Basic Urea-Formaldehyde Resin Chemistry

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Building & Industrial Mat Spring Meeting

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Outline

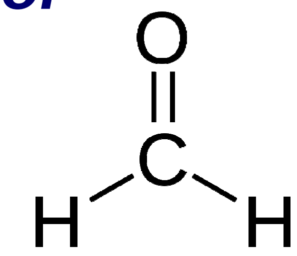
- ***UF Resin Definition, Raw Materials, Reactions***
- ***Typical Resin Requirements and Applications***
- ***Process Matrix in Nonwovens***
- ***Resin Modifications, Cure Speed, Flexibility, Binder Allocation***
- ***UF Resin Aging, Stability and Emissions***

UF Resin Definition

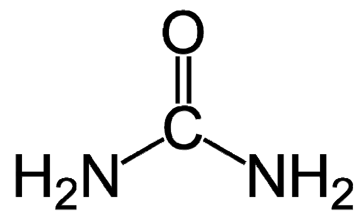
- ***Urea-Formaldehyde Resin (UF)* is a class of synthetic resin obtained by chemical combination of urea and formaldehyde**
- ***UF is a type of thermosetting adhesives:***
  - » ***Polymerizes to a permanently solid and infusible state upon the application of heat***
  - » ***Acid curing***
  - » ***Good water tolerance***
  - » ***High cross-linking ability***
  - » ***High degree of versatility***
  - » ***Inexpensive***
  - » ***Used in a wide variety of applications***

UF – Major Raw Materials

- **Formaldehyde ⇨ Gas ⇨ 37- 56% solution**
  - *Natural gas (methane – CH_4) ⇨ Methanol (CH_3OH)*
  - *Methanol ⇨ Formaldehyde (CH_2O)*



- **Urea – white crystalline powder, prills**
  - *Natural gas ⇨ Ammonia (NH_3)*
  - *Ammonia (NH_3) + Carbon Dioxide (CO_2) ⇨ Urea (CH_4N_2O)*



UF – Reaction Stages

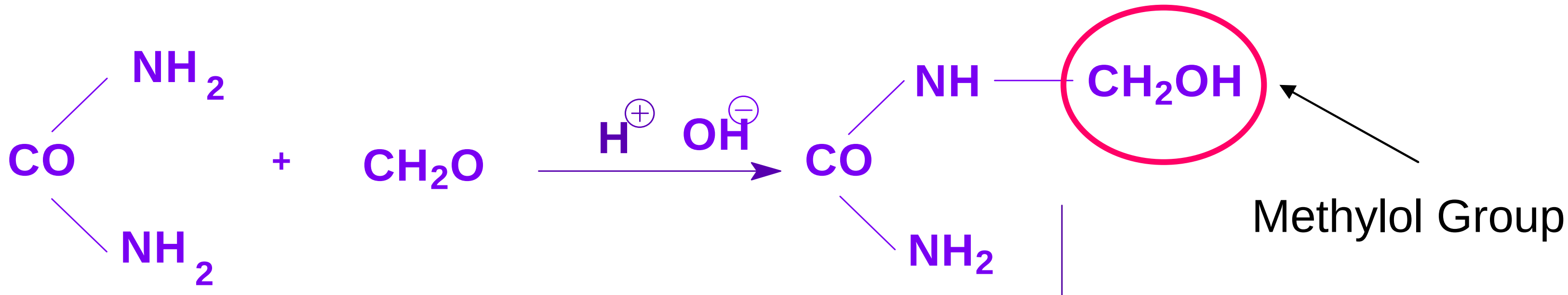
Two Major Stages in Urea - Formaldehyde Reaction:

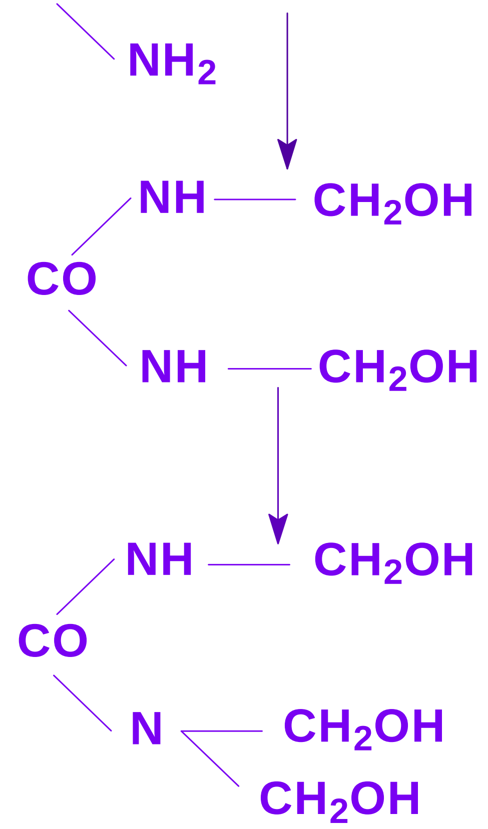
1. Methylolation (Electrophilic Substitution)

- *Initial reaction from mixing urea with formaldehyde*
- *First step in the resin manufacturing process*
- *Exothermic part of the resin manufacturing process*
- *Not much MW or viscosity build*

2. Condensation

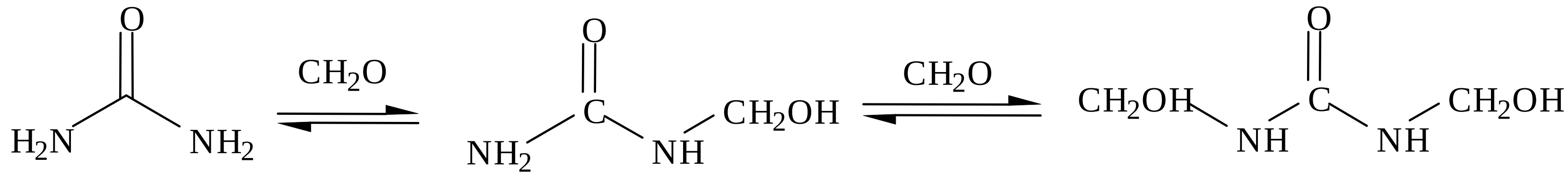
- *Secondary reaction from mixing urea with formaldehyde*
- *MW and viscosity build during this stage*
- *Water is lost with the formation of ether or methylene linkages*
- *Ether linkages are more water soluble, methylene linkages are not*
- *The higher MW, the lower resin water dilutability*





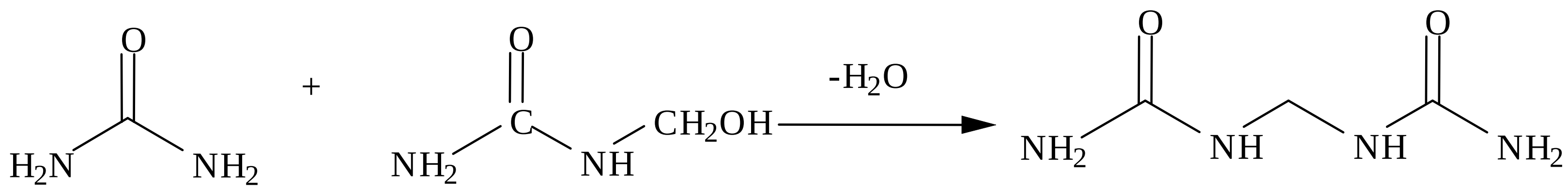
Formation of mono-, di- and trimethylolureas

