Electron Beam Technology for Printing and Packaging Applications

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Electron Beam Technology

- Industrial uses for over 30 years
- Accelerated electrons produced using electrically operated filaments
- Low energy equipment is self-shielded
- Ionizing radiation initiates acrylate polymerization without photoinitiators
- Considered to be more food friendly compared to UV
- Very consistent output
  - Beam current ramps with line speed to give constant dose
  - Excellent cross-web uniformity
  - Output does not degrade with time
- High throughput

Presentation Outline

I. EB Printing and Packaging Applications

II. Advances in Low Energy EB Equipment

EB Technology for Printing and Packaging Applications

- Web offset printing
- Flexo printing
- Gravure printing
- EB clear coating over conventional inks
- EB laminating
- Specialty converting: holograms, transfer coating, specialty inks, etc.

EB Web Offset Printing

- Advantages
  - Commercial >25 years
  - Wet trap paste ink technology well established
  - Low plate cost
  - Low ink usage
  - High print quality
  - Variable repeat technology (VSOP)
  - Current use for cartons, labels, paper based pouches, and multi-wall bags
- Challenges
  - Extensible substrates
  - High ink coverage (first down or last down white)
  - Offset printing not familiar to most package printers
  - High capital cost of press equipment
  - Little current use in flexible packing

Central Impression Web Offset Printing

- New press technology from Comexi
- Offset stations with variable repeat sleeves mounted on a CI drum
- Combines advantages of web offset printing with ability to use extensible films

EB Flexo Printing

- Interstation EB not practical
- Need strategy to trap inks after each color
  - Wetflex (Sun Chemical)
  - EasyRad (TechnoSolutions)
  - Paste Ink System (IdeOn)
  - Dual UV-EB

Wetflex™ EB Ink Technology

- Description/Advantages
  - Developed by Sun Chemical
  - Allows flexo application of multiple ink colors without interstation drying
  - Curing is accomplished with a single EB unit at the end of the press
  - Inks contain limited amounts (about 20%) of water
  - Attractive for food packaging (water replaces monomer content for viscosity reduction)
  - High print quality due to low dot gain
- Challenges
  - Ink stability/dirty printing in long runs
  - Requires specially modified ink handing equipment
  - Wet trapping over first down white ink
  - Inks available only from Sun

EasyRad EB Ink Technology

- TechnoSolutions business venture formed by partners in Brazil
  - Antilhas (package printer)
  - Saturno (ink manufacturer)
  - Comexi (press manufacturer)
- Public announcement of demonstration at Antilhas August 2009 (www.pack.com.br/blog)
- Flexo printing with CI press platform
- Final EB cure only; no interstation drying necessary for ink trapping
- High solids solvent/EB hybrid
- Compliance with VOC emission standards?

Solvent/Water Free Paste Ink System

- Recent US Patent 7,997,194 to IdeOn LLC
  - Paste ink >5000 cps
  - Little or no VOC content
  - Apply with photopoylmer based letterpress or flexo plate
  - Wet trap multiple colors and cure with single EB unit
- Ink metering system described in Patent Application publication US 2011/0192297
- No known current commercial installations

Dual UV-EB Curing of Inks

- Description/Advantages
  - Interstation UV cure with low power lamps followed by final cure by EB
  - Uses well known stable UV flexo ink technology
  - Excellent print quality due to low dot gain with 100% solids inks
  - Faster press speeds compared to UV curing alone
  - No limit on ink sequence or density of inks that may be used
  - Potential for food packing using low levels of migration resistant photointiators
  - EB effectively completes the cure of UV inks **without** nitrogen inerting
- Challenges
  - Higher capital costs to install both UV and EB equipment
  - Need press, EB equipment, lamp equipment, and ink supplier partners to demonstrate commercial viability
- Patent
  - US 5,407,708 covering dual UV-EB cure for CI-flexo assigned to Sealed Air expires January 2014

EB Gravure Printing

- Patent and publication by IdeOn LLC with Amgraph Packaging
- Water based EB curable inks
- Interstation drying with conventional thermal ovens
- Single EB at end of press to crosslink inks
- Advantages
  - Maintains print quality advantages of gravure
  - Eliminates VOCs from solvents
  - Food friendly: water diluent (no monomer), high molecular weight acrylated polymer dispersions
  - Crosslinked inks have superior resistance properties

