



2005 PLACE Conference
September 27-29 Las
Vegas, Nevada

Optimizing Application Properties of EB Curable Laminating Adhesives for Flexible Packaging

Presented by:

Stephen C. Lapin, Ph.D.

Vice President, Technical Director

Northwest Coatings LLC

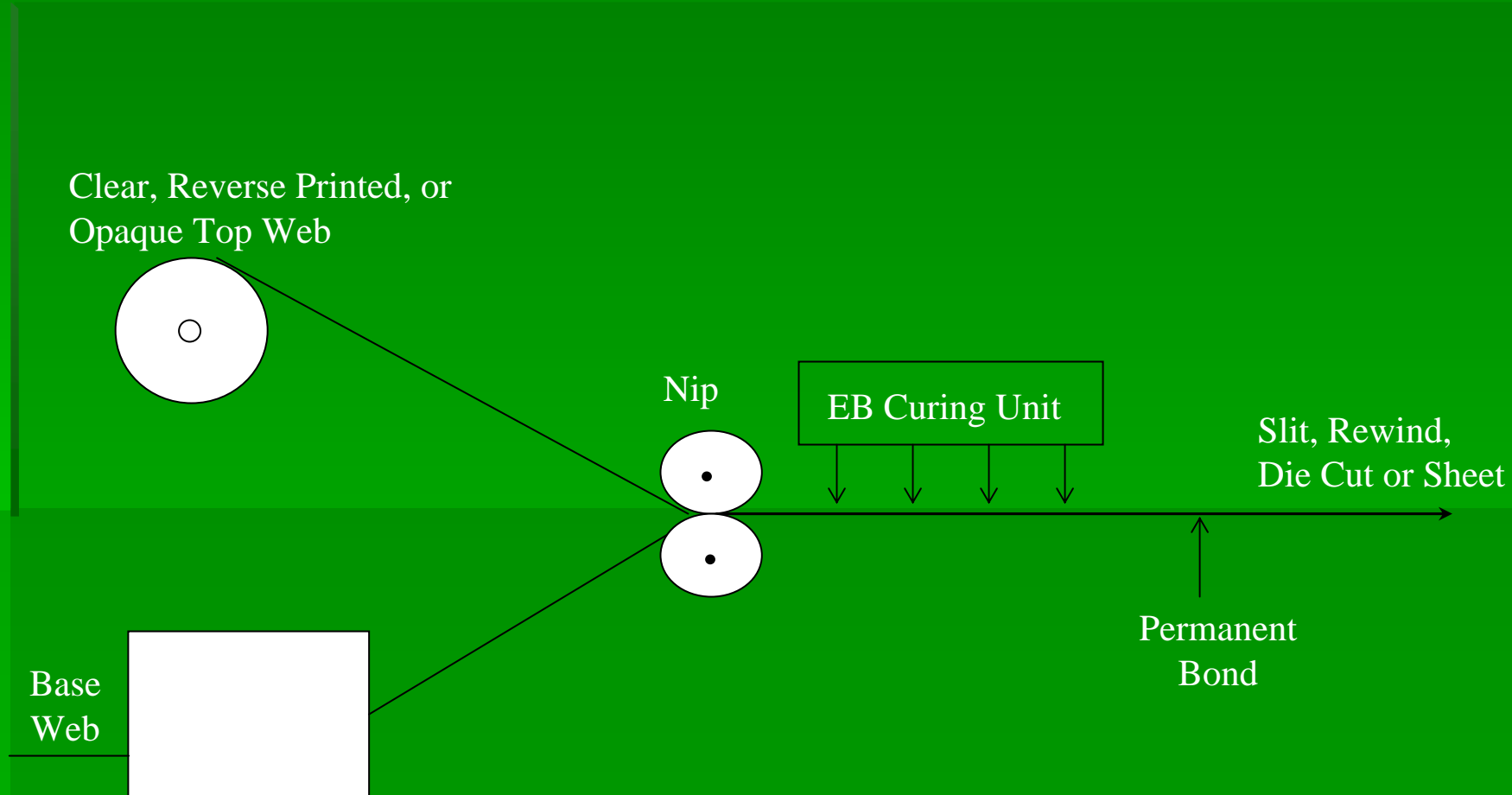
Outline

- I. EB Laminating Background
- II. Laminate Appearance Study
- III. Conclusions
- IV. Future Work

Laminating Technologies for Flexible Packaging

- Extrusion lamination
- Solvent base adhesives
- One-component water base
- Two-component water base
- Two-component solventless adhesives
- UV Curable adhesives
- EB Curable adhesives

Electron Beam Laminating Process



Adhesive Laminating Technology Comparison

2-Component Solventless Laminating Adhesives	EB Curable Laminating Adhesives
Requires accurate mixing of two components	One component, no mixing, remains unchanged until EB exposure
Heated application equipment	Room temperature application
Typical application weight 1.0 lb/3000 ft ² (1.6 g/m ²)	Typical application weight 1.0 lb/3000 ft ² (1.6 g/m ²)
Sensitive to some ink solvents and chemistry	Relatively insensitive to ink solvents and chemistry

Adhesive Laminating Technology Comparison (continued)

2-Component Solventless Laminating Adhesives	EB Curable Laminating Adhesives
Toxicity concerns with residual aromatic amines	No aromatic amines; high conversions minimize uncured material
Requires several days to cure; delayed QC, slitting, shipping, and filling	Instant cure; immediate QC, slitting, shipping, and filling
Multilayer structures requires multiple lamination steps	In-line multilayer lamination possible
Laminate appearance <u>may</u> continue to improve in the roll	Laminate appearance is “frozen” immediately upon cure

Commercial Status of EB Laminating Technology

- Fully commercial with at least 7 different converters in 8 locations
- Largest application – film to paperboard lamination
- Established commercial non-food flexible packaging applications
- Commercial food-packaging application with recognized barrier materials
- Line speeds running up to 750 ft/min with acceptable laminate appearance