Condensation

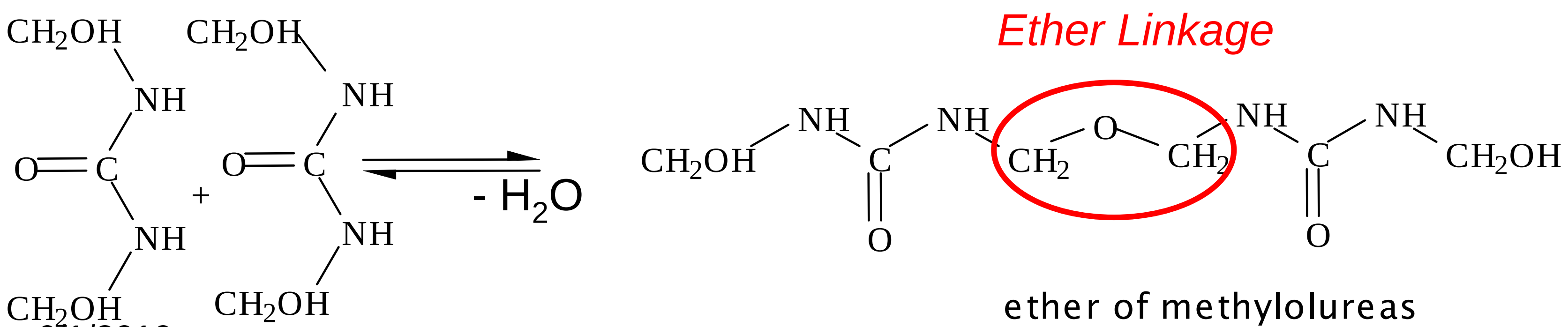


urea mmu dmu

Condensation of methylolureas

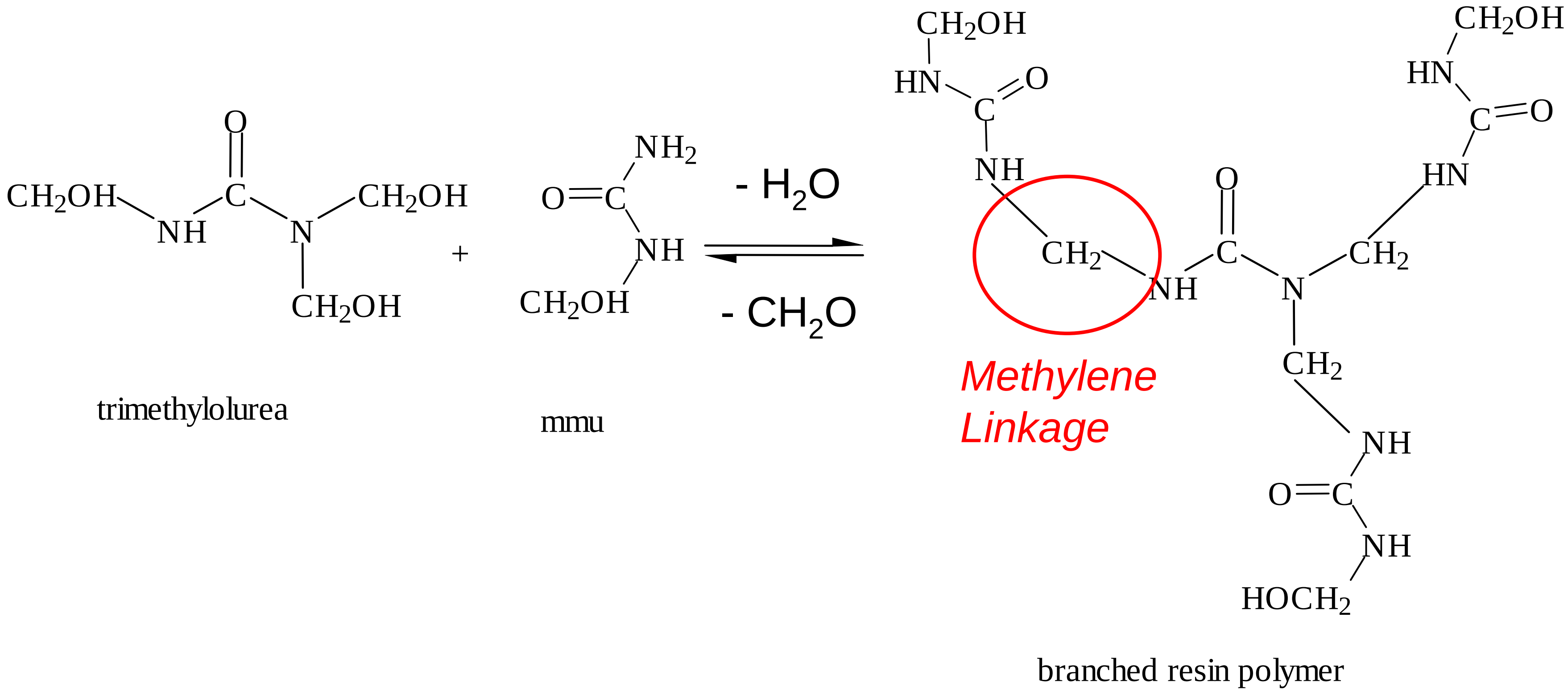


mdu

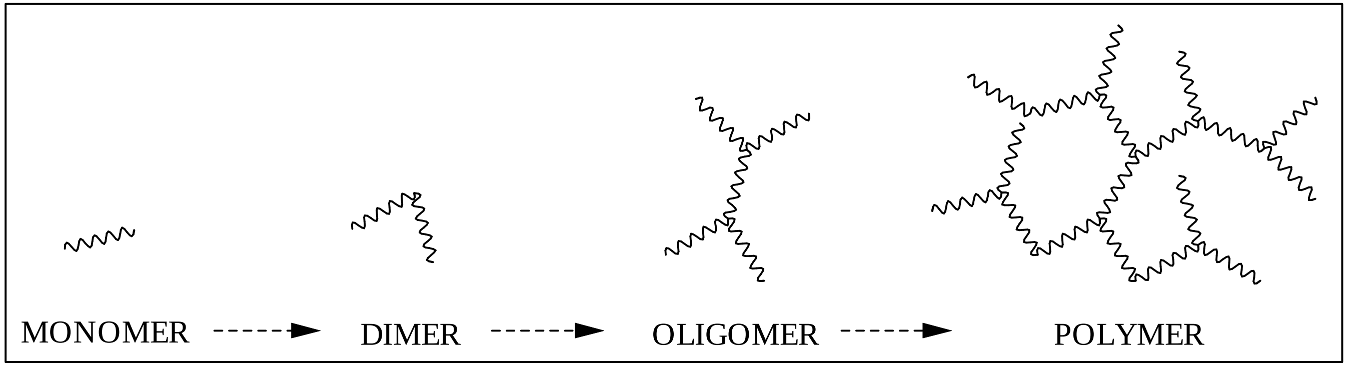


ether of methylolureas

Condensation

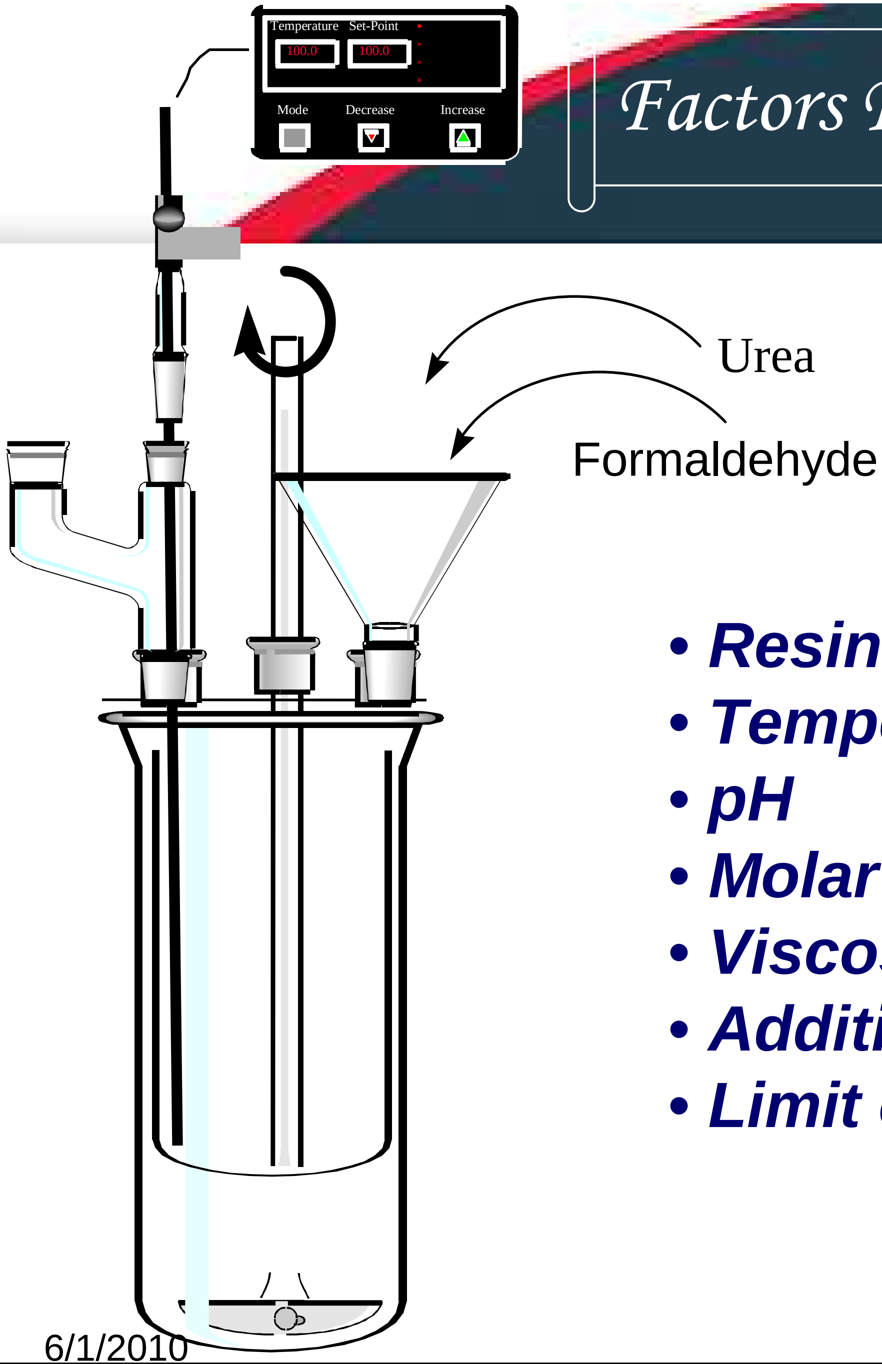


Condensation



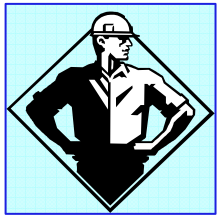
Monomer	Dimer	Oligomer	Polymer
A compound that can undergo polymerization	*A chemical compound formed by the union of two molecules of a monomer*	*A polymer intermediate containing relatively few structural units.*	*A chemical compound Formed by polymerization And consisting essentially Of repeating Structural units.*