EB Clear Overprint Coatings Over Conventional Inks

- Typical configuration is conventional CI press with coating station and EB after tunnel dryer
- Advantages
  - Lower cost by replacing film laminated flexible packing with surface printed and coated mono-web packaging
  - High gloss appearance
  - High heat, mechanical, and chemical resistance of cured EB coating
- Challenges
  - Matching appearance and handling of reverse printed laminated packaging
  - Odor, taint, food law compliance
  - Functional properties (COF, weatherability, ink protection)
  - Patent covering film food packaging applications (Cryovac US 6,528,127)
- Current Applications
  - Outdoor film bags
  - Multi-wall paper bags
  - Paper/foil tobacco package
  - Cold seal release coatings for confectionary packaging

EB Laminating

- Advantages
  - Stable one component adhesives
  - Bubble-free barrier-barrier lamination
  - Lamination in-line or off-line with printing
  - Instant bonding
    - Immediate QC, slitting, die cutting, shipping
    - Enables in-line processing (dye cutting, additional laminate layers)
  - FDA compliance established for select adhesives (FCN 642 -Northwest Coatings)
- Challenges
  - Higher cost compared to 2-component solventless adhesives
  - Good bonding of a limited range of inks and substrates
- Current Successes
  - Folding cartons (film-to-paperboard)
  - Non-food flexible packaging (film-to-film and film-to-paper)
  - Food packaging with foil barrier

Low Energy EB Equipment Development

- Industry defines low energy as <300 kV
- Initial self-shielded low energy beams installed in early 1980's
- Multi-filament gun established as preferred configuration
- New generation of "lower" energy systems introduced in 2000
  - 90 to125 kV
  - Primarily used in the curing of inks and coatings
- Modular sealed tube emitters introduced in early 2000's
  - Performance and reliability have continued to evolve

EB User Requests

- Lower capital costs
- Improved reliability
- Lower cost of operation
- Easy and inexpensive maintenance
- Wider ranges of voltages
- Customization for new applications
- Lager range of web widths
- Non-web product handling