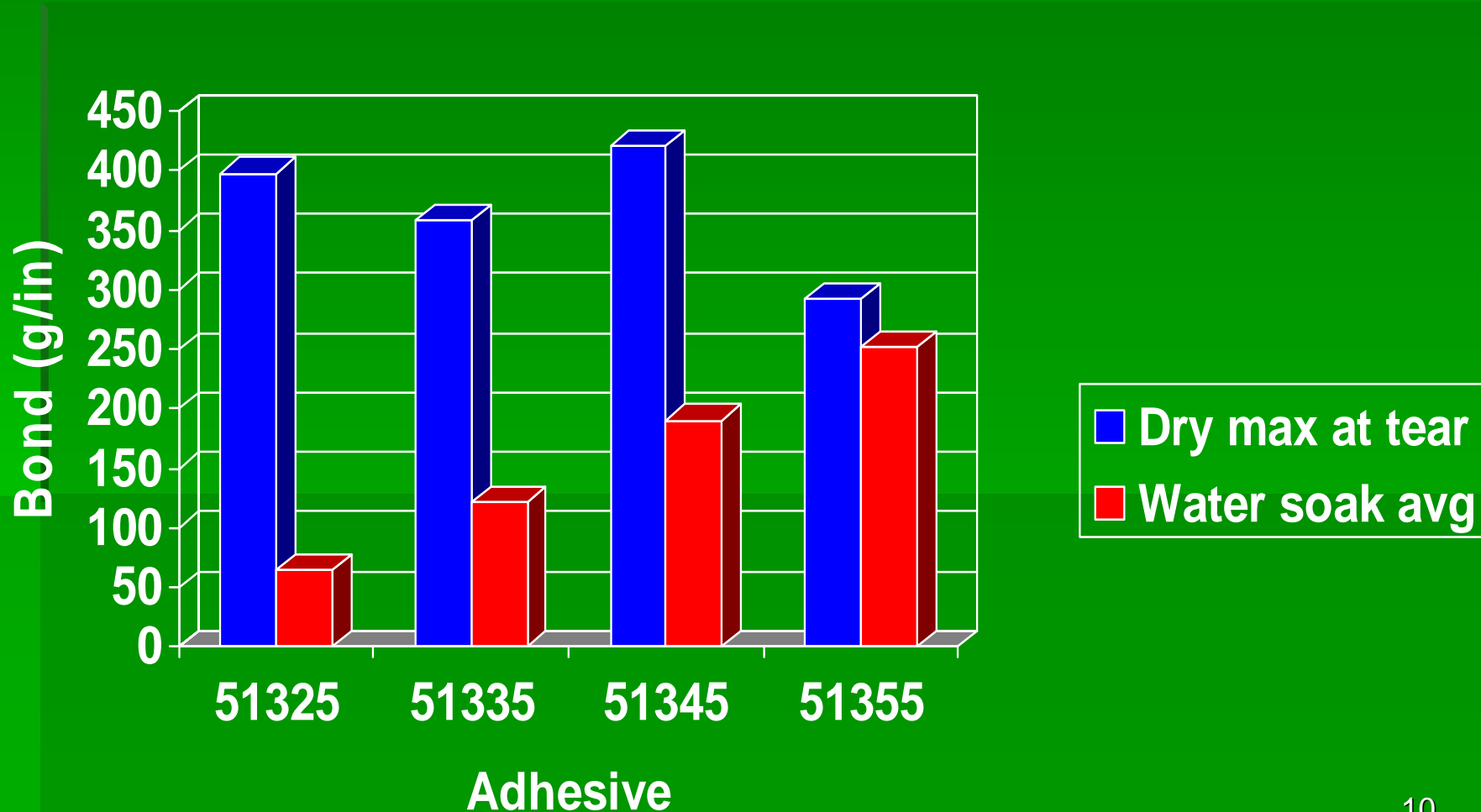
Keys to Broad Commercial Acceptance of EB Laminating Technology

- Meet required bond performance with suitable substrates
- Compatibility with available ink systems
- Suitable for food packaging – FDA compliance, no taint or odor
- Applied cost competitive with other adhesive technologies
- **Consistent good quality laminate appearance**
- No adverse effects of EB on substrates

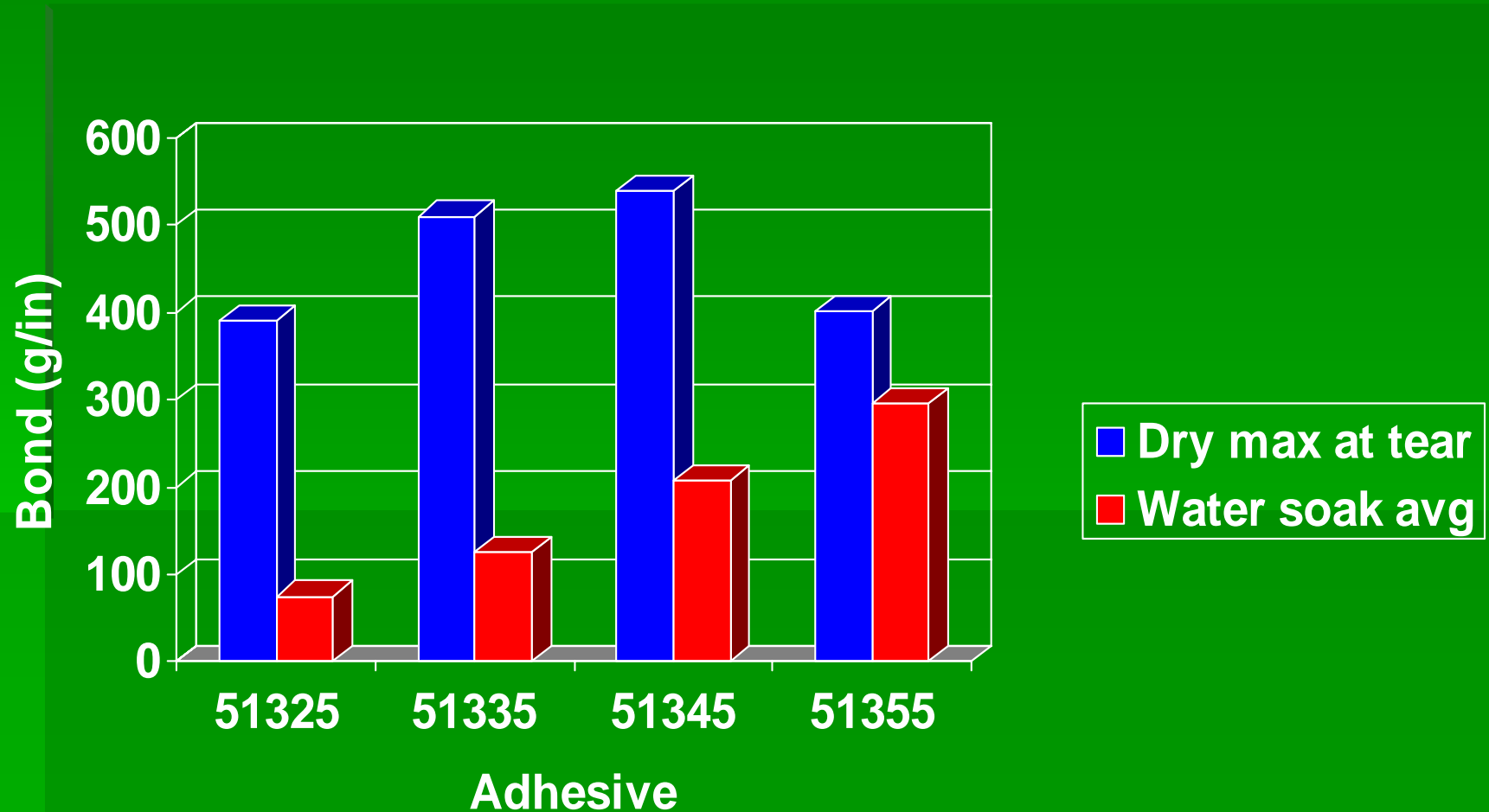
EB Curable Adhesive Properties

Adhesive	Viscosity (cps @ 25 °C)	Relative Hydrophobicity	Cured Tg (°C)
51325	355	1 least hydrophobic	21.5
51335	473	2	22.4
51345	593	3	27.6
51355	852	4 most hydrophobic	29.2

