HP Indigo Division Technical Note

Subject: GMP Polynex Gloss (25µm) and Matte (26µm) compatible Pack Ready Film feasibility test report

1. **Background:**

   Compatible Pack Ready Films are commercially available thermal films that can be used as laminates over print for flexible packaging using the Karlville Pack Ready laminator.

2. **Objective:**

   The purpose of this trial is to test the functionality of two compatible films against two type of digital prints – surface printed Met-PET/PE and reverse printed BOPP

3. **Procedure:**

   3.1 Each roll underwent a feasibility matrix testing different lamination conditions in order to find the optimal working window per composition. The roll was examined for:

   - Curling
   - Wrinkles
   - Lamination performance between the laminate and the ink

   The lamination was performed under the following conditions:

Unwinder 1	Unwinder 2	Temperature [°C]	Speed [m/min]	Wrapping angel [deg.]
EVA/BOPP (Matte)	Ink/MET-PET/PE	100	40	90
EVA/BOPP (Matte)	Ink/MET-PET/PE	100	30	90
EVA/BOPP (Matte)	Ink/MET-PET/PE	120	40	60
EVA/BOPP (Matte)	Ink/MET-PET/PE	120	20	0
EVA/BOPP (Matte)	Ink/MET-PET/PE	120	30	0
EVA/BOPP (Matte)	Ink/MET-PET/PE	140	40	0
EVA/BOPP (Matte)	Ink/MET-PET/PE	140	60	0
EVA/BOPP (Matte)	Ink/BOPP	120	30	0
EVA/BOPP (Matte)	Ink/BOPP	120	30	30
EVA/BOPP (Matte)	Ink/BOPP	120	40	30
EVA/BOPP (Matte)	Ink/BOPP	120	30	15
EVA/BOPP (Gloss)	Ink/MET-PET/PE	100	40	60
EVA/BOPP (Gloss)	Ink/MET-PET/PE	120	30	0
EVA/BOPP (Gloss)	Ink/MET-PET/PE	120	40	0
EVA/BOPP (Gloss)	Ink/MET-PET/PE	120	40	30

- The lamination bond strength (LBS) was tested using the standard T-peel testing procedure, according to ASTM D1876.

3.2 The best laminate was form each compositions was sealed under the following conditions and examined for

- Color change
- Seal area appearance

Sealant layer	Upper jaw type	Lower jaw type	Upper jaw temp [C]	Lower jaw temp [C]	Force [N]	Dwell time [sec]
PE	Flat 1" + Teflon	1" Silicon + Teflon	170-240	RT	450	1, 2
	Grooved 1"	Grooved 1"	170-200	RT	450	1, 2
BOPP (Print)	Flat 1" + Teflon	1" Silicon + Teflon	120-180	RT	450	1, 2
	Grooved 1"	Grooved 1"	120-180	RT	450	1, 2

4. Results:

4.1 LBS results taken immediately after lamination process. Best conditions samples were tested 48 hours after lamination process as well

Unwinder 1	Unwinder 2 (Print)	Temperature [°C]	Wrapping angle [deg.]	Speed [m/min]	Overall appearance	LBS at t=0hrs [N/in]			LBS at t=48hrs [N/in]		
						Patch #22	Patch #16	Patch #11	Patch #22	Patch #16	Patch #11
EVA/BOPP (Matte)	MET-PET/PE	100	90	40		2.4	2.1	12.7	NA		
EVA/BOPP (Matte)	MET-PET/PE	100	90	30		3.5	3.3	8.6	NA		
EVA/BOPP (Matte)	MET-PET/PE	120	60	40	Stripes + wrinkles	5.5	4.8	11.8	NA		
EVA/BOPP (Matte)	MET-PET/PE	120	0	20		8.7	8.1	13.0	NA		
EVA/BOPP (Matte)	MET-PET/PE	120	0	30		6.4	6.1	10.7	9.5	9.3	12
EVA/BOPP (Matte)	MET-PET/PE	140	0	40	Cloudiness	6.1	5.7	11.3	NA		
EVA/BOPP (Matte)	MET-PET/PE	140	0	60	Cloudiness	3.2	2.5	7.3	NA		
EVA/BOPP (Matte)	BOPP	120	0	30	Pinching	5.1		NA	NA		
EVA/BOPP (Matte)	BOPP	120	0	20	Curling	5.2		NA	NA		
EVA/BOPP (Matte)	BOPP	120	30	30	Stripes + wrinkles	5.9		NA	NA		
EVA/BOPP (Matte)	BOPP	120	30	40	Light curling	5.8		NA	NA		
EVA/BOPP (Matte)	BOPP	120	15	30		5.9	6.1	Tear	Tear		
EVA/BOPP (Gloss)	MET-PET/PE	100	60	40		4.1		NA	NA		
EVA/BOPP (Gloss)	MET-PET/PE	120	0	30		6.2	5.9	8.4	5.6	4.6	8.8
EVA/BOPP (Gloss)	MET-PET/PE	120	0	40	Cloudiness	3.5		NA	NA		
EVA/BOPP (Gloss)	Ink/MET-PET/PE	120	30	40	Stripes + wrinkles	4.8		NA	NA		