Factors Effecting Resin Characteristics



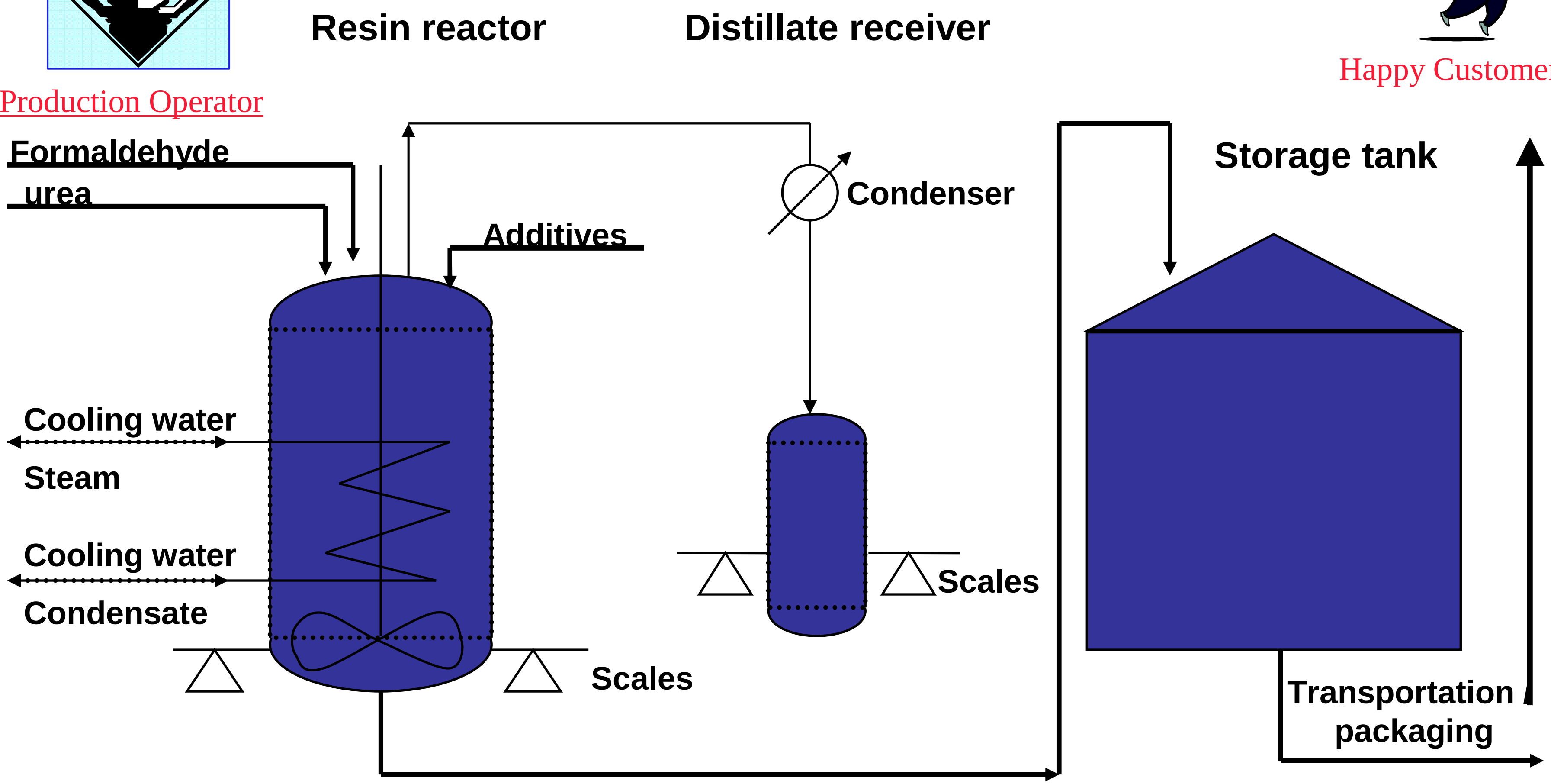
- ***Resin Technology / Composition***
- ***Temperature***
- ***pH***
- ***Molar Ratio***
- ***Viscosity (Advancement and Solids)***
- ***Additives***
- ***Limit on Free Formaldehyde***

UF Production



The Production Operator

Happy Customer



UF Applications

- ***UF resins are designed for the underlying application, and usually for a specific customer***
- ***Majority of UF is used in wood applications - composites, particleboards, etc.***
- ***Big volume is also used in glass mat / nonwovens production. Resin could be used:***
  - ***Alone***
  - ***As a major component of a binder system***
  - ***As a minor component/cross linker in the binder with thermoplastic resins for specialty applications***

Binder Definition

- ***Chemical binders* are essential raw materials for non-wovens added to the web already formed or to the batt of fibers in forming stage.**

- ***Functions of a binder*:**
  - ***Primary – to hold fibers in pre-determined form***
  - ***Secondary – to improve web properties***

Process Matrix - Nonwovens

Type of white water system – HEC, PAA, AO and additional additives

Glass fiber produced in various grades, diameters, lengths w/wt sizing

UF Resin

Latex – SBR, SBA,

Acrylics, VA, etc.

Chemical Binder

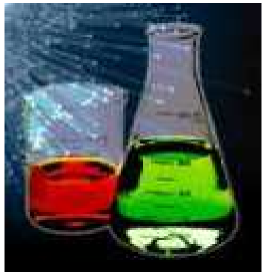
Process

Factors Impacting the Product Strength

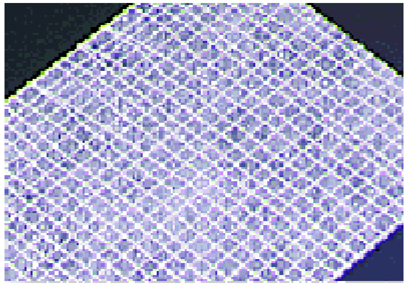
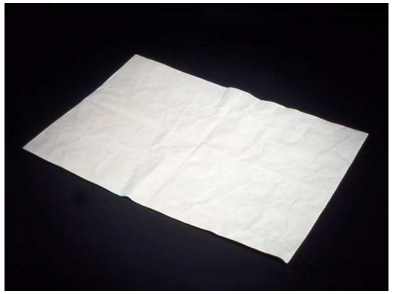
- ***Substrate***



- ***Binder***



- ***Interactions between substrate and binder***

Typical Resin Requirements

- ***Stability and adequate shelf life***
- ***A wide operating window***
- ***Tack characteristic associated with the plant and process conditions***
- ***Cure speed appropriate for the process***
- ***Targeted physical properties – tensile, tear (flexibility / rigidity)***
- ***High water dilutability***
- ***Emissions – level and type***
- ***Compatibility with process water***
- ***Compatibility with additives – latex, defoamer, etc.***
- ***Low cost***

Resin / Binder Selection

The binder is selected for defined application based on different aspects:

- ***Cure speed***
- ***Physical attractive forces between polymer chains (e.g. reaction and/or compatibility with process additives)***
- ***Chemical crosslinking***
- ***Film formation***
- ***Wetting ability***
- ***Binder allocation***

Factors Affecting Cure Speed

1. **Molar Ratio**
   - MR range in UF is 0.6 – 2.0
   - The higher MR, the faster cure
   - The higher MR, the higher emissions
2. **pH**
   - Resin buffer capacity
   - Catalyst system
   - Additives in the system – e.g. latexes
3. **Molecular size**
   - In general, larger molecules, faster cure
   - Size of molecules has impact on viscosity
4. **Additives**

Factors Affecting Appearance, Durability

The main factors:

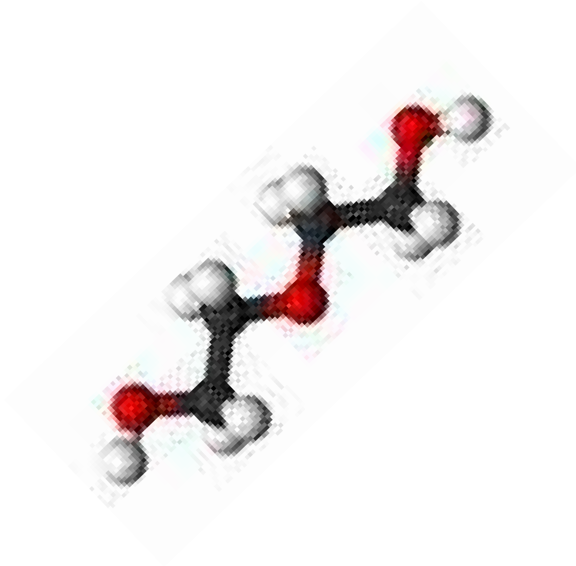
1. ***Formation of ether and methylene linkages (MR, pH, T)***
   - ***ether linkages – clear resin***