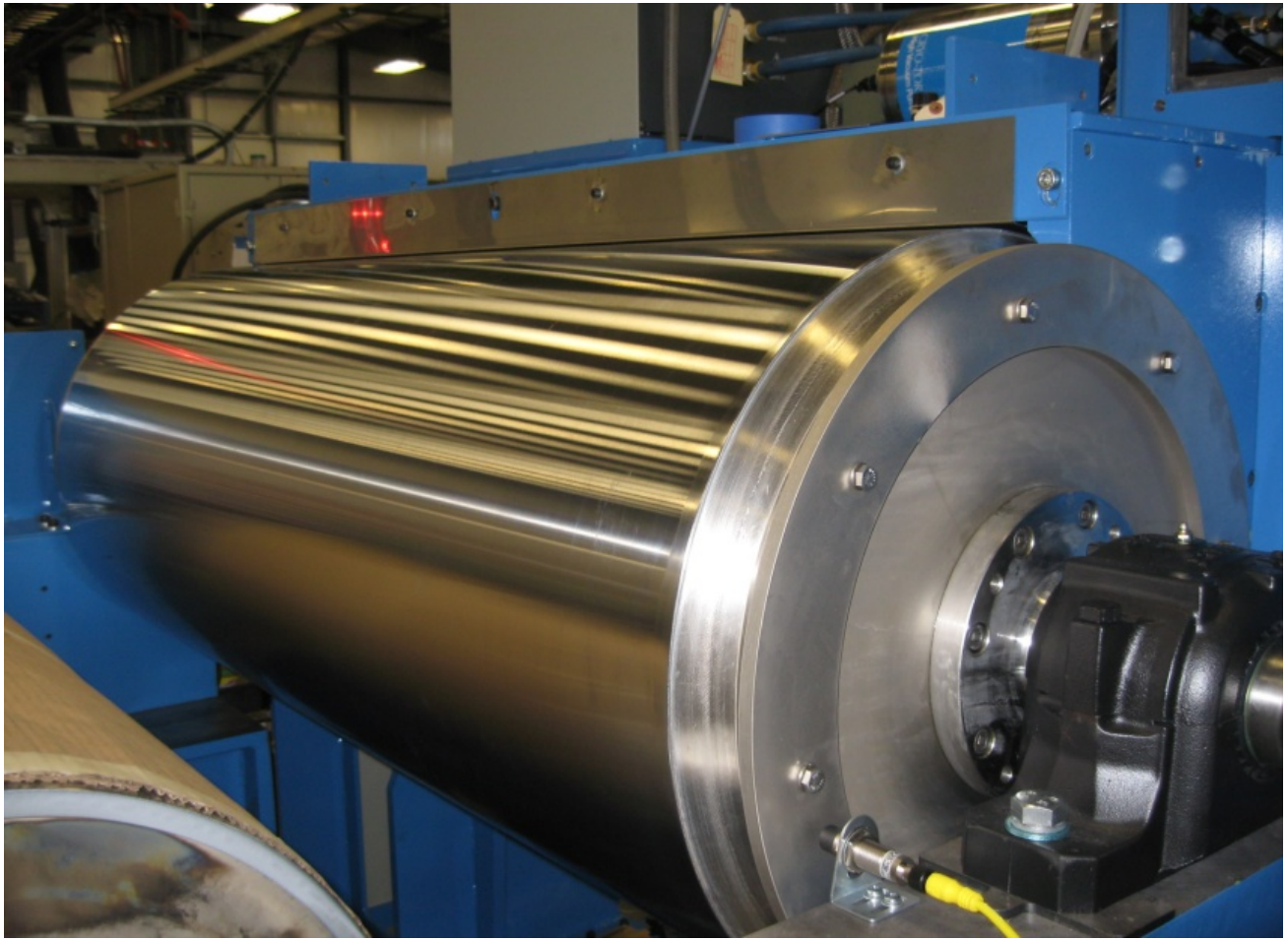
New Advancements in EB Equipment

- Integrated shield roll
- Low profile side fire
- Integrated converting on shield roll (4-in-1 System)
- Extended voltage range for lower energy systems
- Digital high voltage power supplies
- Sealed tube emitters
  - Narrow web curing systems
  - 3-D curing systems
  - Lab systems
- Ultra-low energy EB systems

Integrated Shield Roll

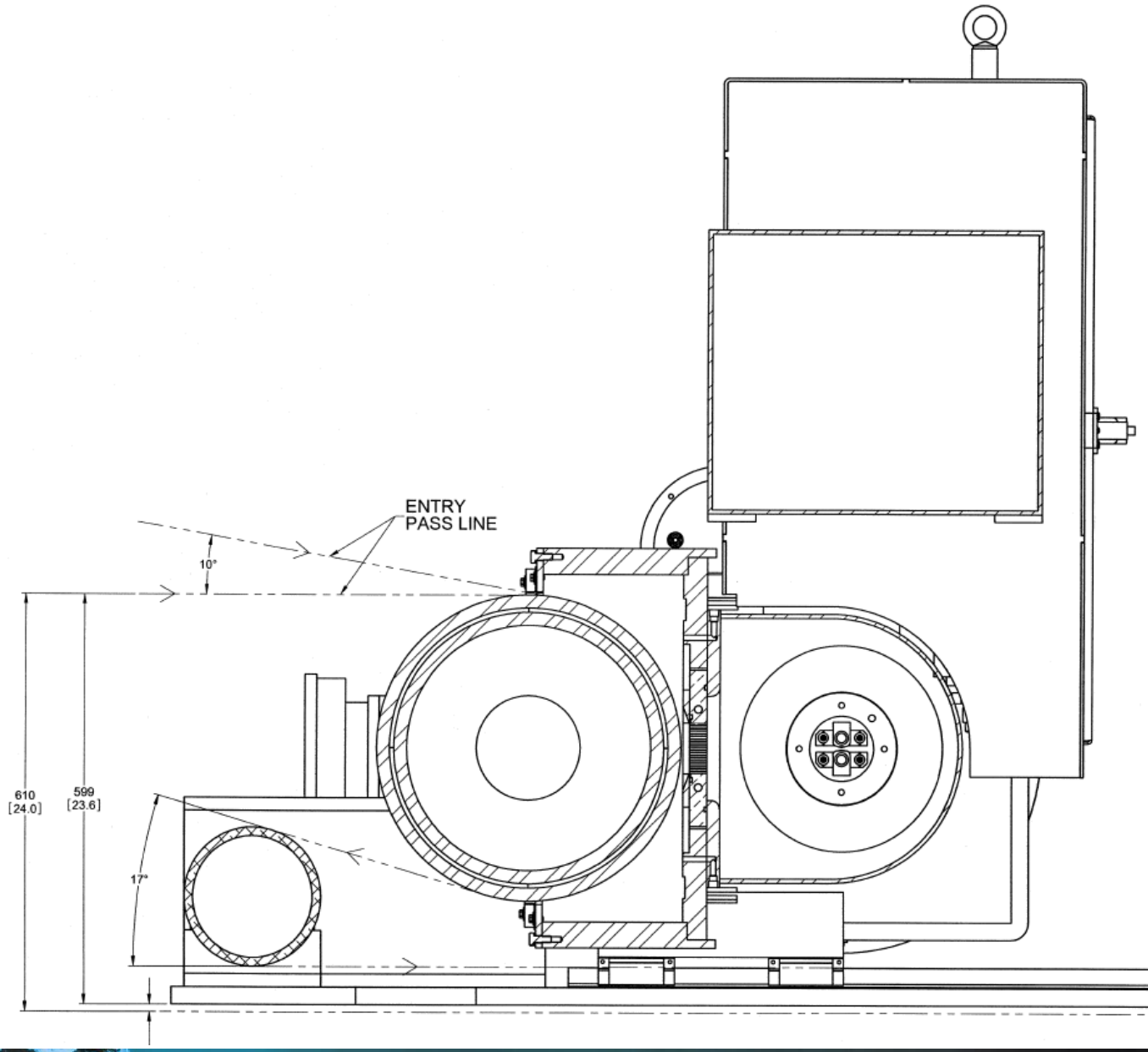
- New patented (US 8,106,369) design
- Supports the material and serves as a functional portion of the shielding
- Reduced machine size
- Reduced volume for inerting
- Optimum temperature control for heat sensitive substrates
- Facilitates integration of other processes on the exposed roll surface
  - Roll coaters, extruders, nips, etc.

