabric and Wire Rolls, Soft Top Press, Smoothing Press Rolls, Center Press Rolls, Size Press Rolls, Fountain Rolls, Distributor Rolls, Applicator Rolls

BNJ170– BNJ250

Hardness: 170 - 250 P&J **Thickness:** ¼" - 1 ½"
Temperature Resistance: 250 °F

Specially formulated for softer roll positions. Exhibit excellent abrasion resistance, low hysteresis & superior chemical resistance. Will provide positive drive where wire slippage may be of concern.

Applications: Lump Breaker Rolls, Cylinder Couch Rolls

HYJ170– HYJ250

Hardness: 170 - 250 P&J **Thickness:** ¼" - 1 ½"
Temperature Resistance: 275 °F

This family of compounds has been specially formulated for softer roll positions. They exhibit excellent abrasion resistance, superior release, and outstanding chemical resistance. They will provide positive drive where wire slippage may be of concern.

Applications: Lump Breaker Rolls, Cylinder Couch Rolls

HN9921

Hardness: 5 - 15 P&J **Thickness:** ¼" - 1"
Temperature Resistance: 325 °F

This compound is high performance paper compound. It exhibits superior abrasion resistance, low hysteresis and superior chemical resistance. It will provide positive drive where wire slippage may be of concern. The compound's outstanding heat and chemical resistance allows it to outperform typical hard rubber compounds especially at higher operating temperatures.

Applications: Wire Rolls, Felt Rolls, Breast Rolls, First Return Roll, Hard Press Roll, Breaker Stack, Top Center Press, L/ P Rolls, Smooth Size Press, Hard Size Press.

HNJ0521 – HNJ9921

Hardness: 5 - 99 P&J **Thickness:** ¼" - 1 ½"
Temperature Resistance: 325°F

This family of high performance compounds has been specially formulated for paper making applications. They exhibit superior abrasion resistance, low hysteresis and superior chemical resistance. They will provide positive drive where wire slippage may be of concern. They're superior heat and chemical resistance, which enable them to outperform typical rubber compounds especially at higher operating temperatures.

Applications: Suction Couch Rolls, Breast Rolls, fabric and Wire Rolls, Soft Top Press, Smoothing Press Rolls, Center Press Rolls, Size Press Rolls, Fountain Rolls, Distributor Rolls, Applicator Rolls

NRJ0101

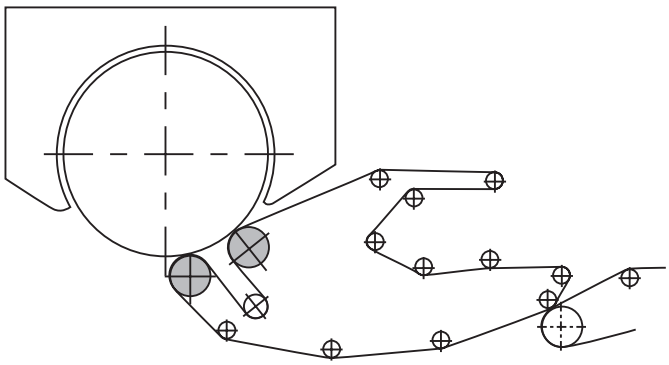
Hardness: 0 - 1 P&J **Thickness:** ¼" - 5/8"
Temperature Resistance: 250 °F

This compound is a specialty 0 – 1 P&J paper compound. It exhibits excellent abrasion resistance, superior hysteresis and wet traction characteristics. The compound's outstanding hardness stability enables it to outperform typical Natural Rubber ebonite.