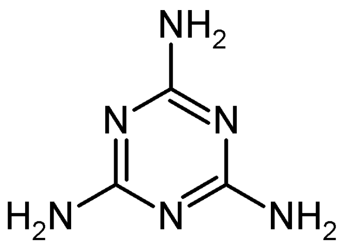
     $-CH_2-O-CH_2-$
   - ***methylene linkages – opaque***

     $-CH_2-$
2. ***Used additives***
3. ***Cooking time***

Major factors affecting resin flexibility / rigidity

- ***MR***
- ***Cross-linkers***
- ***pH***
- ***Additives***





$-(CH_2-CH=CH-CH_2-CH-CH_2-)n-$

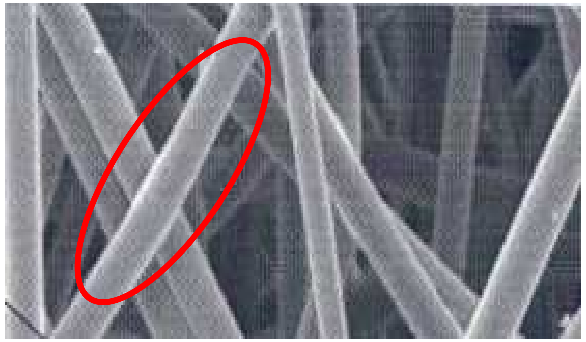
Compatibility with Latex

UF chemist can make resin more compatible with latex by adjusting:

- ***Resin's Molecular Weight***
- ***MR***
- ***Selecting components and additives***
- ***Designing the right buffer capacity of the resin to match or enhance the latex properties***

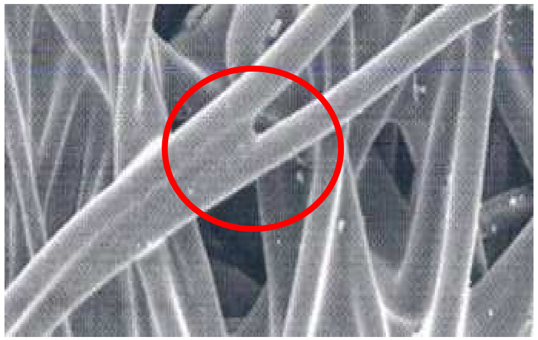
Optimum Binder Allocation

- ***An even binder coverage over the whole fiber***

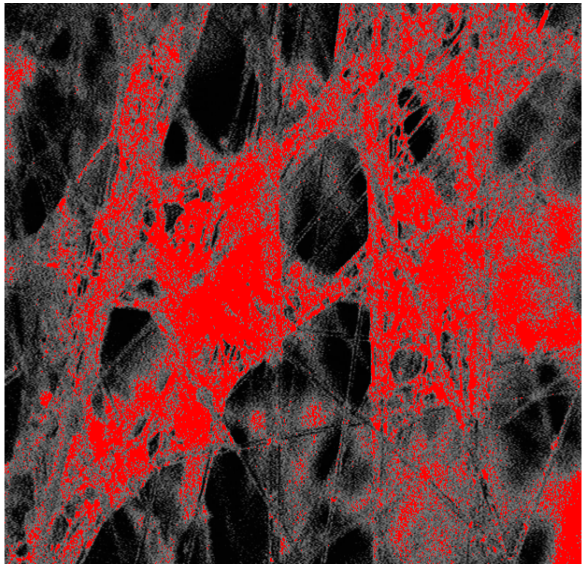


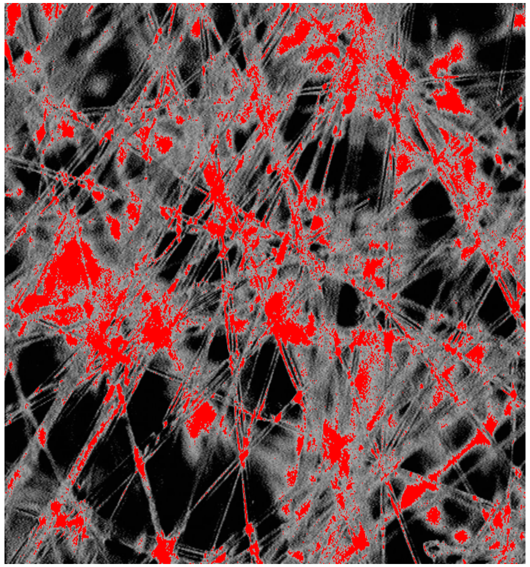
OR

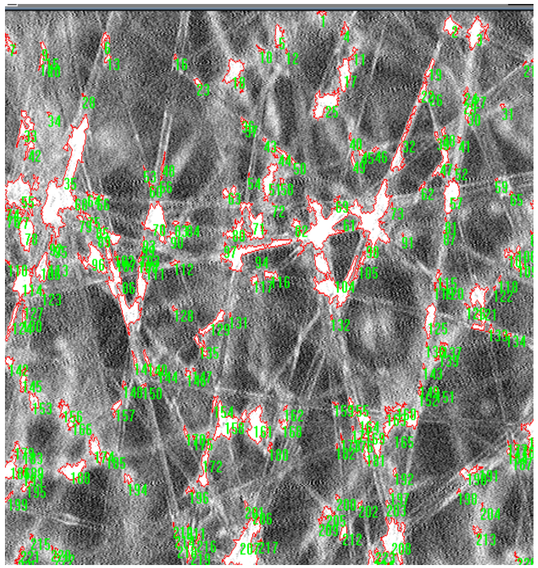
- ***The binder concentrated at the fiber cross-points***



Wetting Ability







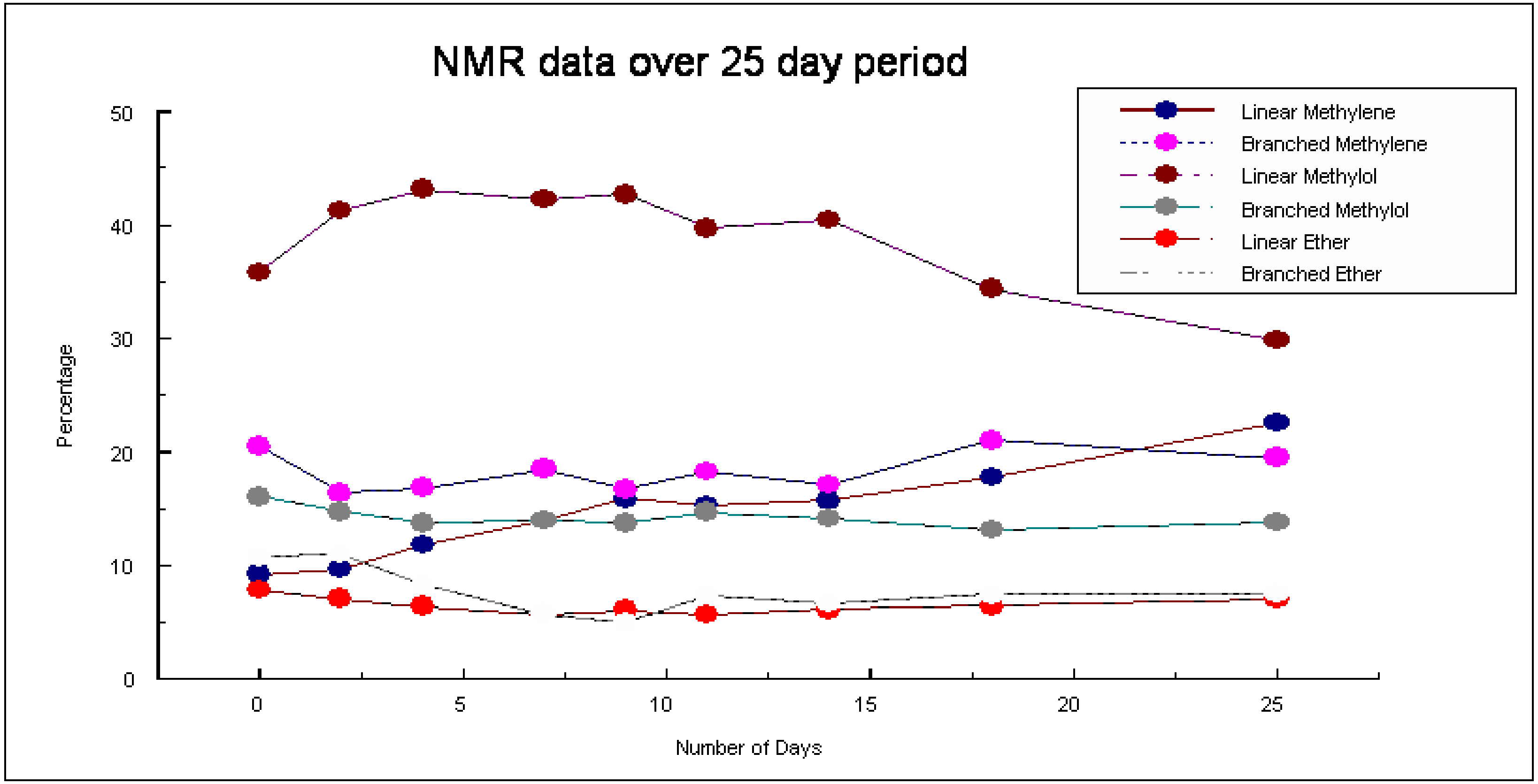
Different resins composition, different wetting properties