Integrated Shield Roll



Low Profile Design

- Ideal for variable sleeve web offset presses
  - No need to raise the press or dig a pit for the beam
- Low entry height – varies with sleeve size
- New design maintains “side fire” orientation
- Easy access for foil change
- Uses integrated shield roll technology
- Allows printing on heat sensitive films such as shrink sleeve label stock


ENTRY
PASS LINE
10°
610
[24.0]
599
[23.6]
17°

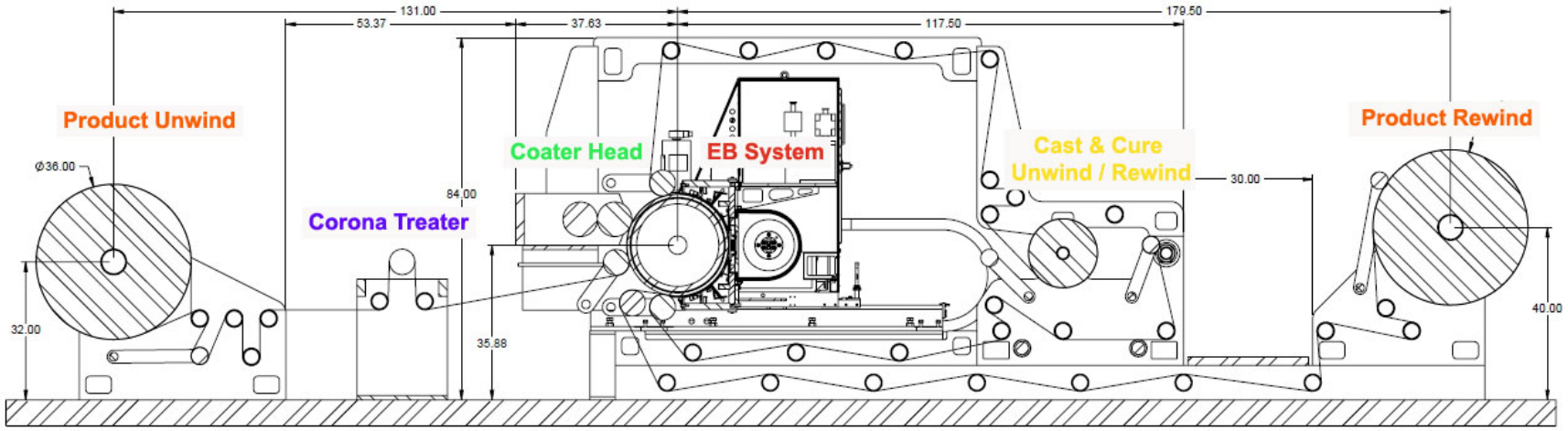
Low Profile EB on Variable Sleeve Web Offset Press

