

Towards Zero Defects in Solution Coating

Outline

1. Zero Defect Control Approach
2. Initial analysis
3. Process Rollers
4. Static Bars
5. Surface Quality



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ZERO DEFECT APPROACH

The Approach

- Count the defects
- Identify the causes of defects
- Look at sources of defects
- Prioritise detailed analysis
- Implement solutions
- Review outcome

Major Causes of Defects

– Contamination

- Particles
- Organic and other contamination

– Surface Quality

- Surface Energy
- Adhesion

– Scratches

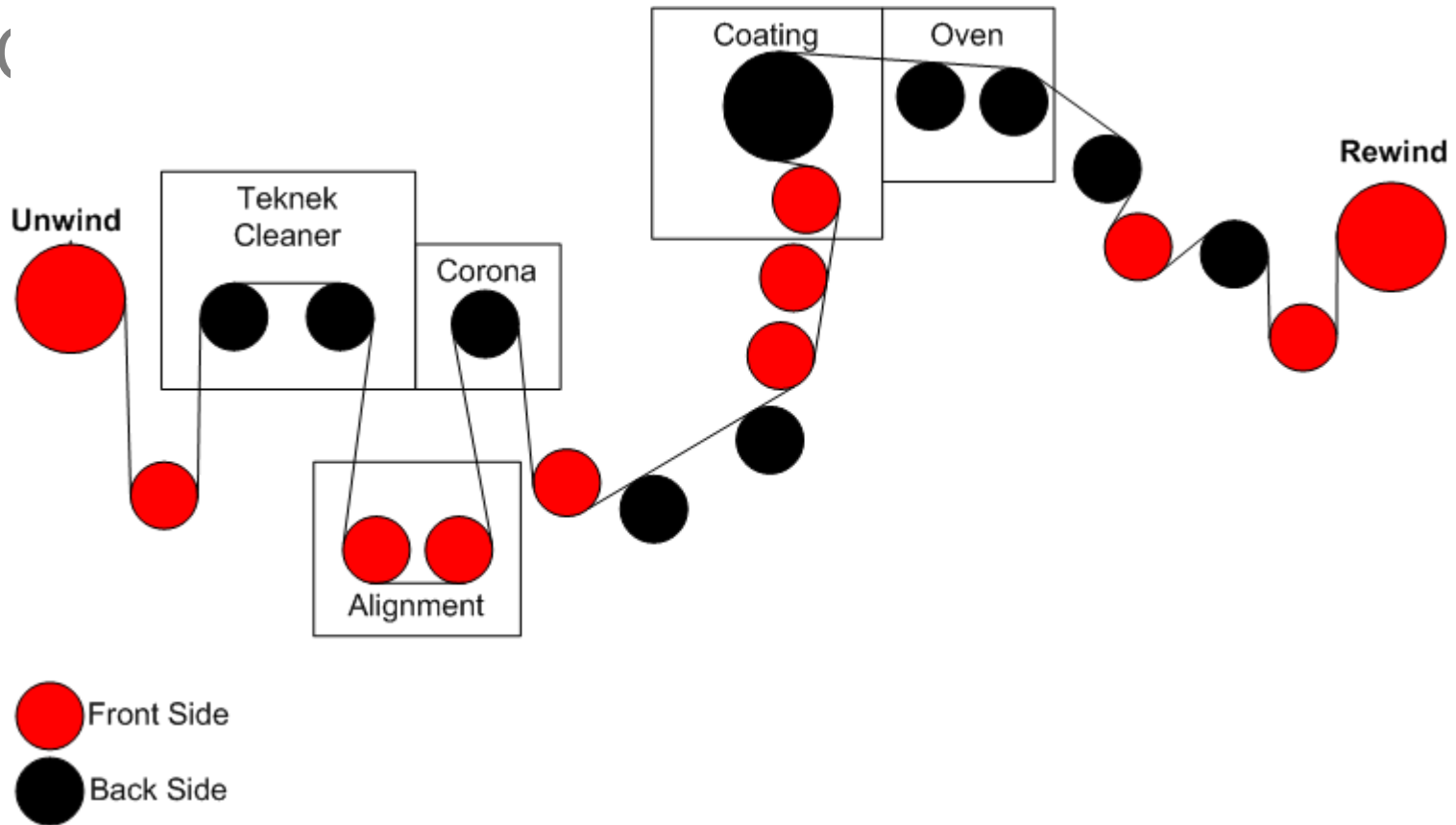
Sources of Defects

- **Substrate**
 - How dirty is the base film
- **Environment**
 - Is the process in a cleanroom
- **Process**
 - Review of particle generating parts

INITIAL ANALYSIS

Test Coating Line

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Testing



- **Test Location**

- Holst Centre, Holland
- Coatema Coating Line , Slot Die
- Coating PET Film with PEDOT and other combinations