Effects of UF Resin Aging

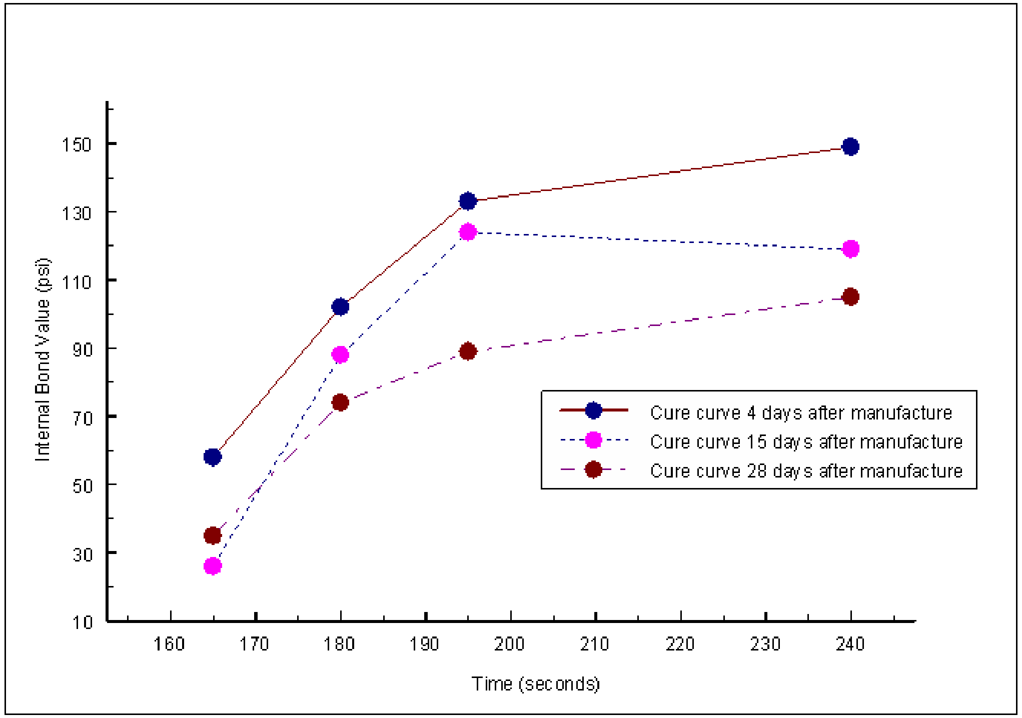
- *Aging mechanism of U-F resins depend on the*
  - *Final Formaldehyde/Urea molar ratio,*
  - *Storage pH*
  - *Free urea in the resin*

- *Aging of U-F resins involve*
  - *Changes in resin structure*
    - *Initial increase in linear methylol groups*
    - *Subsequent decrease in linear methylol groups*
    - *Corresponding increase in linear methylene groups*
    - *Minor changes in branched methylol and methylene groups*
    - *Decrease in free urea*
  - *Increase in bulk viscosity*
  - *Decrease in absolute molecular weight*
  - *Decrease in cure speed*
  - *Decrease in ultimate bond strength*

Functional Group Changes upon aging

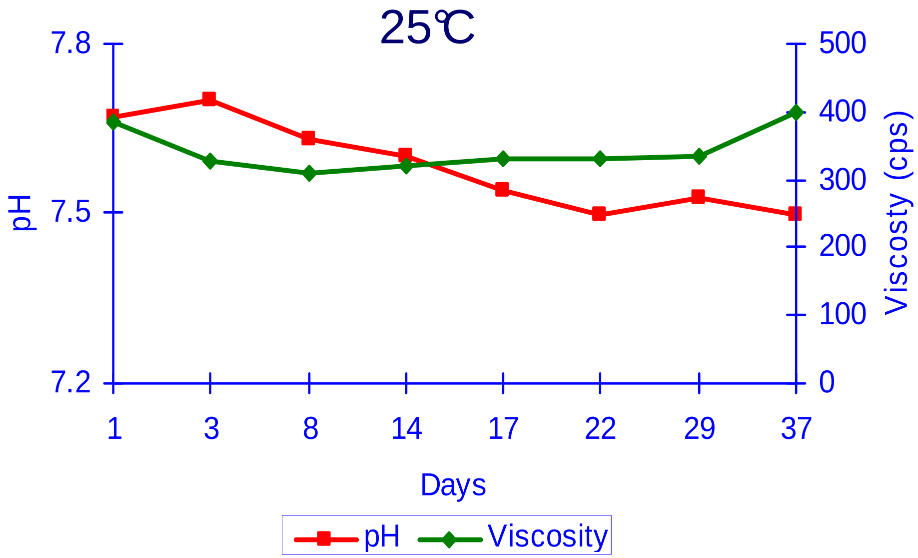


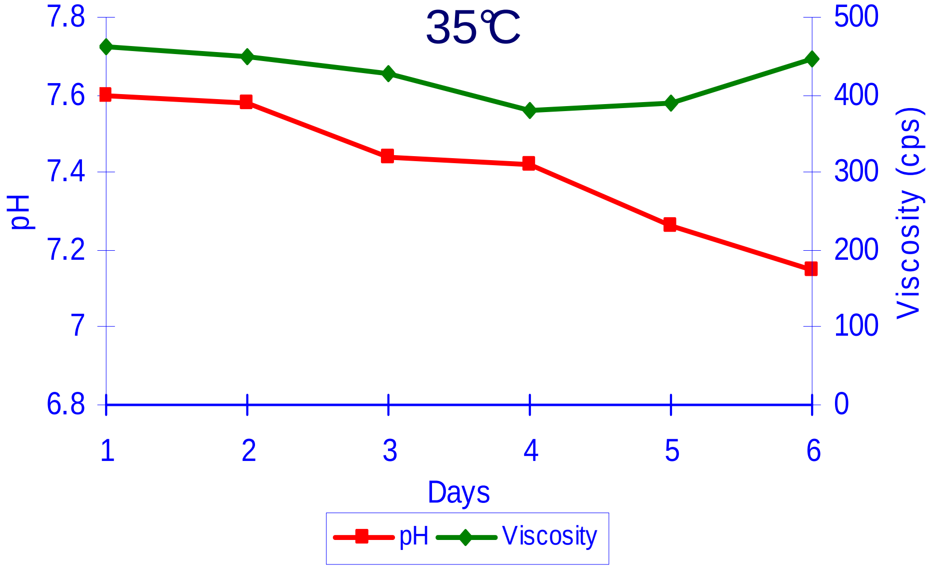
Aging vs. Cure Speed

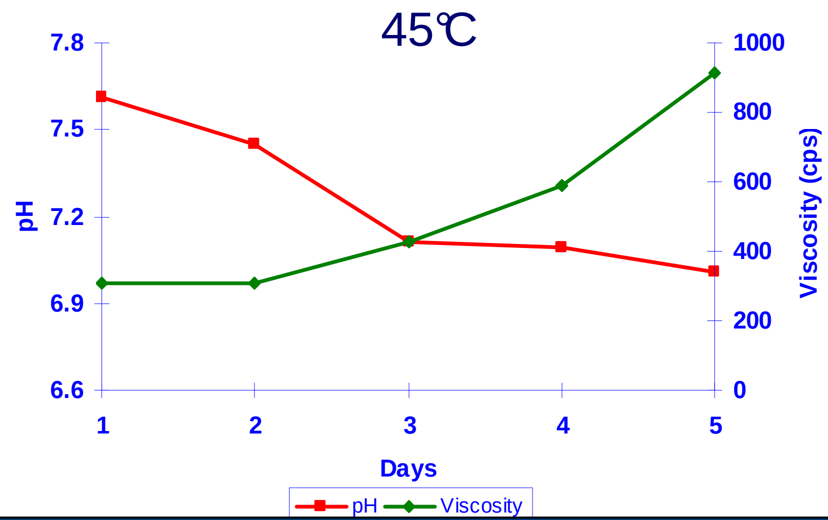


- ***Although bulk viscosity is an important parameter used to monitor process ability of the resin, it does not provide a measure of resin performance upon aging***
- ***The increase in bulk viscosity as resins age probably results from associative forces such as hydrogen bonding.***
- ***Decrease in cure speed is related to decrease in molecular weight and methylol content rather than an increase in methylene content .***