Paper Compounds - Standard List

Compound	Hardness P&J	Applications
WET END		
F1988B/F1985	0 - 2	Wire guide roll, felt rolls - extremely hard wearing
Dynamite, F7244D	0 - 2	Felt rolls-resists build up of paper on the roll surface
F7287G	200	Lumpbreaker rolls
F7315G	175	Lumpbreaker rolls
F7289BL	200	Couch rolls
F7314B	10	Drive rolls
F7204B	15/17	Drive rolls
NR9993	0 - 2	Wire guide roll, felt rolls - lower viscosity than F1988
PRESS SECTION		
F7265D	0-2	Press rolls, centre press rolls
F6499B/L	10	Suction press rolls (HNBR/Zeoforte)
F7314B	10	
F7204B	15/17	Press rolls and blind drilled press rolls (nitrile)
F7303B	20	
F7304B	25	
F6498B	17	FTNBR for press rolls on high speed lines
F6497B	20	
F6492B	27	
F6598B	17	HNBR for Yankee cylinder rolls at 150˚C
COATING SECTION		
F7265D	0-2	Nitrile size press rolls and Coater backing rolls
F7204B	15/17	
F7303B	20	
F7304B	25	
F7256B	55	
F27232B	65	
F27244BL	55	Hypalon for Coater backing rolls. Very consistent hardness on large rolls and hard wearing
F27301BL	65	
COATING SECTION		
F7282D	2-5	Base for F7244D & F7265D

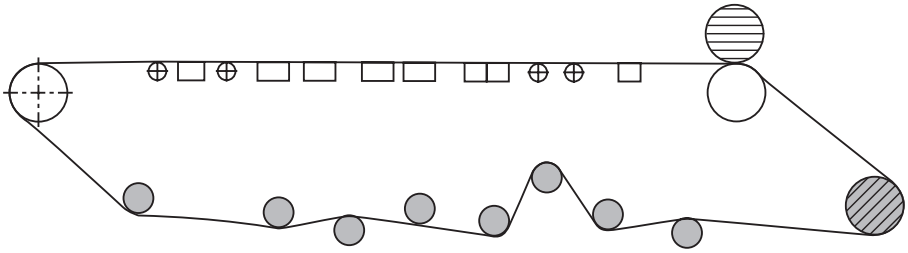
Tissue Machine



Suction press, plain press and blind drilled roller - F7204B, F7303B

F7204B	15	P&J
F7303B	20	P&J

Paper Machine -
Wet End



Wire guide rolls - F1988B

Wire drive roll - F7314B, F7204B

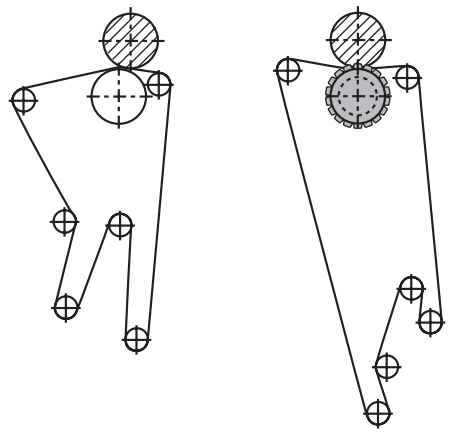
Lumpbreaker Roll - F7315G, F7287G

NR9993	0-2	P&J	Easier flowing version of F1988B
F1988B	0-2	P&J	Classic Hard Ebonite

= NR

NR9993	0-2	P&J
F1988B	0-2	P&J
NR9993	0-2	P&J
F1988B	0-2	P&J

Paper Machine -
Press Section & Suction Press



Bottom Press Roll F7204B, F7303B, F7304B

Top Press Roll F7244D, F7265D

Suction press roll F6499 B/L

Felt Rolls F7244D

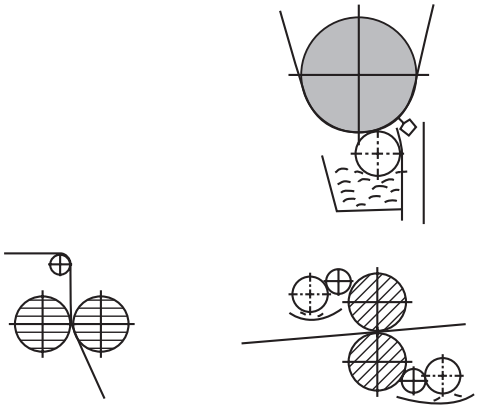
F7204B	15	P&J
F7303B	20	P&J
F7304B	25	P&J
F7244D	0-2	P&J
F7265D	0-2	P&J