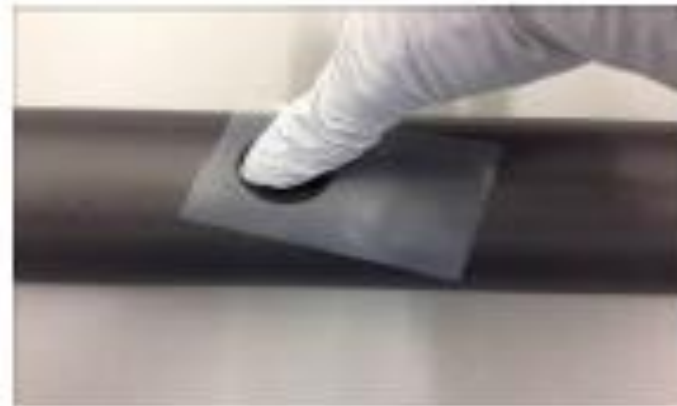
- **Contamination Measurement**

- Particles collected from each roller with PMC (particle Measure Card), data taken from full face of rollers.
- Particles counted using Partsens Particle Counter

PMC Card



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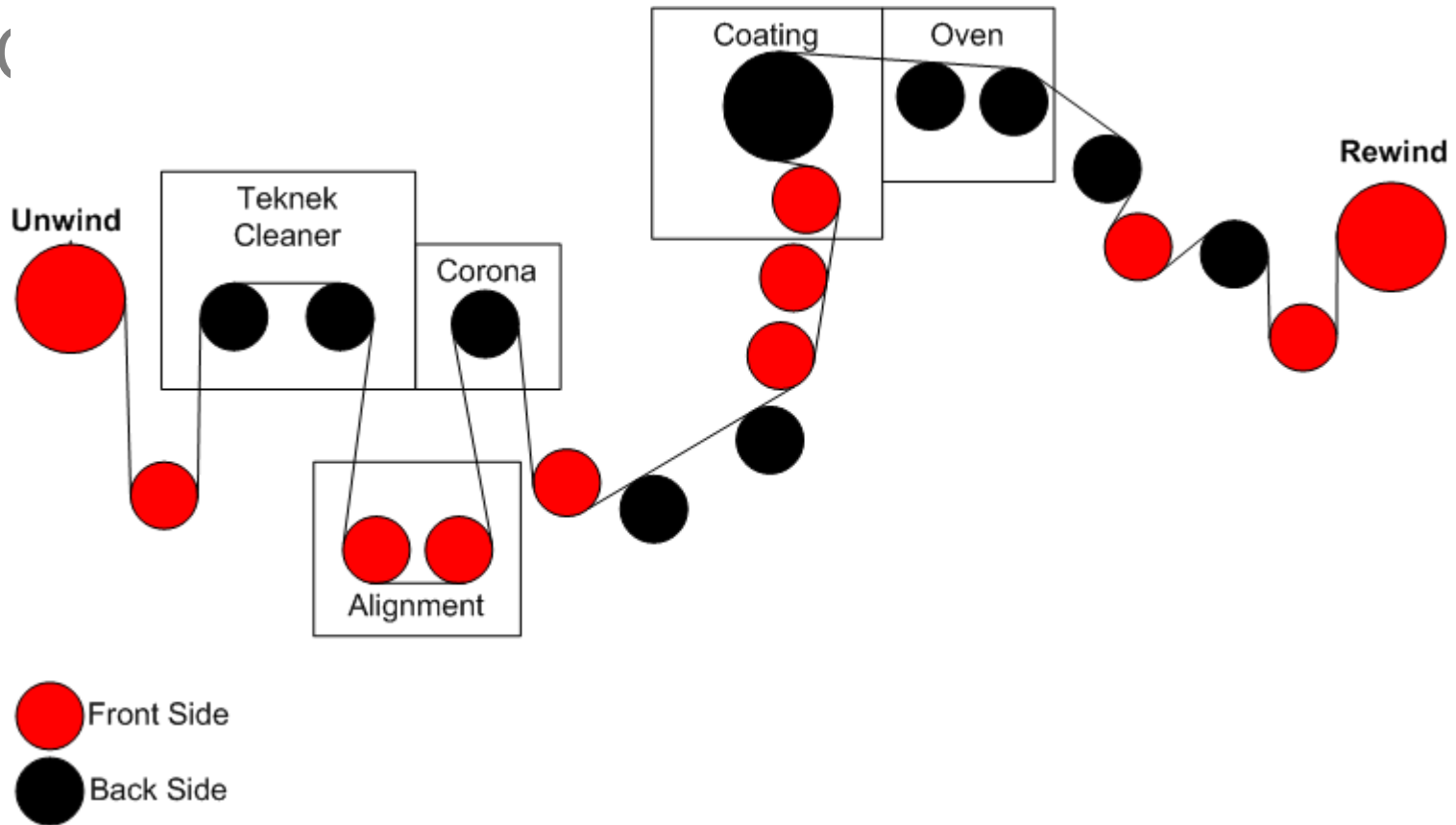
Initial Results

- **Substrate**
 - Ave 3750 particles per m²
- **Environment**
 - Adds 260 particles per m² per pass
- **Process**
 - Adds 1800 particles per m² per pass