Resin Stability







Emissions and Curing By-Products

- ***Water***
- ***Formaldehyde***
- ***Methanol***
- ***Low molecular weight compounds***

UF Decomposition Products

Ammonia modified UF resin at >400℃:

- ***Decomposition products of UF part: CH_2O, HCl, HCN, CO_x, SO_x, NO_x, Na_xO_x, sodium carbonate & other organic compounds***

- ***Ammonia-flammable, will flash off***

- ***Low flashpoint amines - will flash off with heat with the presence of characteristic ammonia odor, decomposition products include CO_x, NO_x***

Acknowledgements

I would like to thank Teong Tan,
Mark Anderson and Reggie Mbachu
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Building & Construction

A business group of Dow Advanced Materials Division

Understanding Latex Binders

JEAN M. BRADY

MAY 21, 2010

Agenda

- What is a Latex Binder?
- Designing a Latex Binder
- Nonwoven Performance

Latex in Glass Mat Products -

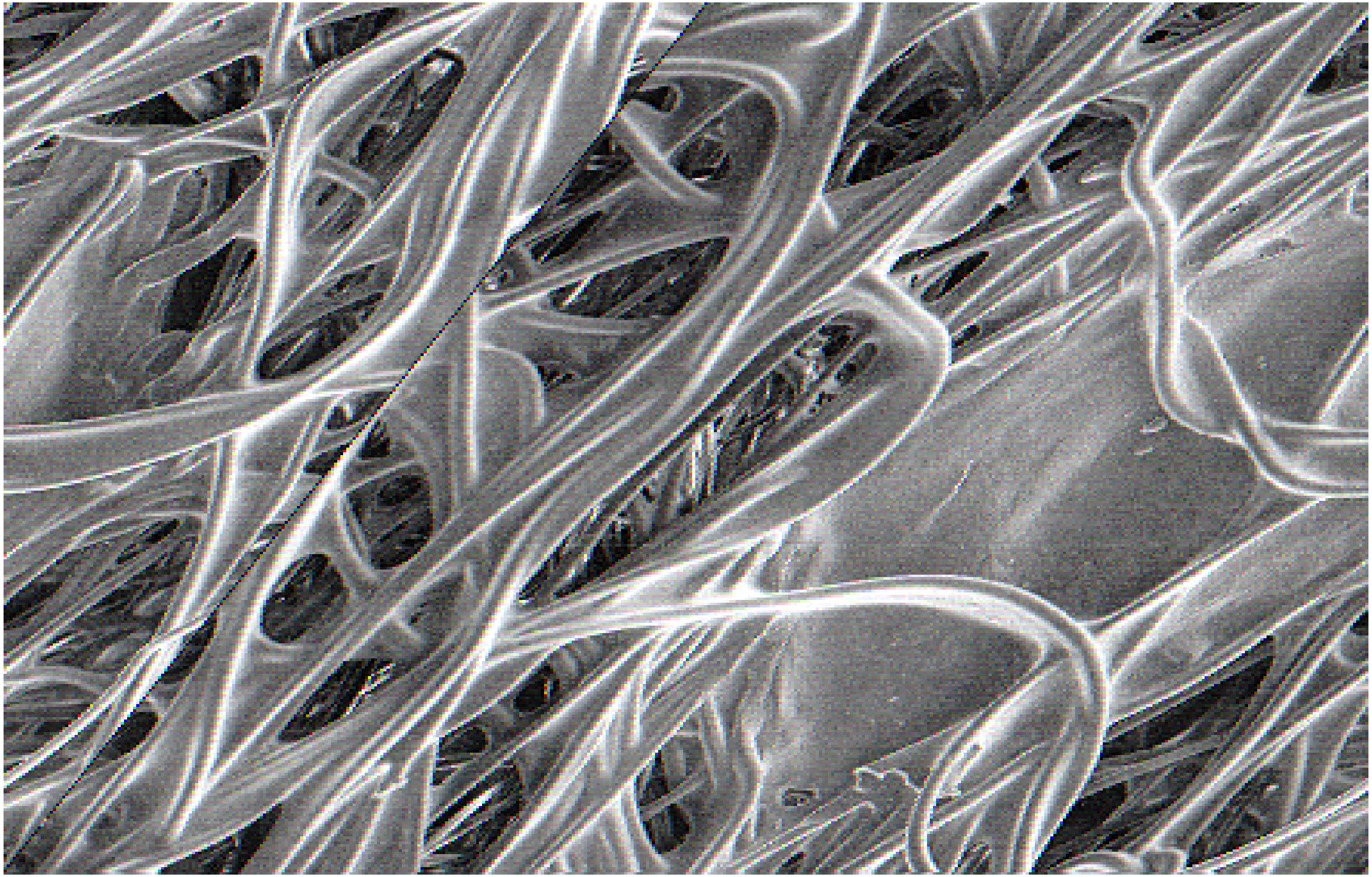
3 distinct functions

1. **Additives to UF (Roofing mat, up to 12wt%)**

2. **Sole Binders (Specialty mat)**

3. **Coatings**

Latex as Glass Mat Binder (x500)



Latex Binders

- **Water Borne**

- **Versatile**

  e.g. UF Modifier *or* Sole Binder *or* Coating

- **Tailor properties: Flexibility**

  Hydrophobicity

  UV, Solvent resistance

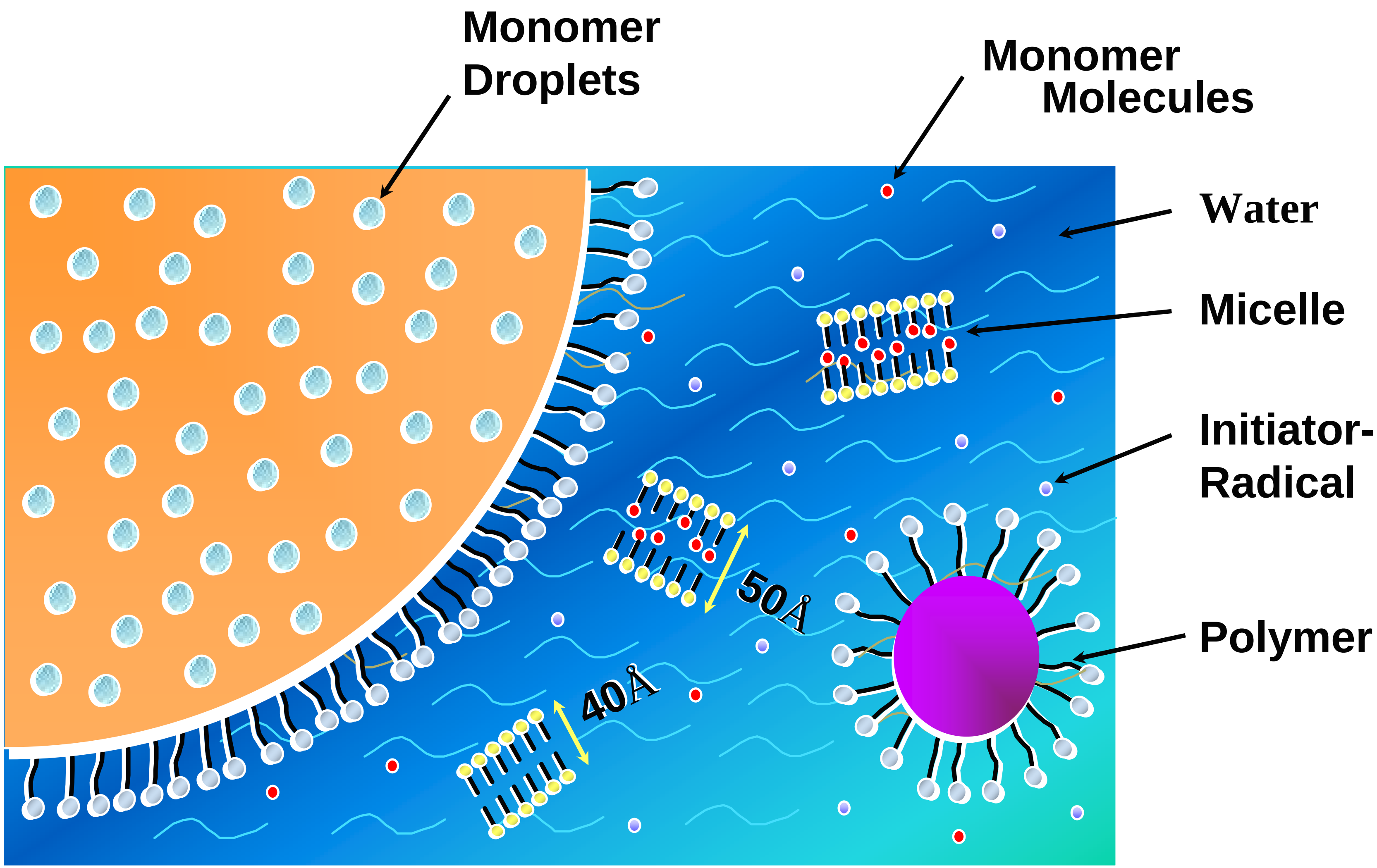
Latex made by *Emulsion* Polymerization:

- **Polymerization occurs in each particle** ***monomer migrates through H2O to particle*** **(100-1000 nm diameter)**

- **Polymers (& most monomers) are *NOT* water soluble.**

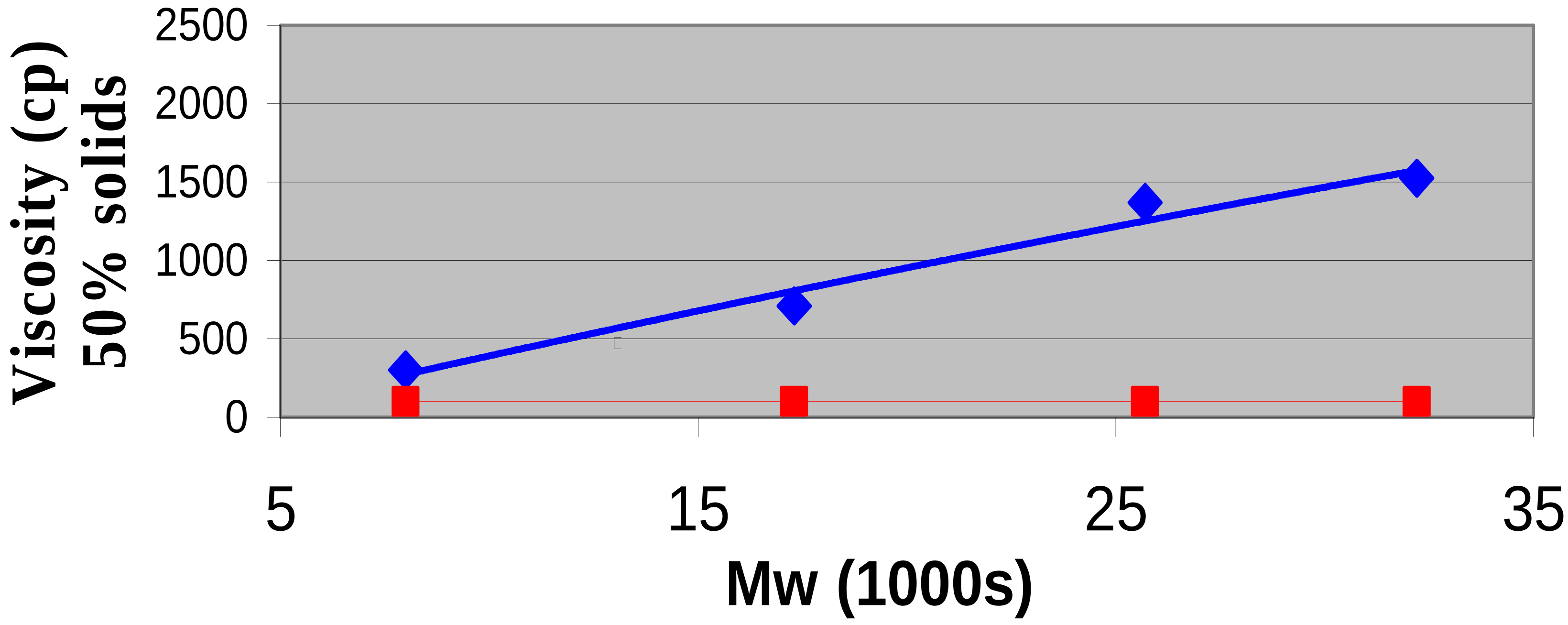
- **Polymer particles are stabilized by surfactants & colloids**

Emulsion Polymerization Schematic



Viscosity vs. Molecular Weight

Water soluble Polymer vs. Latex



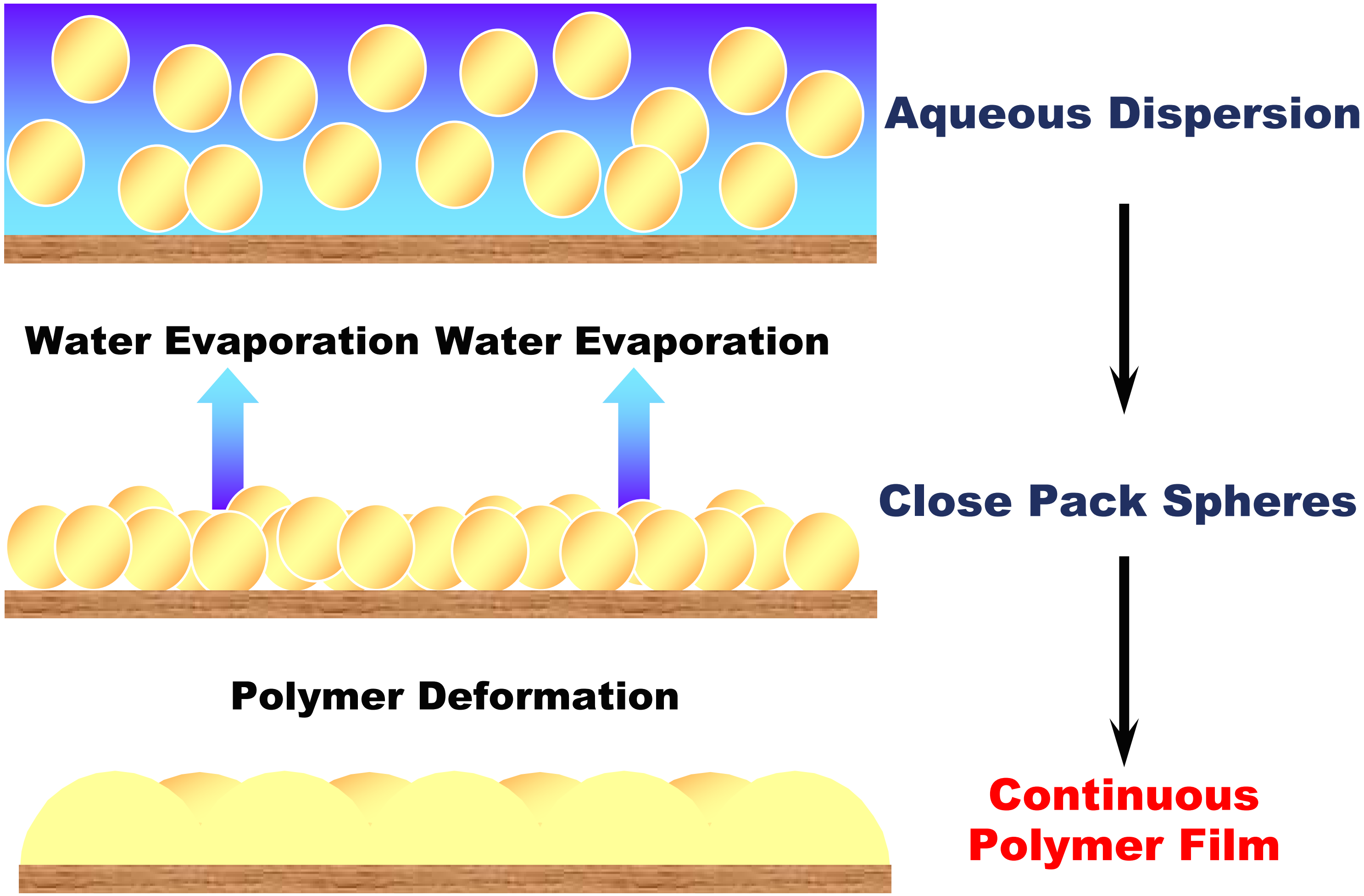
The Life of a Latex Particle…

- **Formation & Growth of Polymer Particle**
  variable composition, Mw, particle size

- **Particles (wet) deposited** onto substrate
  curtain coater, spray, roll coat

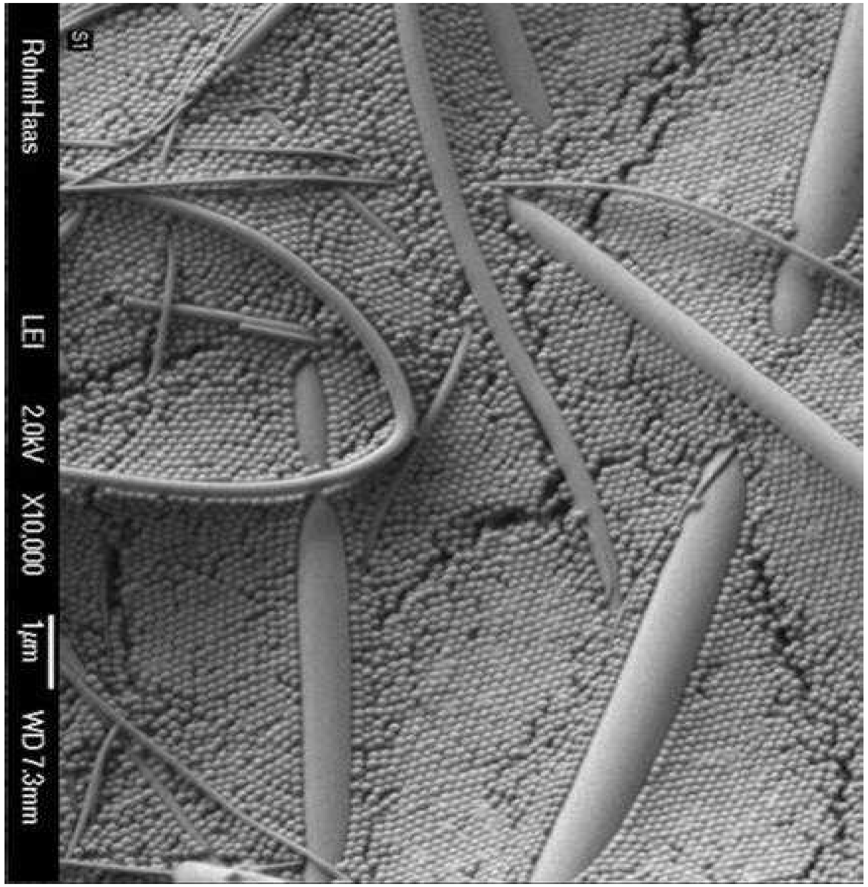
- **Film Formation Process:**
  Individual particles → Coalesced polymer film
  Coalescents?
  Heat? Time?