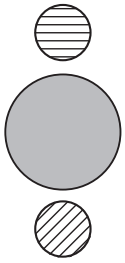
Easy Release

F6499B/L	10	P&J

= HNBR

Size Press and Coating Machines





Size Press - F7204B, F7303B, F7304B

Backing Rolls - F27232B, F27244BL, F27301BL

Coating Rolls - F7204B, F7203B, F7304B

F7204B	15	P&J
F7303B	20	P&J
F7304B	25	P&J
F27232B	65	P&J

F27244BL	55	P&J
F27301BL	65	P&J
7262	15	P&J
7270	25	P&J

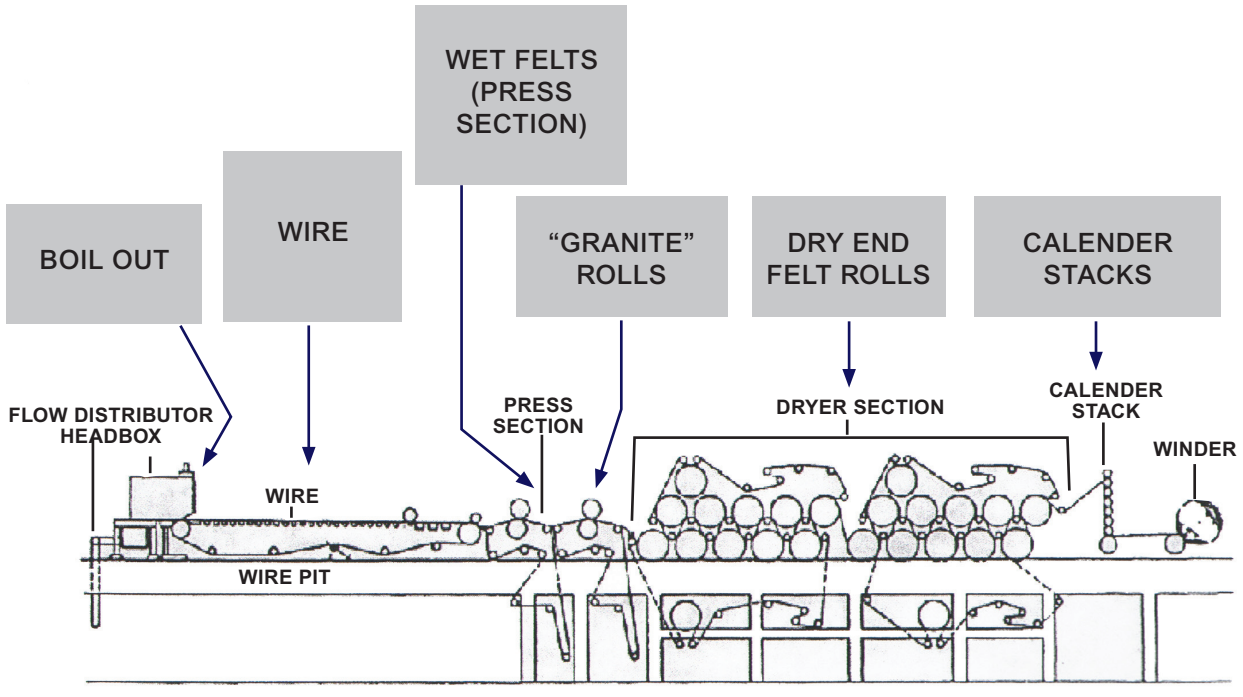
Paper Industry

Papermaking Operating Speeds

Pulp Drying Machines	325-500 FPM
Board Drying Machines	1300-2400 FPM
Liner Machines	1650-2950 FPM
Fine Paper Machines	2950-3950 FPM
Newsprint Machines	3300-4925 FPM
Tissue Machines	3950-6500 FPM

History of Pulp & Papermaking

1st Papermaking in China	100 AD
1st Paper mill in North America	1690
Patent for 1st papermaking machine	1798
Patents for Fourdrinier bros.	1803
1st continuous paper machine	1807
Patent for cylinder paper machine	1809
1st Fourdrinier machine in US	1827
Ground wood pulping developed	1870
Sulfite pulping patent in US	1874
Kraft pulping process invented	1884



Paper Mill Line Diagram

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