PROCESS ROLLERS

Process Rollers

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Cleanliness of Rollers

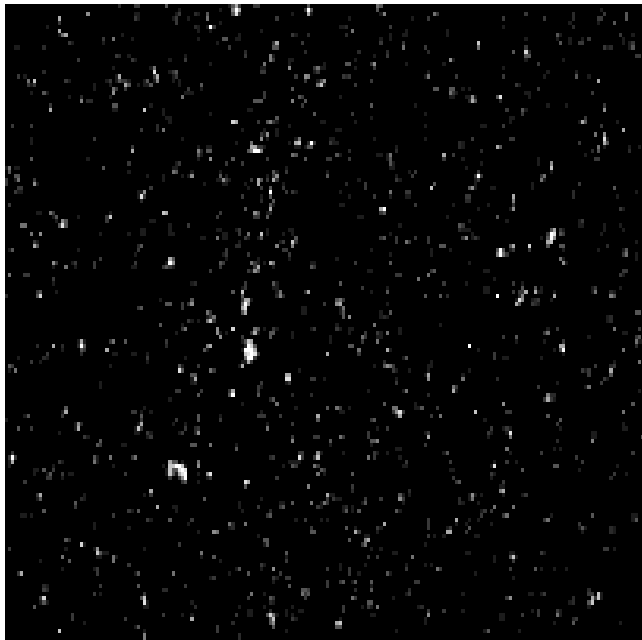
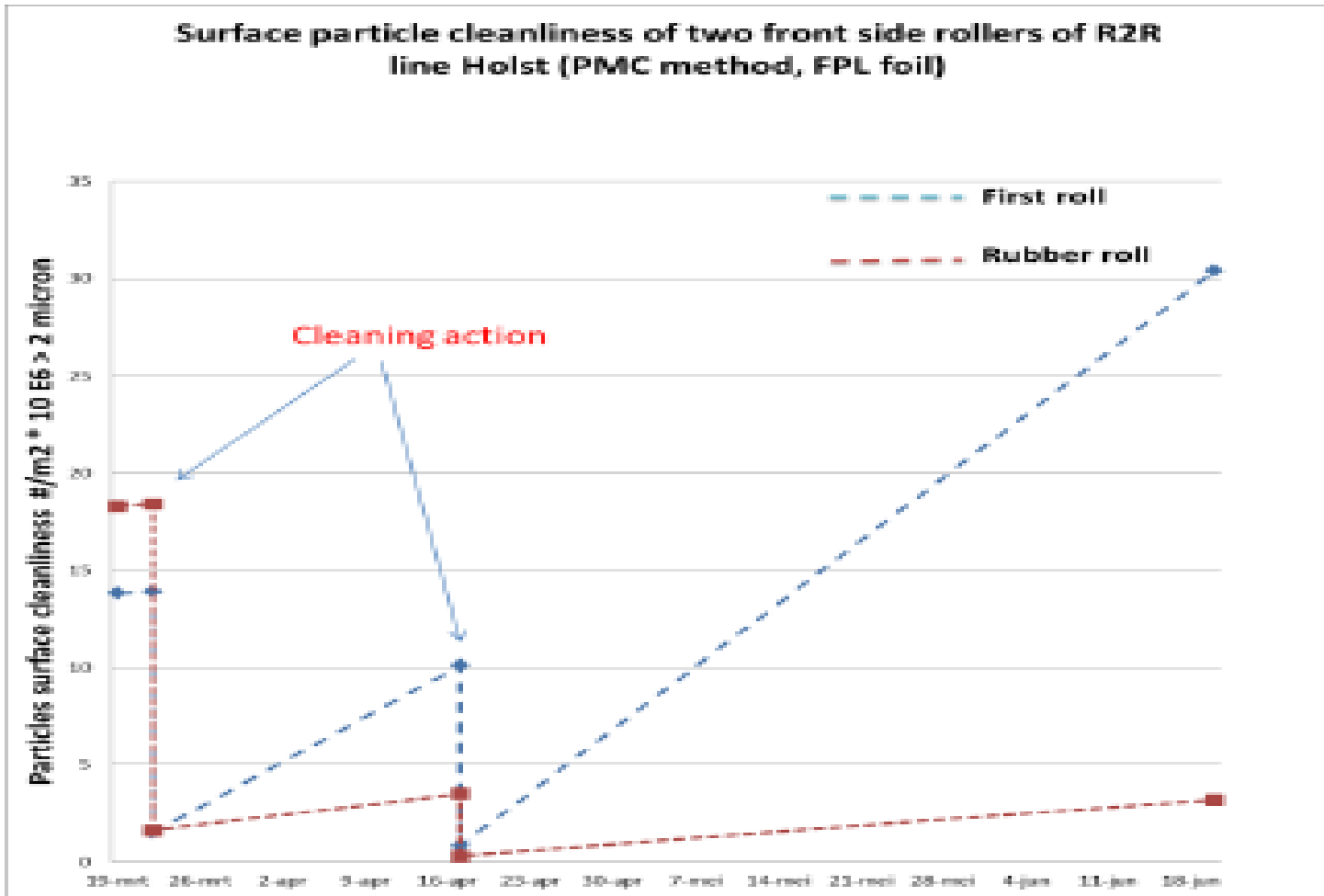