4.2 Seal test results

Top ply	Second ply	Dwell time [s]	170°C	180°C	190°C	200°C	210°C
EVA/BOPP (Matte)	Ink/MET-PET/PE	0.5	0.3	0.8	40	65	95
		1	56	91	>100	>100	NA
EVA/BOPP (Gloss)	Ink/MET-PET/PE	0.5	0	0	41	45	47
		1	1.9	49	74	86	>100
Top ply	Second ply	Dwell time [s]	120°C	130°C	140°C	150°C	160°C
EVA/BOPP (Matte)	Ink/BOPP	0.5	0	0	0	0	2.2
		1	0	0	0.4	4	4.6

- Note: Sealing for BOPP/ink//EVA/BOPP done through printed substrate, since GM BOPP could not be sealed!

4.3 Sealed area appearance

Top ply	Second ply	Jaws type	Sealing temperature [°C]	Dwell time [s]	Sealed area visual appearance results
EVA/BOPP (Gloss)	MET-PET/PE	Flat	170-240	1	Good appearance up to 220°C
				2	Good appearance up to 200°C
		Grooved	170-200	1	BOPP distortion at 190°C
				2	
EVA/BOPP (Matte)	MET-PET/PE	Flat	170-240	1	Good appearance up to 220°C
				2	Good appearance up to 200°C
		Grooved	170-200	1	BOPP distortion at 190°C
				2	

- Note: For Grooved jaws ink creeping observed, related more to ink stability.

5. Conclusions:

- BOPP substrate found to be non-sealable, hence BOPP//EVA/BOPP sealing area appearance was not tested
- LBS results show good lamination performance between the thermal film and the digital print under specific working point. 120°C at 30m/min with minimum wrapping angle found to be the optimal conditions for good lamination appearance and LBS.
- At chosen working point LBS increase even further for BOPP matte substrate, when re-testing after 48hours
- Low NIP temperature (100°C) provides good lamination but compromises the LBS values
- For higher NIP temperature and wrapping angle, the BOPP substrate starts to deform, causing shrinkage in TD right before the NIP, resulting in aggressive wrinkles defect (GMP recommended lamination temperature for both substrates per TDS is 88-100°C).
- When rising the speed with high NIP temperature, cloudiness observed both at gloss and matte laminates, suggesting insufficient heat for EVA melting.
- With Flat jaws, sealing shows good appearance up to 220°C (for 1sec dwell time), and up to 200°C (for 2sec dwell time). With grooved jaws appearance is good only up to 180°C. For higher temperatures BOPP starts to distort.

6. **Summary:**

Both matte and gloss BOPP substrates may yield high LBS values with good visual lamination appearance. But, for high LBS, the identified working window is very narrow. Those BOPP substrates revealed to be sensitive to heat (in comparison to what tested so far), where the tradeoff of BOPP shrinkage in one hand and bad appearance (cloudiness) on other hand is very clear. It is difficult to laminate at high speed with compensation of higher temperature, since both cases may occur. Working with lower temperatures may provide the desired lamination appearance, but the LBS are weak (~2.5-3.5N/inch).
The sealing test reveals that BOPP is non-sealable, suggests that this substrate may be processed only as tap-on-top. The seal strength is dictated solely by the underlying (printed) substrate, in this case the MET-PET/PE and BOPP.

Overall, we find both gloss and matte (BOPP) compatible films to **pass** the feasibility trial and can be recommended for use with Pack Ready Lamination, with restriction of using the substrate as sealing layer.