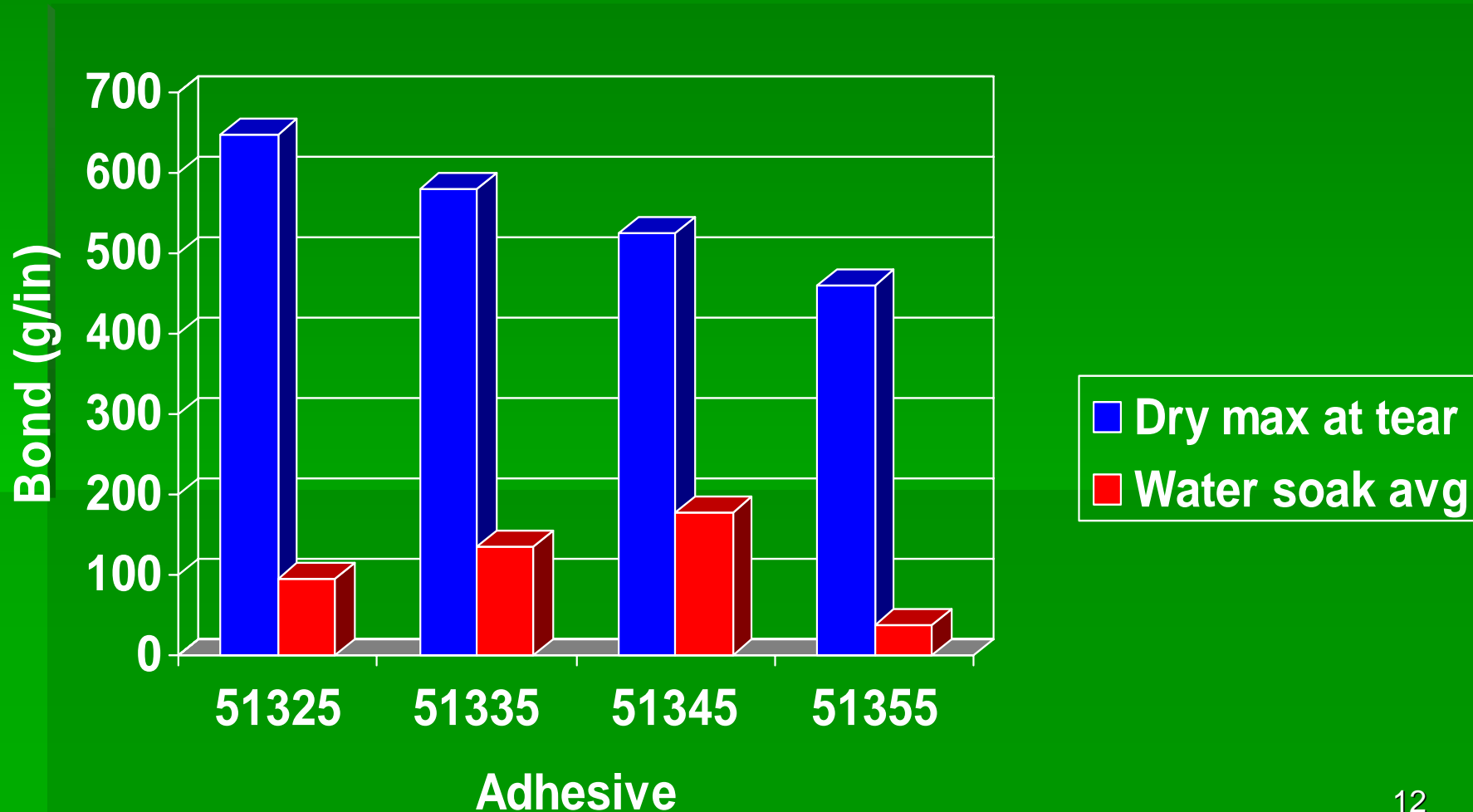
Dry and Wet Bond Strength: Chemical Treated PET/Aluminum Foil



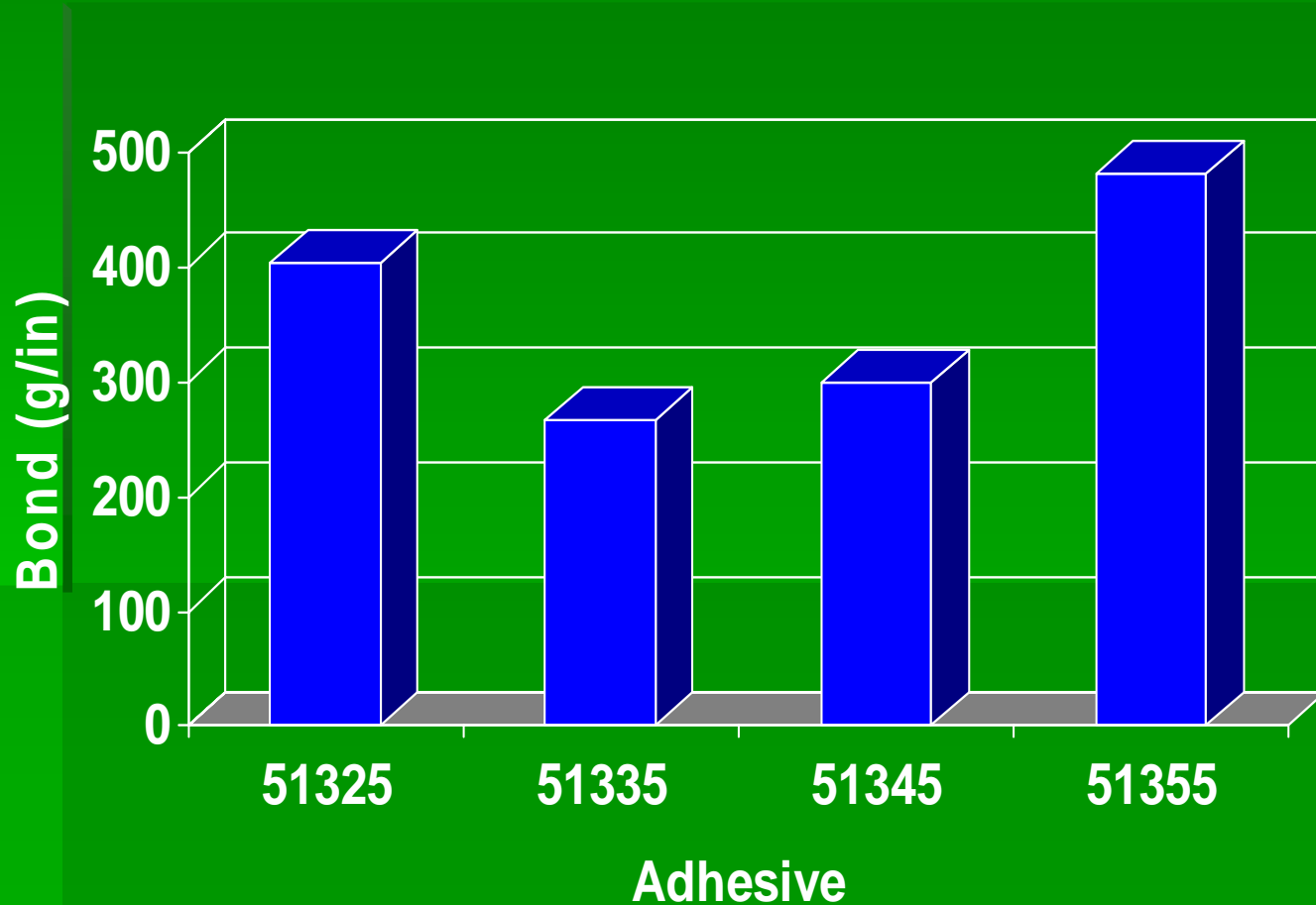
Dry and Wet Bond Strength: Chemical Treated PET/LLDPE