Photo **Before cleaning** 4972: 1354
particles/photo



Photo **after cleaning** 4975: 15

Impact of Cleaning



Impact on substrate

date	FS roller particle level #/m ² *E6	processing adders #/m ² pass
17-apr	0,77	231
17-apr	6,75	764
jun-20	7,40	875
22-mrt	10,10	1528

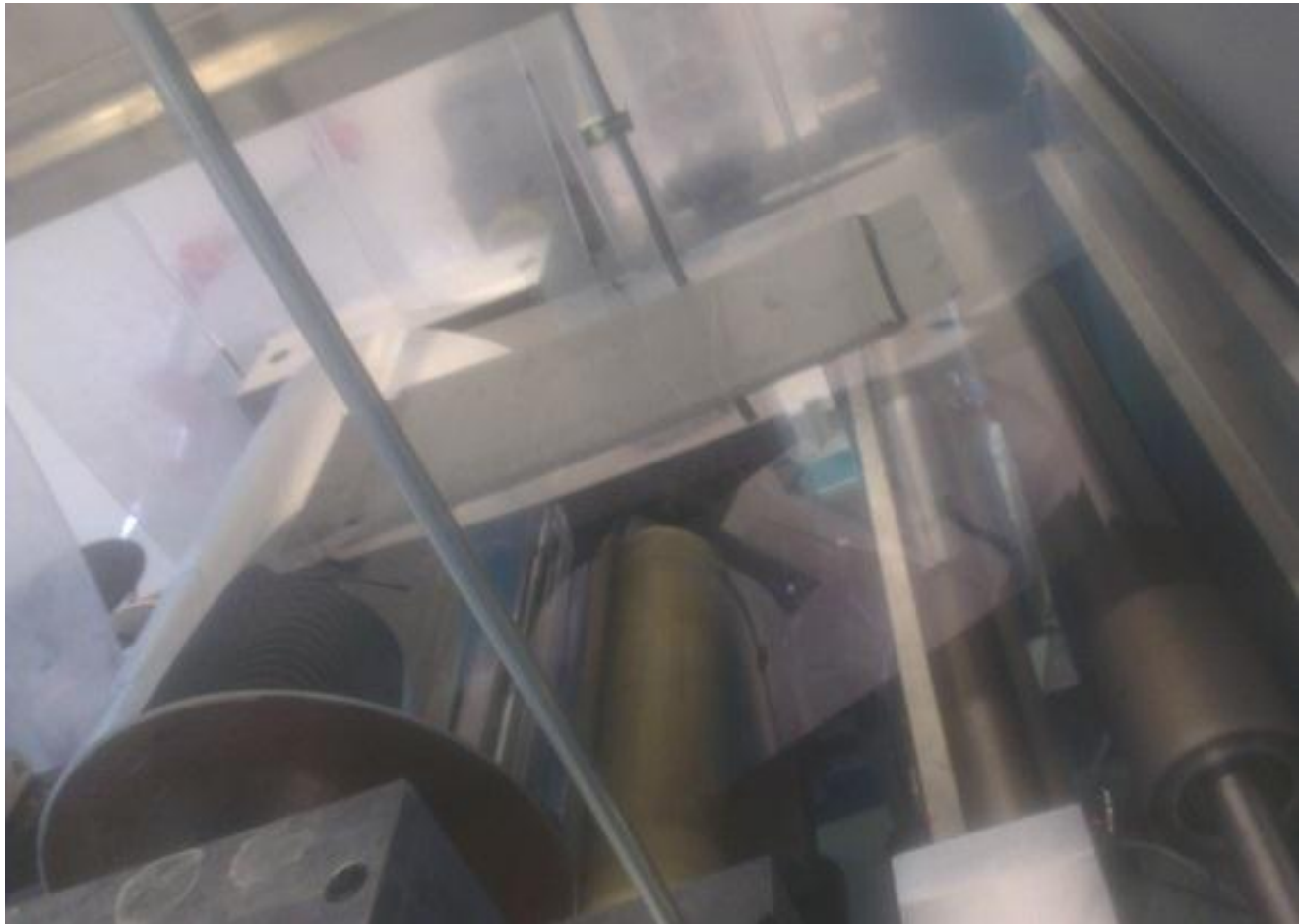
Roller Cleaning Solution

- What is it?
 - Proven Teknek cleaning polymer produced as a sheet
 - Attached to the web
 - Travels down the web and cleans each roller
 - Removed at rewind
 - Cleaned and reused – lasts for around 1 month

Cleaning Sheet in Action



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Cleaning Sheet - Results

- How effective is Teknek Cleaning Sheet?

Location	Uncleaned	After PRC
Cleaning sheet	6	
F/S after Unwind	324	7
F/S after Corona	70	7
F/S under Coater	362	3
Nip roller	94	2
F/S after Splice	64	4
F/S before Rewind	81	2

Summary



- Process rollers get gradually contaminated
- Contamination can transfer to the substrate
- Cleaning the process rollers is essential
- Elastomer cleaning is a proven concept
- The new Roller Cleaning Sheet is an easy, very cost effective way of reducing defects.