4-in-1 Package Decorating System

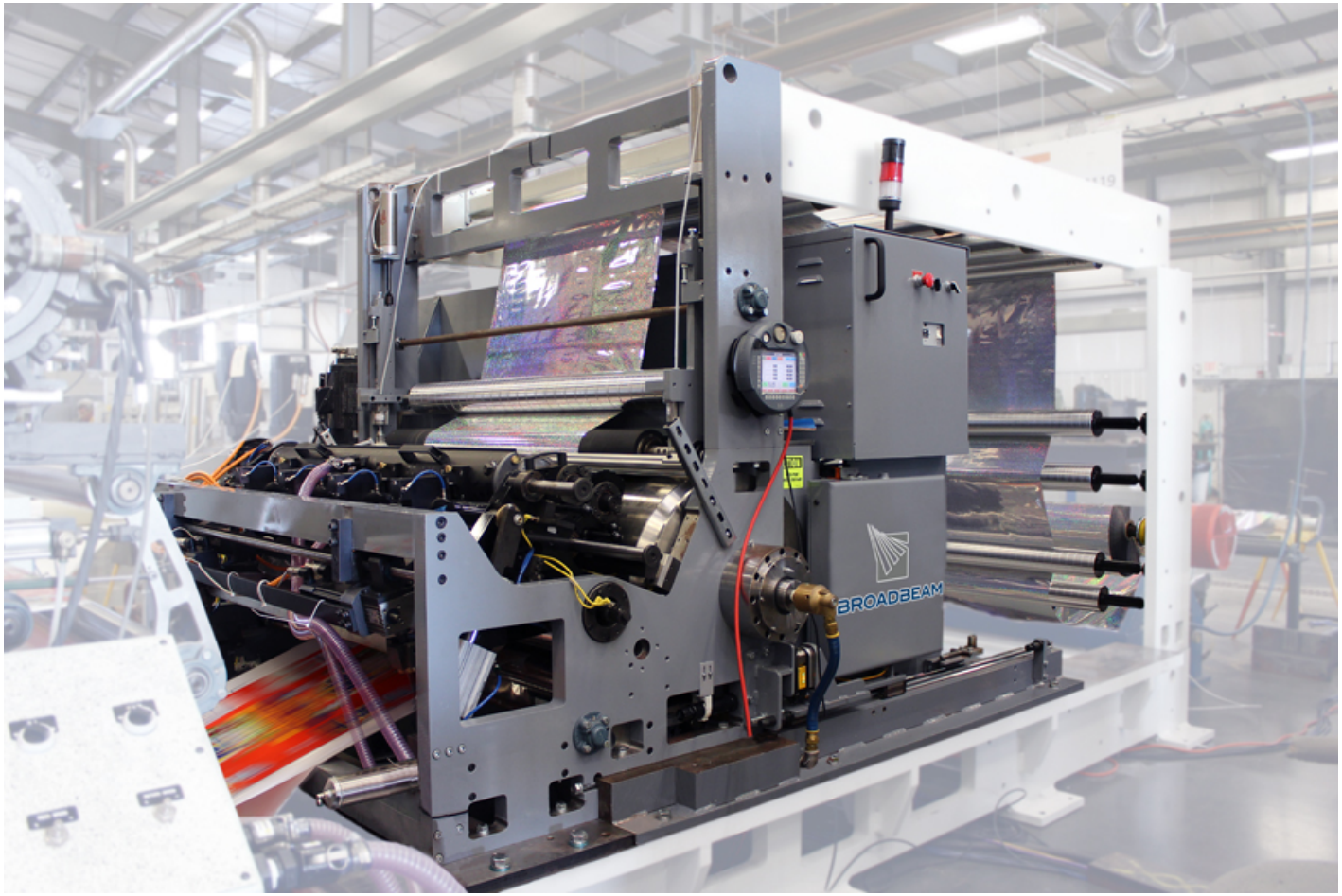
- Flexo coating station and nip rolls integrated directly on EB shield roll
- Four modes of operation
  - EB coating
  - EB laminating
  - Cast & Cure (hologram embossing)
  - Cold foil transfer
- May be in-line of off-line with printing