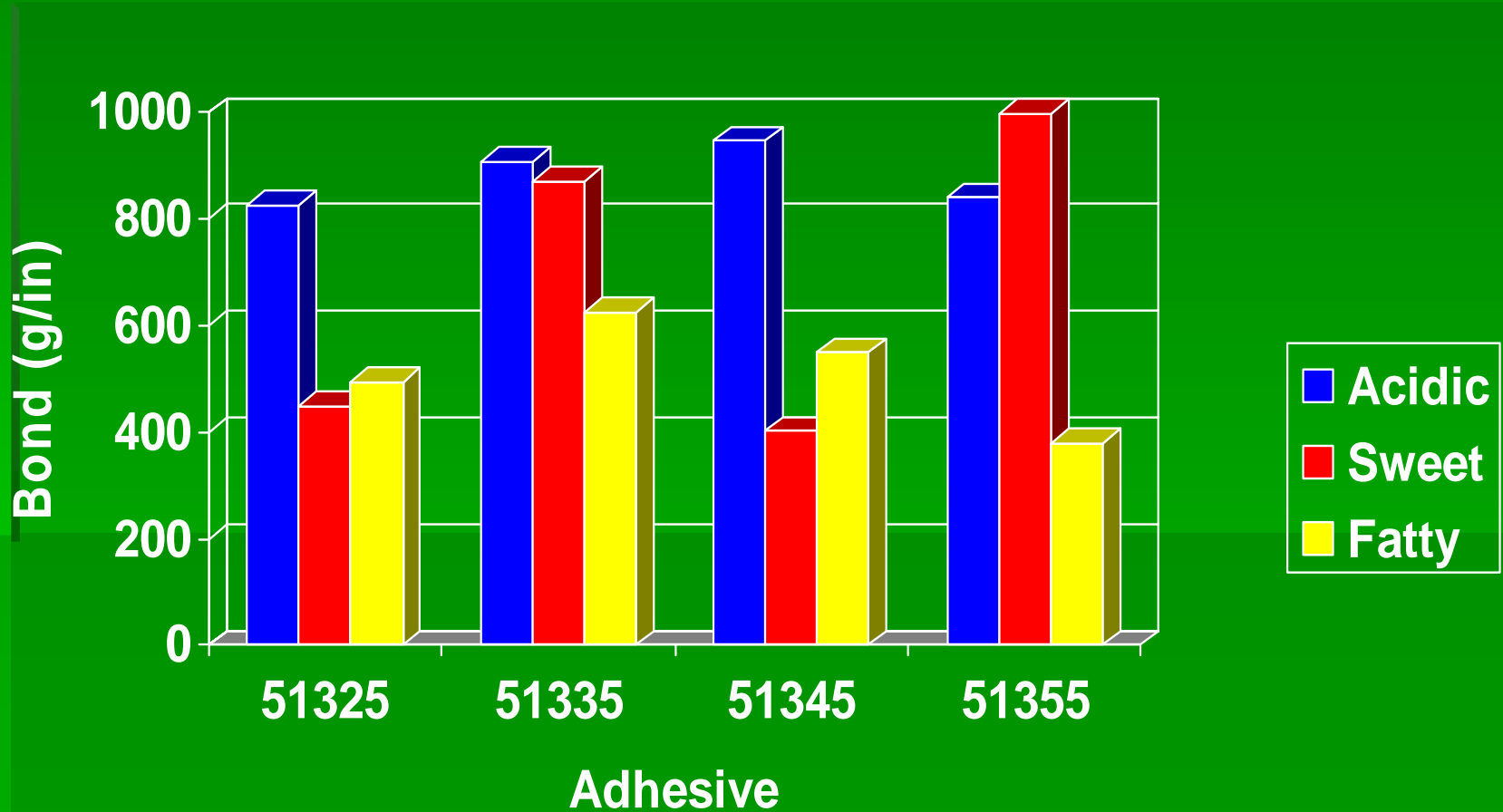
Dry and Wet Bond Strength: oPP/LLDPE



Dry Bond Strength: oPP/metallized oPP



Food Product Resistance: Chemical Treated PET/LLDPE



Bond Performance Summary

- Excellent film destruct bonding properties achieved with multiple substrates
- The laminates exhibit good water and food product resistance
- The properties of the cured adhesive affects the maximum bond strength at tear
- The optimum adhesive composition depends on the substrates that are used