STATIC BARS

Issues



- Standard bars problems
 - Emitter Pins
 - Pins slowly erode and shed particles
 - Removes static but adds contamination
 - Field Strength
 - Gaps between emitter pins results in varying field strength
 - This causes striping on coating
 - Particularly with thin, low viscosity coatings

New Technologies

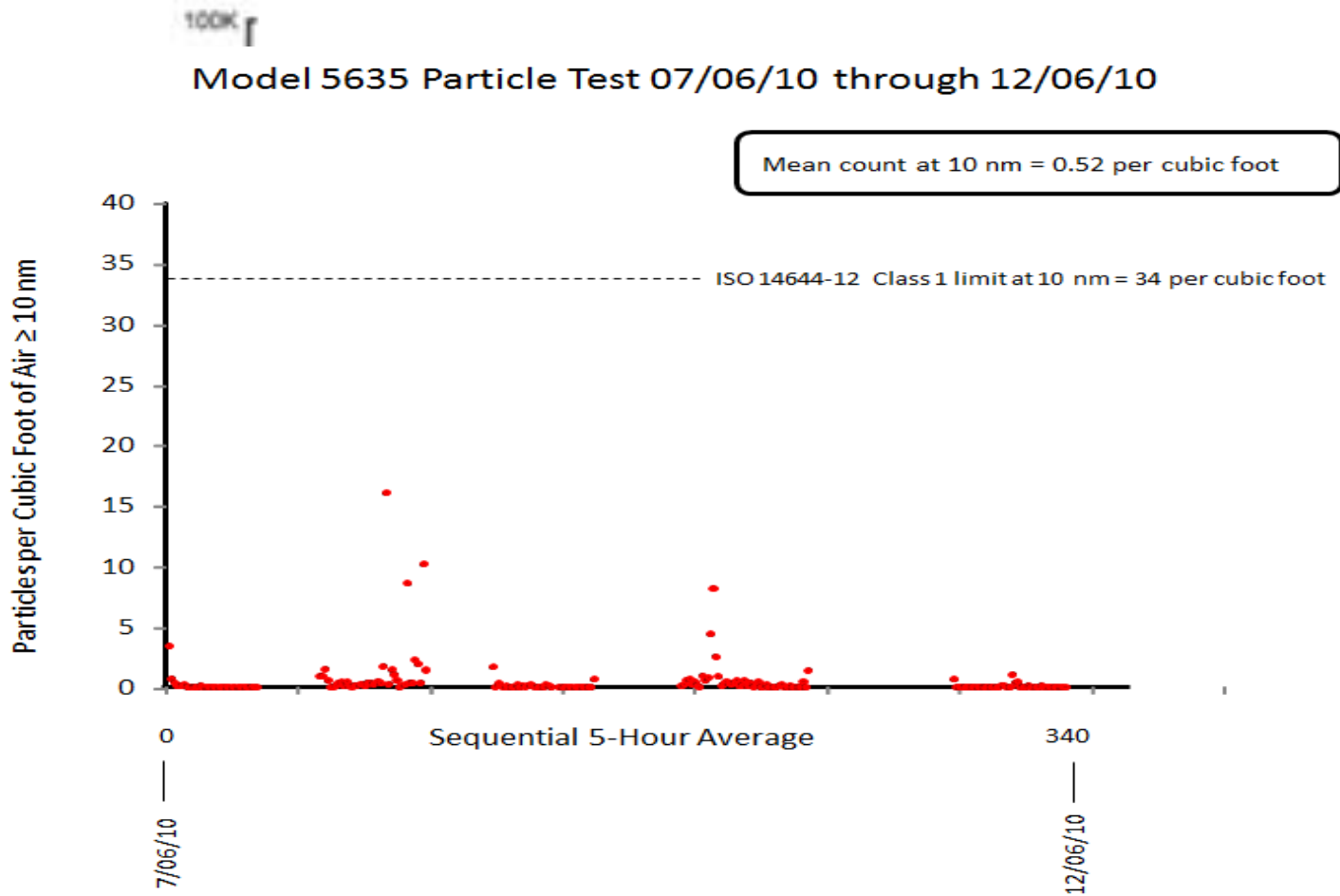
- **Single silicon crystal emitters**
 - Very low particle emission
 - No metal particles
 - Long life
 - Low maintenance
- **Active Wire Bar**
 - Generates even field across the web
 - Low particle emission

Test Protocol



- No.1 Pin based bars
 - Bar placed in HEPA chamber
 - Measure particles $\geq 10^{-9}\text{m}$
 - Particle count over time using Condensing Nucleus Counter
 - Measure regularly over 5 days
 - 4 bars
 - 2 x Standard pins Pulsed DC
 - 1 x Standard pins Pulsed AC
 - 1 x **Single Crystal emitter pins- 5635 (ITW)**
- No.2 Wire based bar 5710 (ITW)
 - 6 months in HEPA Chamber
 - Laser Particle Counter $\geq 100^{-9}\text{m}$