4-in-1 Package Decorating System

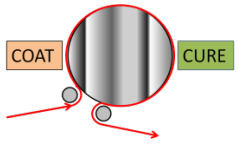
Enabled by process integration with integrated shield roll



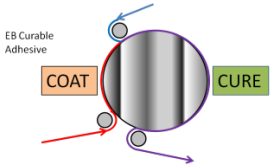
4-in-1 Package Decorating System



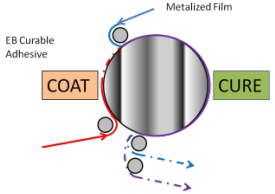
Examples of 4 in 1 Curing



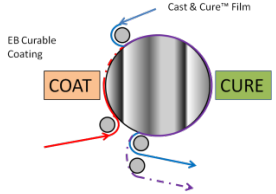
Coating



Lamination



Cold Foil Transfer

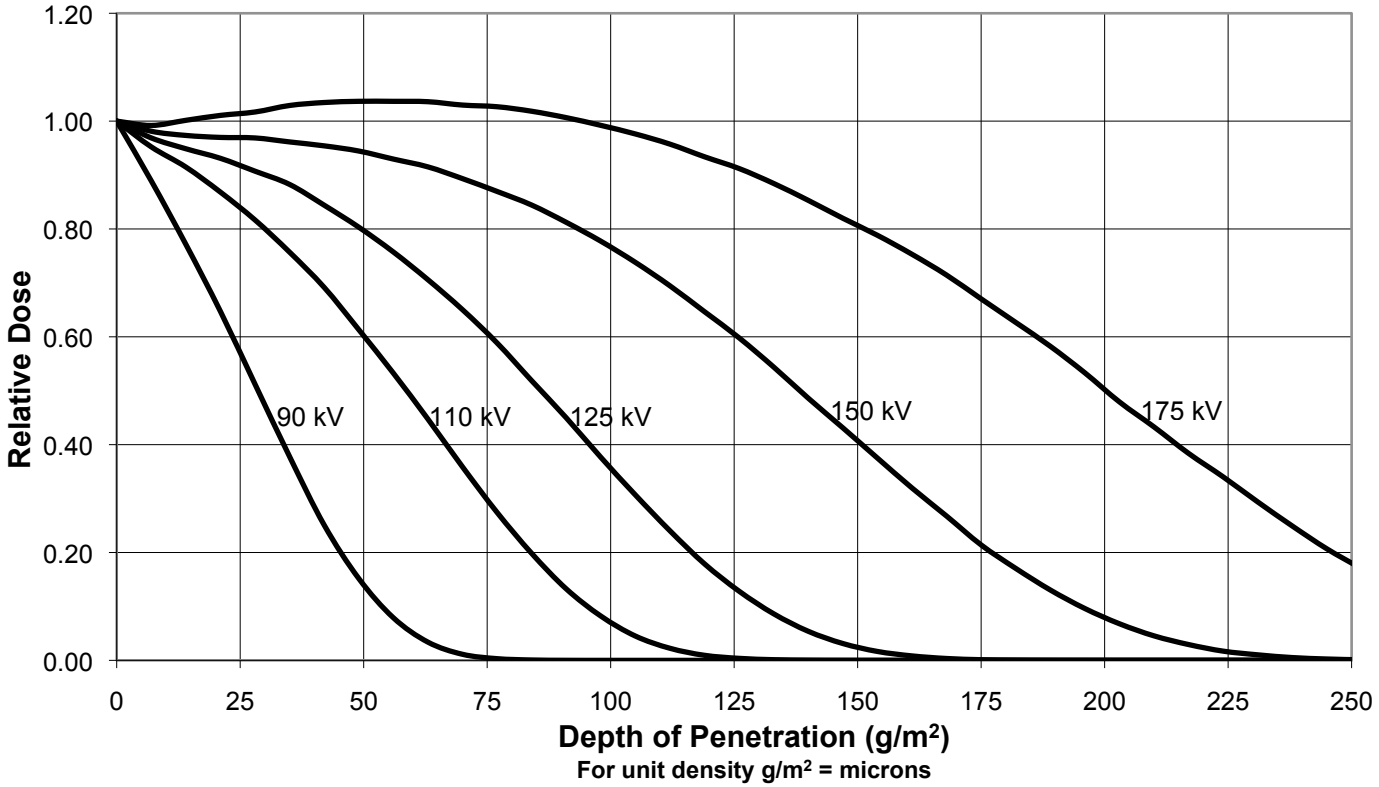


Cast & Cure™

Extended Voltage Systems

- Same size profile as new generation lower energy EB systems
- Energy range increased up to 175 kV
- Maintains “side fire” orientation for easy foil access & changing
- Penetration up to 150 microns
  - Film crosslinking
  - Pressure sensitive adhesive crosslinking
  - Simultaneous curing of inks on the outside surface and sterilization of food contact surface
- More cost effective than current industrial EB processors