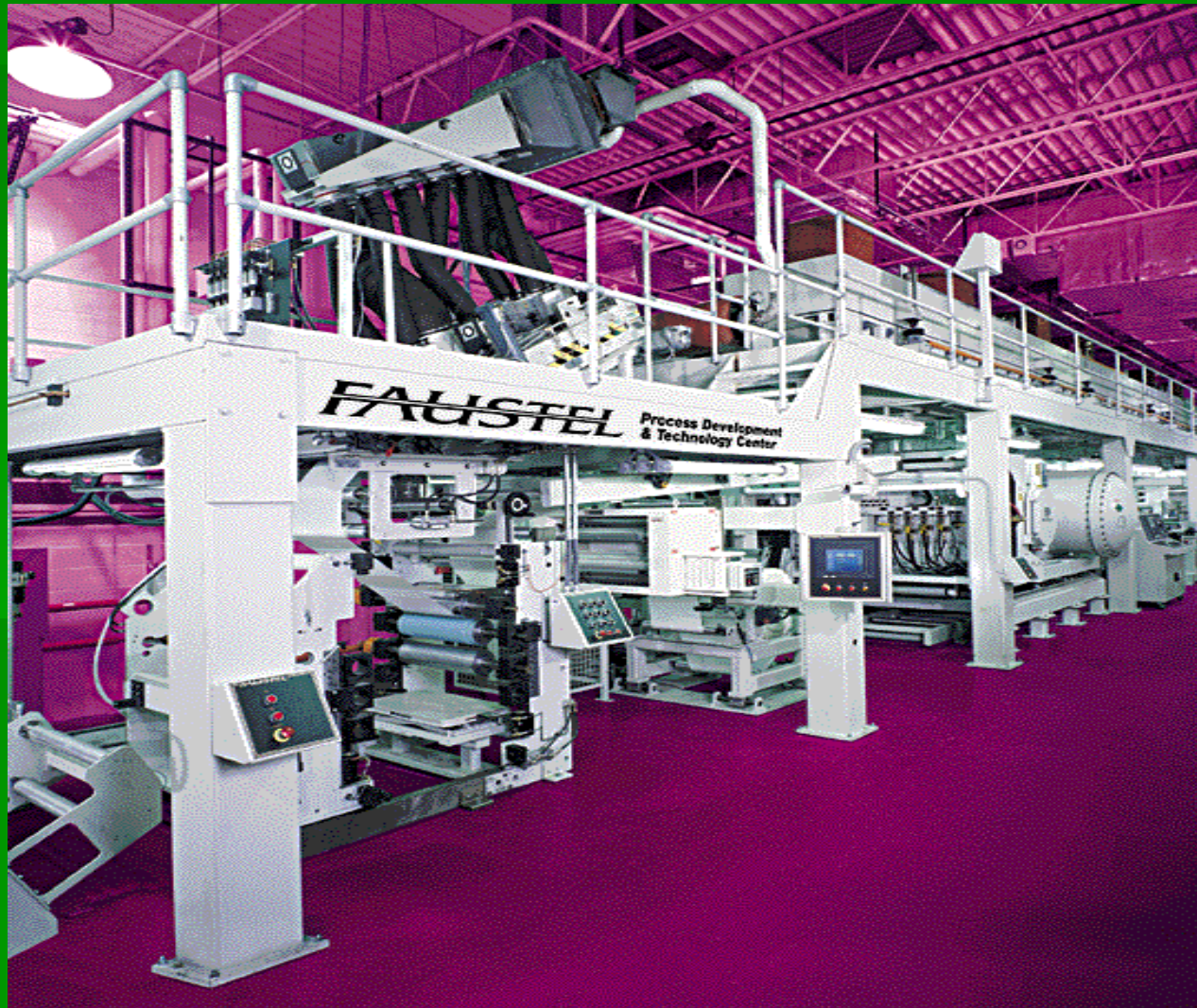
Optimizing EB Adhesive Laminate Appearance

- Challenge
 - The appearance of two-component solventless adhesive laminations can improve as the adhesive continues to flow out in the roll
 - The appearance of EB adhesive laminations are “frozen” immediately upon cure
- Approach – Conduct study to optimize EB laminate appearance

EB Adhesive Lay-Down and Appearance Study

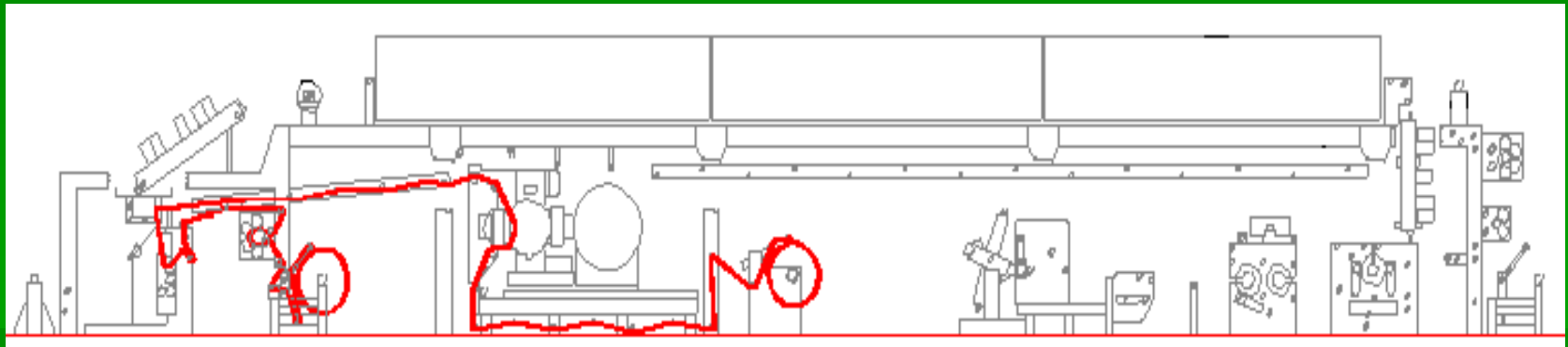
- Study Conditions
 - Faustel Technical Center pilot line
 - Optimize adhesive lay-down (more critical than nip conditions)
 - Offset gravure application (preferred over direct gravure and multi-roll coating application)
 - Coat and EB cure adhesives on PET without lamination
 - Rate the optical appearance of the applied adhesive:
 - 1= best, 5 = worst
- Factors Studied
 - Gravure and application roll direction and speed
 - Web speed
 - Corona treatment
 - Adhesive temperature
 - Adhesive flow additives (modifications A, B, C)