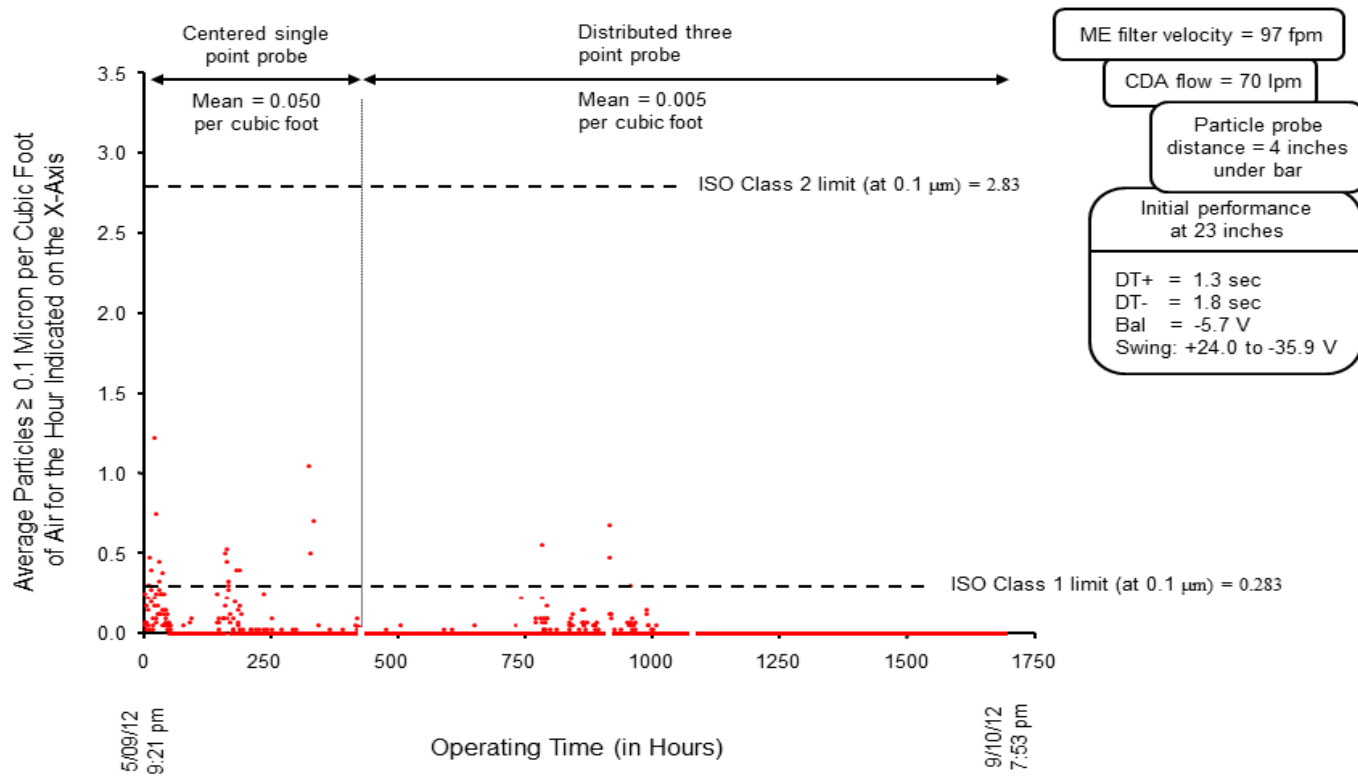
Results – Emitter Pins



■ Pulsed DC Mean = 223.2	▲ Pulsed DC Mean = 25.5
● Pulsed AC Mean = 828.1	● 5635 MP Mean = 0.52

Results – Active Wire Bar

Average Particles ≥ 0.1 Micron per Cubic Foot of Air Versus Operating Time (Hours) for the 1 Meter 5710 Bar After Clean-down, Showing ISO Class 1 Compliance



Summary



1. Conventional bars emit many particles
 - Single Crystal bars meet ISO 14644 Class 1 Extended – ultra clean
2. Conventional emitter pin designs produce non linear fields across the web
 - Active Wire bar meets ISO 14644 Class 2- ultra clean
 - Does not cause striping



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SURFACE QUALITY

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Quality requirements

- Particle Free
- Scratch free
- Surface energy greater than coating surface tension to ensure wetting
- Consistent all over the film

Particle Issues

- Major cause of coating defects such as streaks
- Can cause scratching of substrate
- Affects functionality
- Causes repeat defects at rewind

Organics Issues

- Organics can migrate to film surface
- Variation in surface energy - over time and within a roll
 - Increasing issue for thin coatings
 - Increasing issue for low viscosity coatings
- Organics can cause point delamination –
 - Pin holes
- Medical applications – sterile is best
 - Removing biologicals is an advantage