Depth/Dose Curve for Low Energy EB Up to 175 kV



Extended Voltage Low Energy Systems

175 kV system with 24 inch integrated shield roll

High Voltage Power Supply

- Newly available high frequency, switch-mode power supplies
- Power factor above 0.90
- Significantly reduced power consumption
- Integrated digital signal processors
- Configuration and diagnostics via Ethernet
- Fast (50 microsecond) control
- Replace SF_6 insulating gas (greenhouse gas) with silicone oil
- Compact size
- High voltage cable connection allows remote installation

High Voltage Power Supply

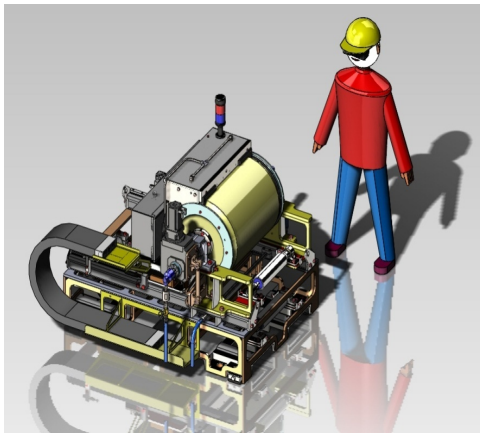
Sealed Tube Emitters

- Modular design
- 16 inches (400 mm) wide
- Voltage ranges of 90 to 180kV
- Speeds up to 300 ft/min (100 m/min) with 30 kGy dose
- New developments providing significant increase in foil life (over 6000 hours)
- Integrated systems based on sealed tube emitters enable new applications
  - Narrow web printing and converting
  - Curing of 3-D surfaces
  - Lab curing units

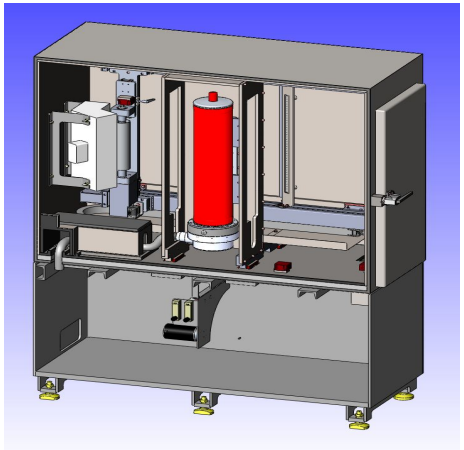
Seal Tube EB Systems

Emitter, Cable, Power Supply

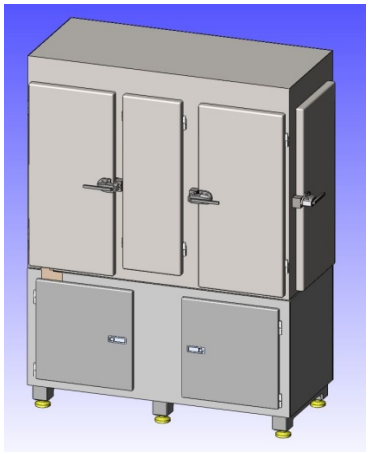
EB Systems Based on Sealed Tube Emitters



Narrow web application
with integrated shield roll



Custom 3-D curing
application with
sealed tube emitter



Narrow Web Printing Technology

Incorporating Sealed Tube Emitter Based EB System

- EB curing of thick / high density ink layers
- Supplemental curing of current UV inks
- EB inks and coatings designed for food packaging
- EB adhesive lamination
- Cold foil transfer