Faustel Technical Center Pilot Line

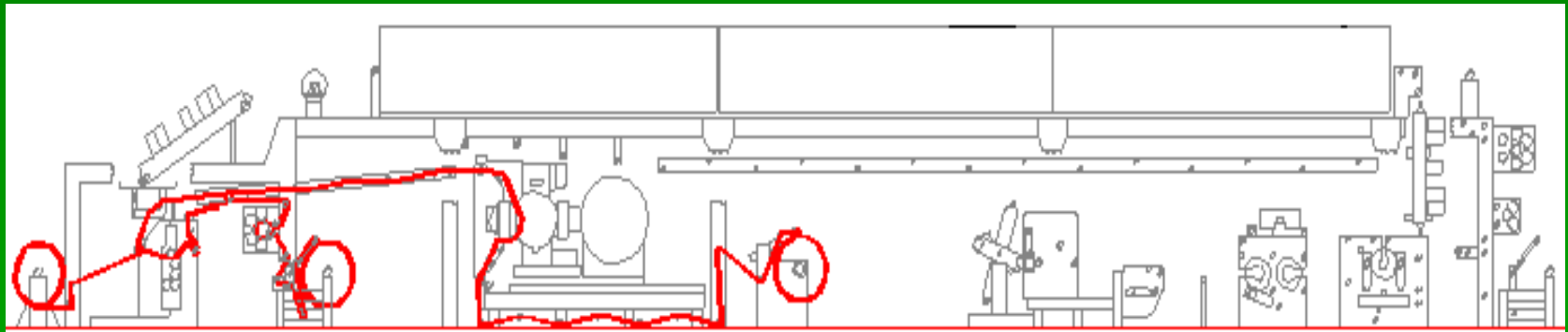


EB Coating Web Path

Faustel Technical Center Pilot Line



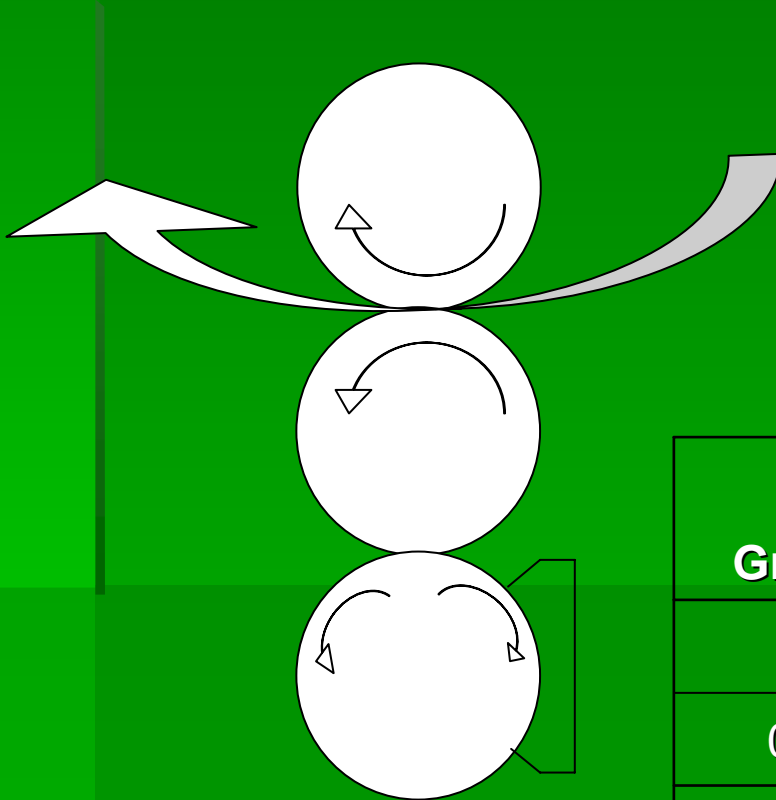
EB Laminating Web Path Faustel Technical Center Pilot Line



EB Laminating Adhesive Variables

Adhesive	Viscosity (cps @ 25°C)	Liquid Surface Tension (dynes/cm)	Relative Foaming	Description
51345	600	44.6	Low	Base adhesive
51345A	600	36.7	Moderate	Surfactant Type A
51345B	600	38.0	High	Surfactant Type B
51345C	250	33.8	Very Low	Low surface energy diluent

Offset Gravure Application

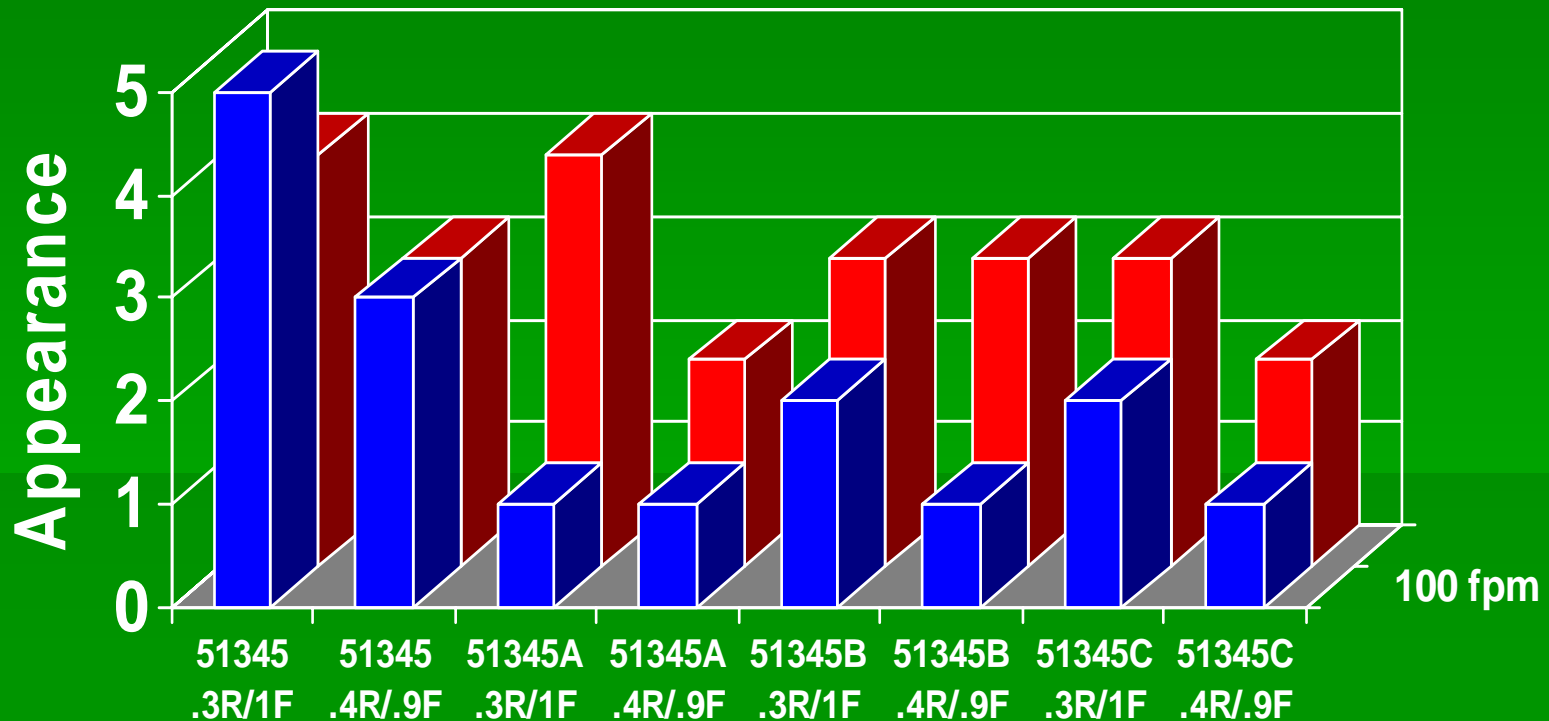


Web Speed = 1.0

Gravure	Application	Adhesive Wt. (lbs/3000ft ²)
1 F	1 F	2.0
0.3 R	1 F	1.1
0.4 R	0.9 F	1.3