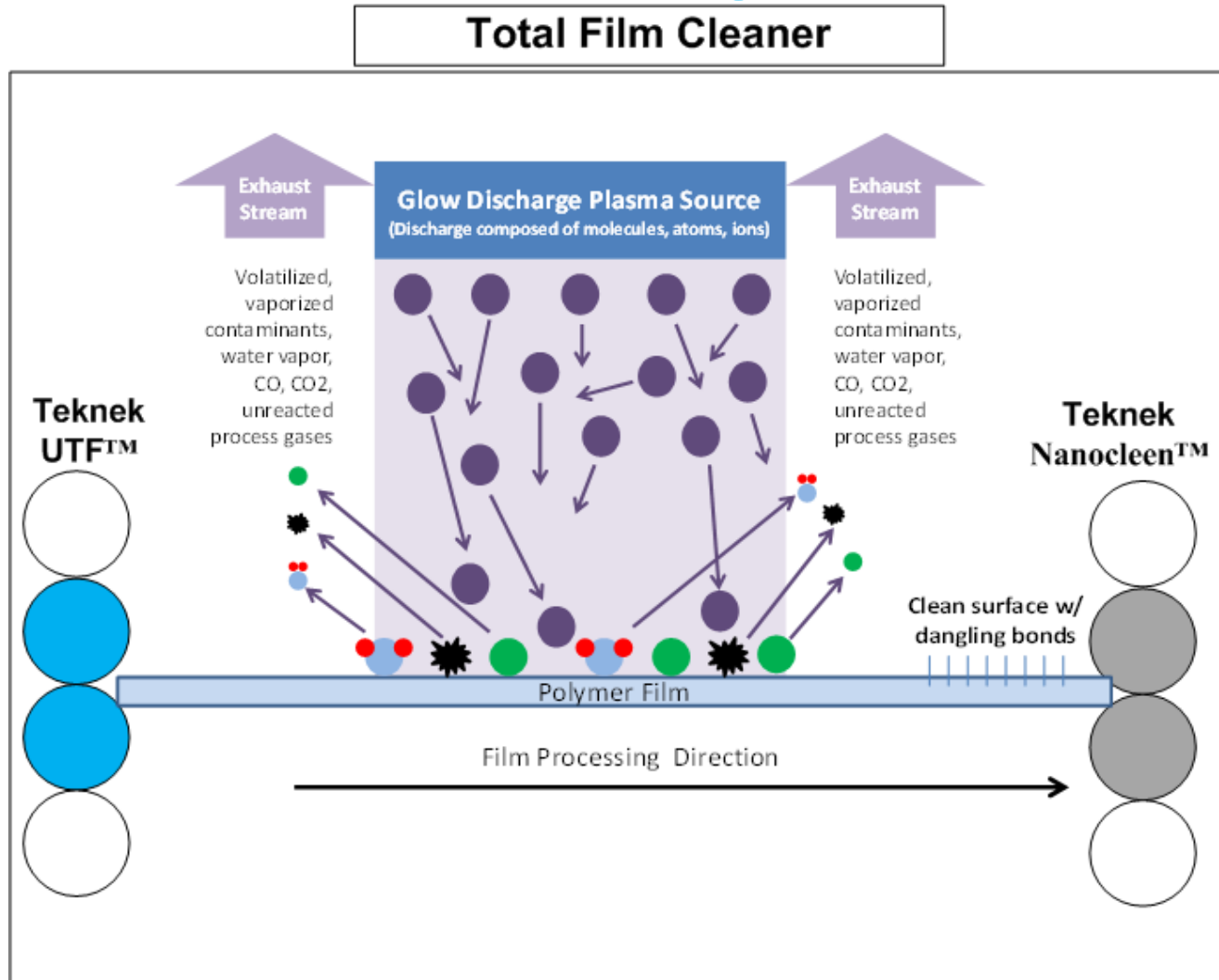
Current Solutions

- Contact Cleaning of web before coating
 - Removes Particles
- Atmospheric Plasma treatment
 - Cannot remove particles
- Corona Treatment of web
 - Removes organics and very small particles but can damage surface
- Vacuum plasma