Narrow Web EB System

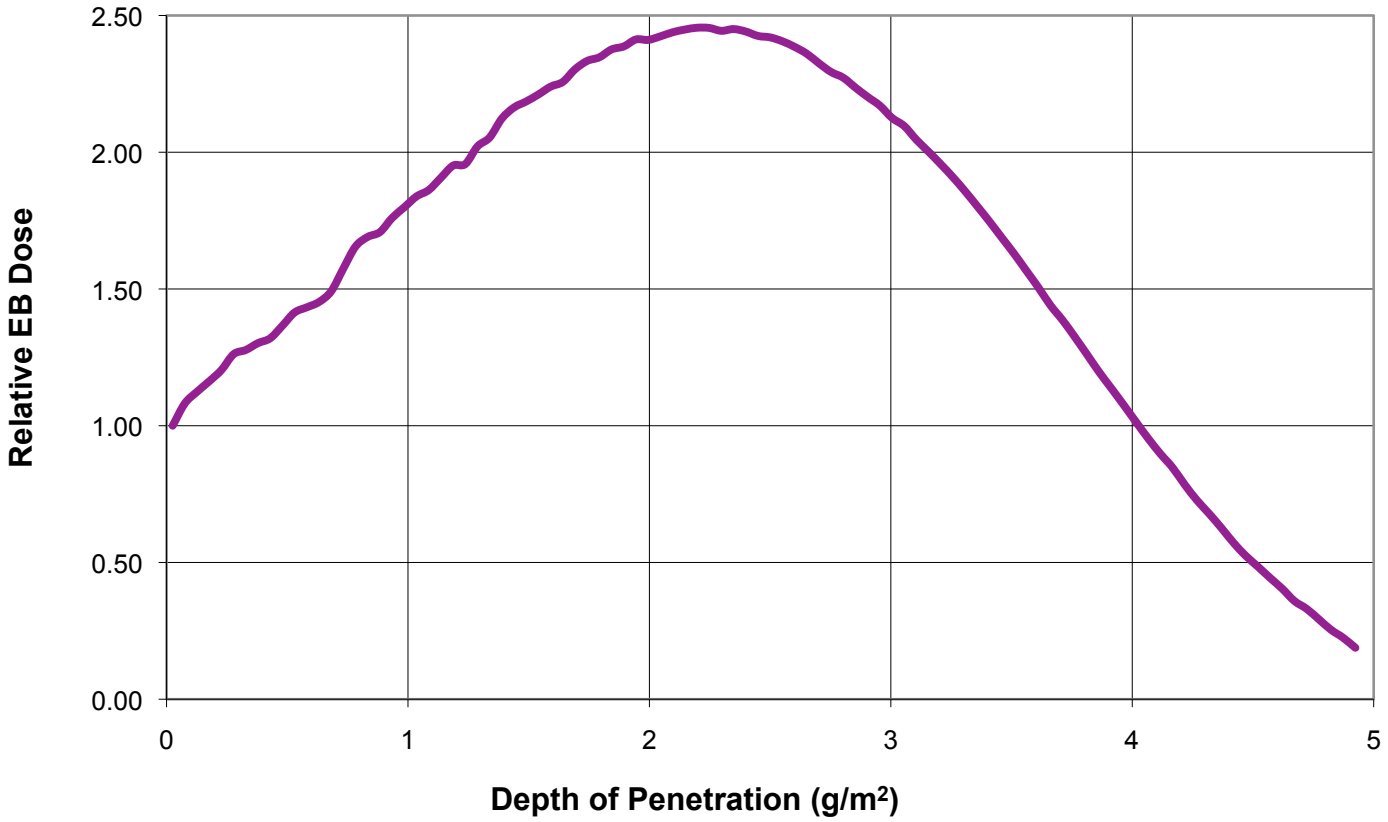
Lab EB Curing System

Ultra-Low Energy Electron Beam Systems

- Ultra-low energy range of 15 kV to 25 kV
- Compact size; widths 20 to 90+ inches
- Digital power supply
- Direct installation in vacuum coating chambers
- Elimination of the need for titanium foil as a vacuum barrier
- Cure coatings that are vacuum deposited or roll coated on a web within a vacuum chamber
- 15 kV EB generated in a vacuum will penetrate coating weights of about 4 g/m^2
- Use together with other vacuum coating processes such as metallization
- EB designed to operate in 10^{-5} torr vacuum range

Depth/Dose Curve for 15 kV EB

(operating in a 10^{-5} torr vacuum)



Thank You

Questions?

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