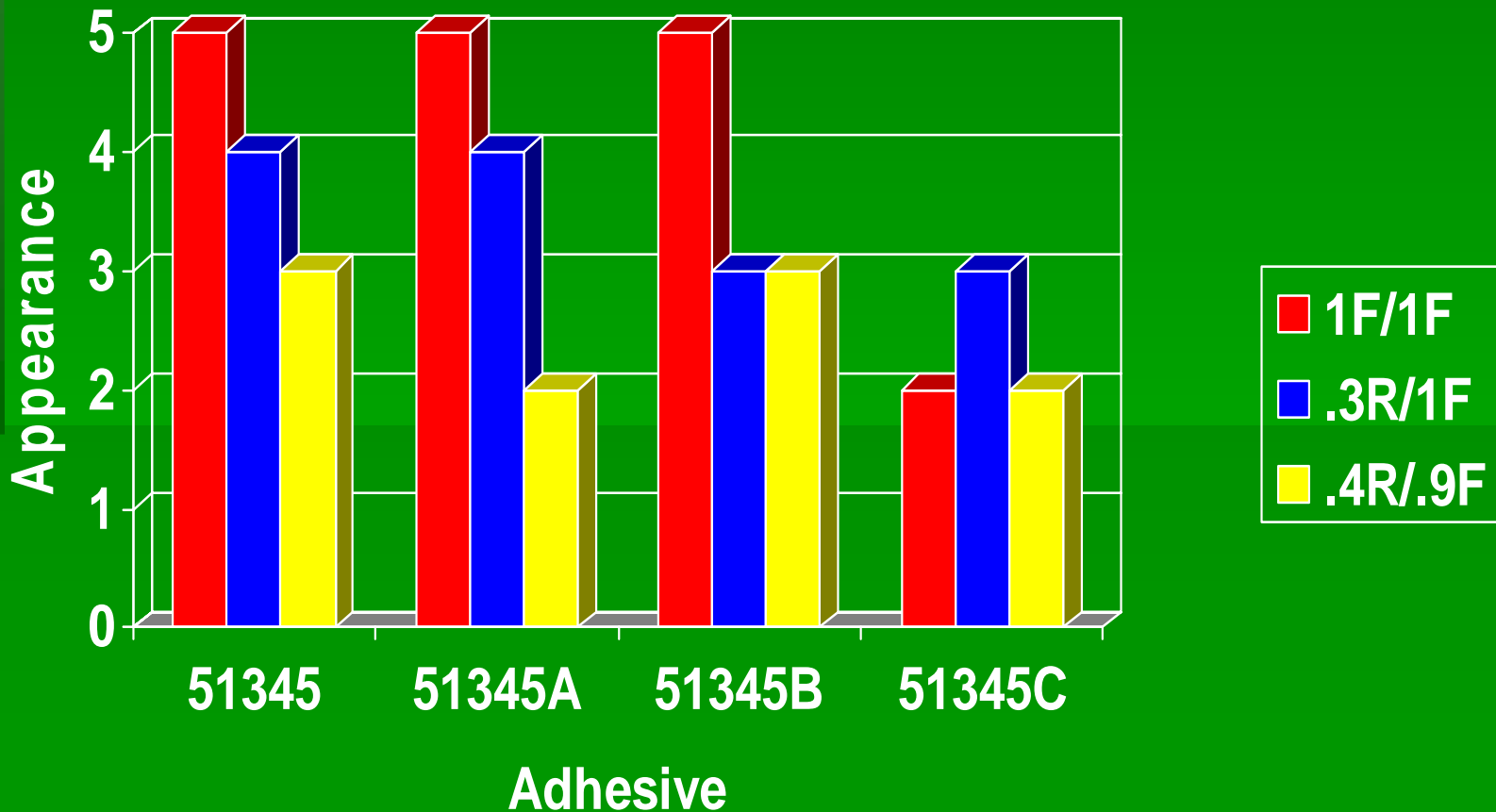
Effect of Web Speed/Adhesive

(room temperature, no corona)