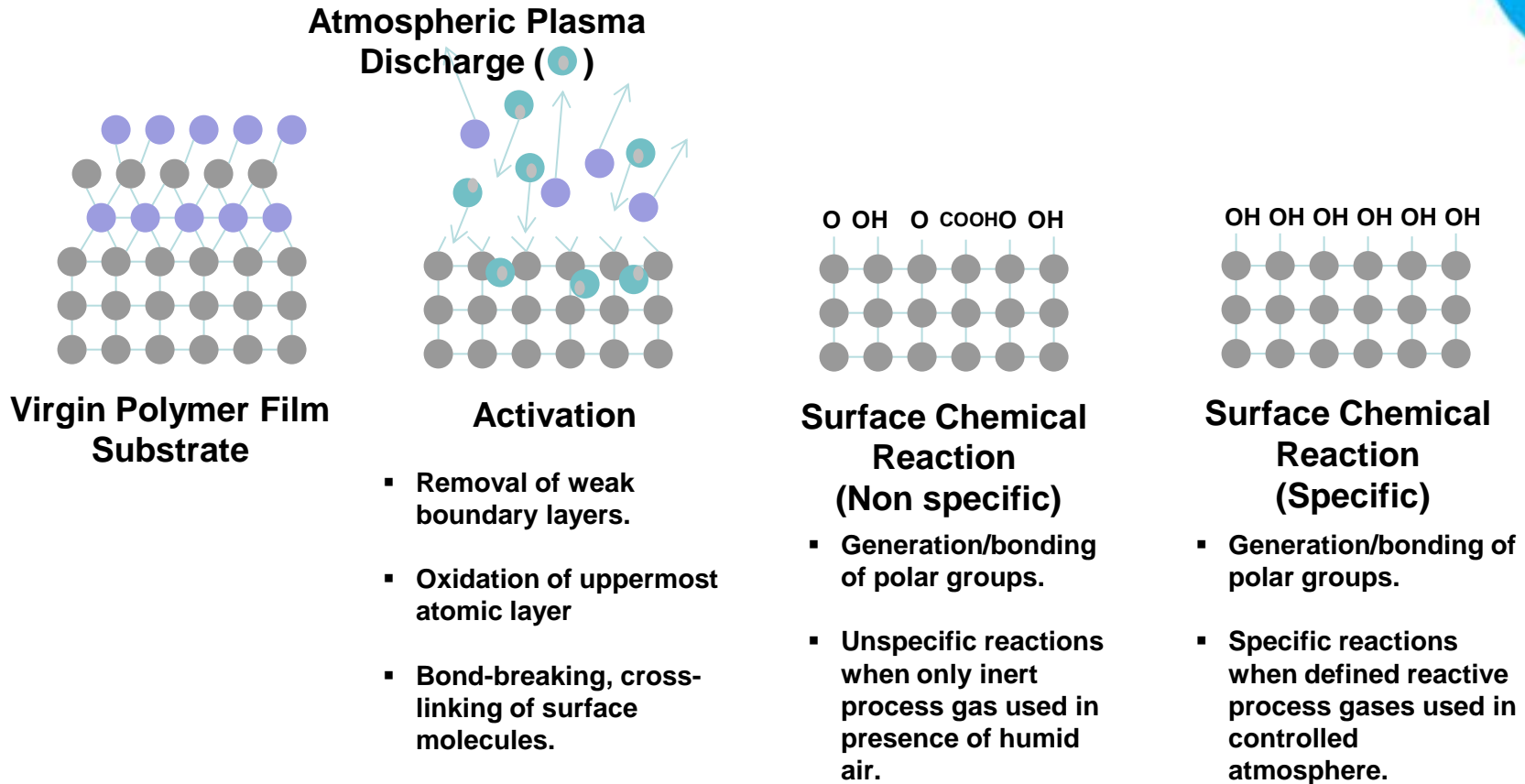
Total Clean Functions

- Three main functions
 - Cleaning , Organics and Particles
 - Surface contamination can affect contact angle
 - Activation
 - Creates reactive groups. Prepares surface for functionalisation
 - Functionalisation
 - Adding gases and pre cursors to modify surface chemistry

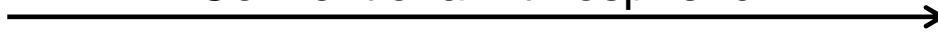
Total Film Cleaning



DDBD Process



Conventional Atmospheric PD



Controlled Atmosphere PD



TFC - Testing

- Tests performed by Eastman
 - XPS performed by Material Interface Inc.
- Substrate – Polyethylene
 - Contains fast migrating Oleamide, typical Film Additive
- Measured Surface Chemistry with XPS
 - Before and after TFC
- Measured Contact Angle across web width
- DDBD Parameters
 - 43watt minutes/m²
 - 100% Nitrogen

TFC – Test Results



Sample	Spectrum	C	N	O	Na	S	Cl	K	Ca
Bare PE	1	89.8	0.9	6.3	1.4	0.1	0.3	0.6	0.2
Treated PE	2	83.8	2.2	13	0.1	-	-	-	-

Sample	Carbon as:				Nitrogen as:			Oxygen as:		Ionic Na	Sulfur as Sulfate	Cl as Chloride	Ionic K	Ca as Carbonate
	C-C,H	C-O	C=O	O-C=O	NO/ Nitride	Organic	Quarternary	=O	C-O					
Untreated PE	82.9	4.3	1.7	1	0.1	0.7	0.1	0	2.3	1.4	0.1	0.3	0.6	0.2
Treated PE	70.4	7.9	3.1	2.3		1.7	0.5	0.3	7.7	0.1	-	-	-	-

Analysis of Polyethylene Samples as Obtained by XPS. Data Normalized Atomic % of Elements Above Atomic Number 2 within 40Å of the Surface

- Change in Surface Chemistry indicates elimination of Oleamide

TFC Test Results 2

Sample	Dynes/cm	Contact Angle - Cross (Transverse) Direction				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Untreated PE	32	97°	97°	97°	98°	98°
Treated PE	44	50°	50°	49°	50°	49°

- Homogenous change across full web width
- 50% reduction in Contact Angle 90 to 50

TFC – Summary



- Teknek Cleaning with unique sealed DDBD provides
 - Removal of all contamination
 - Surface activation
 - Ability to add reactants to change Surface chemistry and polarity
- Operates at normal line speeds and web widths
- Single process takes standard film and converts it into higher value consistent quality film suitable for demanding applications.
- Incorporation of Next Generation Clean Static Elimination prevents re-contamination.