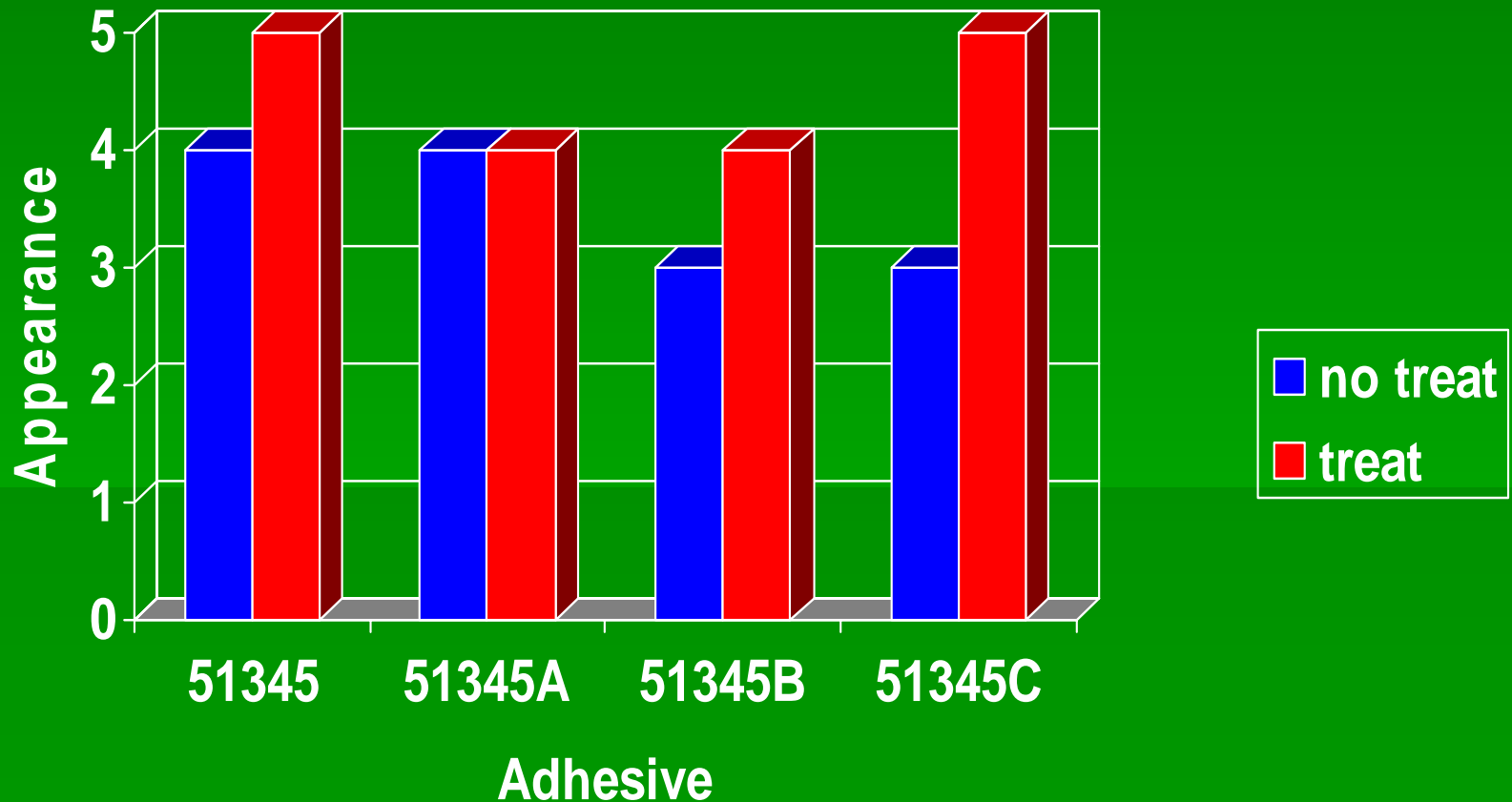


Effect of Coater Set Up and Adhesive Modifications

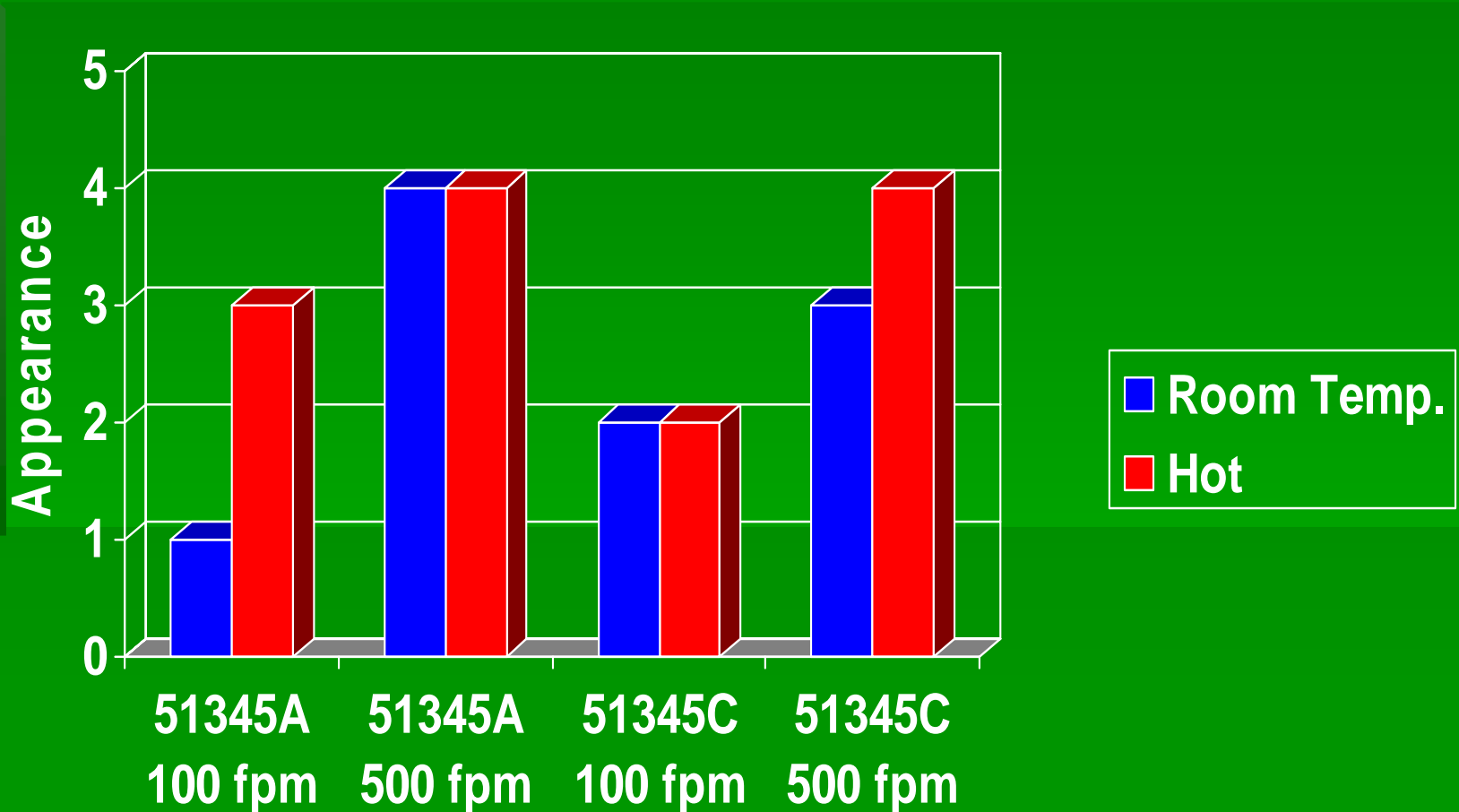
(500 fpm, no corona treatment)



Effect of Corona Treatment (500 ft/min, .3R/1F)



Effect of Adhesive Temperature (no corona treatment)



Conclusions

- Web speed, coater set up, and adhesive modifications have the largest impact on adhesive appearance
- Corona treatment and adhesive temperature have little effect on adhesive appearance
- Excellent high speed EB adhesive laminate appearance may be expected under optimized conditions
- Optimum application conditions for EB adhesives will likely be different than solvent based, water based, or solventless adhesives

Future Work:

Keys to Broad Commercial Acceptance of EB Laminating Technology

- Meet required bond performance with suitable substrates
- **Compatibility with available ink systems**
- **Suitable for food packaging – FDA compliance, no taint or odor**
- Applied cost competitive with other adhesive technologies
- Consistent good quality laminate appearance
- No adverse effects of EB on substrates

Ink Bond Performance

- Nearly all flexible packaging applications involve bonding to printing inks
- It is desirable for EB adhesives to perform with current commercial laminating inks
- Challenge
 - Two-component solventless adhesive extended cure time may allow ink/adhesive interaction which improves bond strength
 - Instant cure of EB adhesives may limit ink/adhesive interaction
- Status
 - Printed films are being successfully EB laminated at up to 750 ft/min with commercial solvent and water based inks
 - Successful trials have been run with polyurethane, polyamide, PVB, and acrylic ink systems
- Future Work
 - Systematic high speed EB lamination study is in progress with multiple known commercial ink systems

Four Ways To Establish FDA Compliance

1. No migration/no food additive position – below 50 ppb detection limit for most materials and applications – **Current EB food applications**
2. Threshold of Regulation Listing – requires non-toxic/non-carcinogen materials with dietary intake less than 0.5 ppb
3. Use materials cleared under existing regulations (Prior Sanction letter, GRAS position, prior Food Additive Petition) – few UV/EB materials have appropriate FDA status
4. Register new materials with FDA through a Food Additive Petition or Food Contact Notification (FCN) application – **In progress**

EB Laminating Adhesive Migration Initial Results

(single side test cell, 40°C/10 days)

	10% Ethanol ^A Migration (ppb)	95% Ethanol ^B Migration (ppb)
2 mil LLDPE	ND	178/155 ^C
0.75 mil oPP	ND	ND

A – Aqueous and alcoholic food simulant

B – Fatty food simulant

C – Two adhesive components

ND – Non-detect, ~20 ppb detection limit

Thank You

PRESENTED BY

Stephen Lapin

Vice President, Technical Director

Northwest Coatings LLC

stevel@northwestcoatings.com