Film Formation



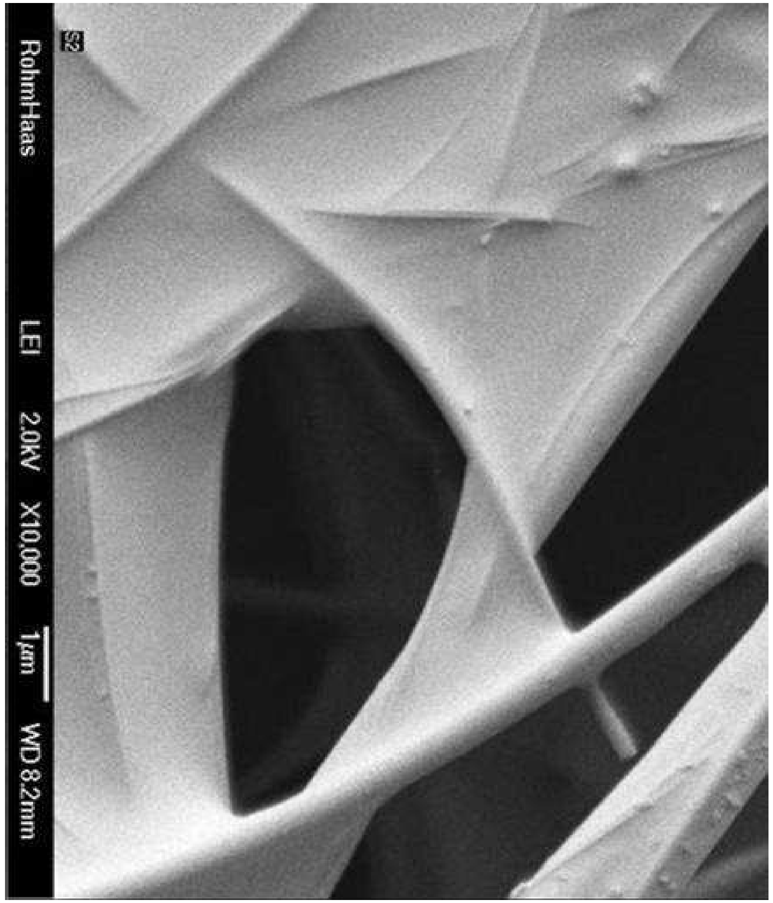
Dried Latex v. Water Soluble Polymer

Latex



St/acrylic latex + polyol, Tg=130C

Aquaset 600



Polyacid + polyol

Nonwoven Performance:

- Tensile Strength (rigidity)
- Tear Strength
- "Elasticity" (extensability)
- Hand or "feel"
- Hydrophobicity

Latex Product Development

Monomer Selection

Process Parameters

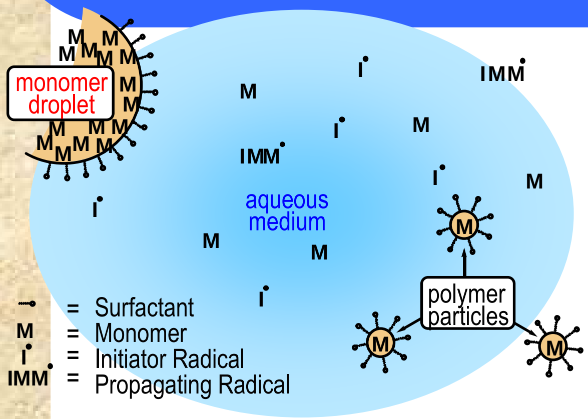
Tg
- Film Rheology
- Hand
- Film Strength
- Heat Resistance

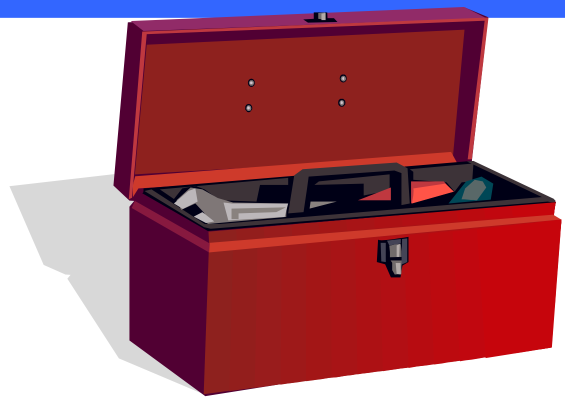
Functionality
- Adhesion
- Mechanical Stability
- Water Resistance
- Post crosslinking
- Solvent Resist.
- Hydrophobicity
- UV Resistance

Molecular Weight Crosslink Density
- Film Strength
- Cohesive Strength
- Heat Resistance
- Tack

Physical
- %Solids
- pH
- Viscosity
- Surface Tension

Particle Size Distribution
- Mechanical Stability
- Viscosity response
- Cohesive Strength
- Flow and leveling
- Coalescence



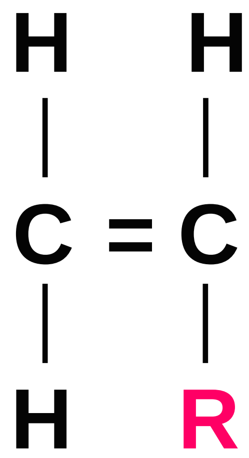


Composition Guidelines

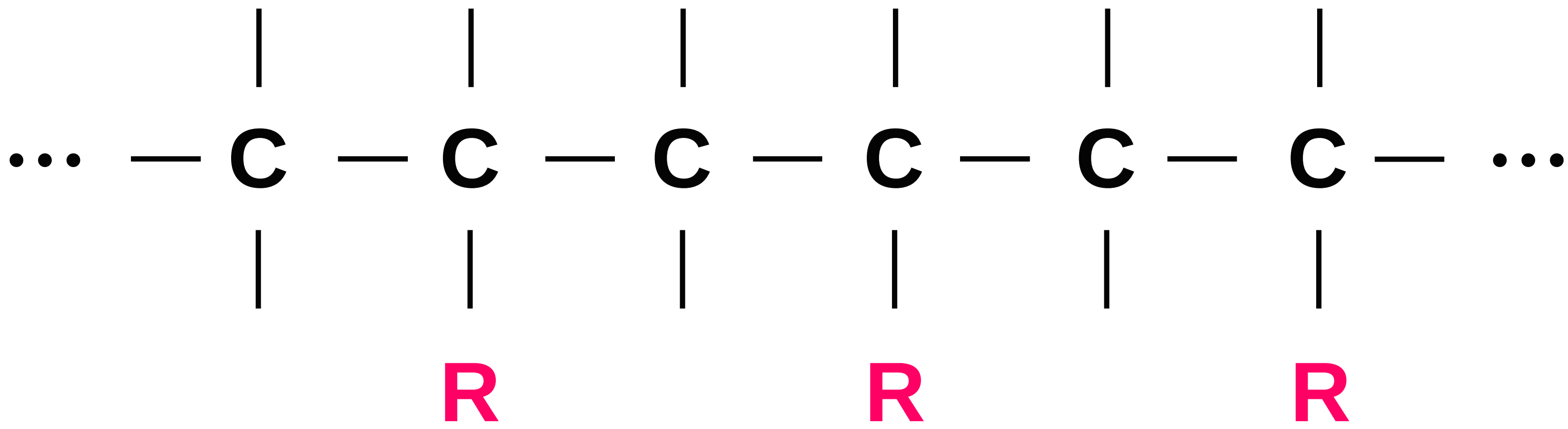
- **Acrylics** (BA, EA, EHA, MMA) for UV resistance.
  - MMA exceptional.
  - EHA for water resistance.
- **Styrene** (St) for Water/alkalai Resistance (hydrophobic)
  - Degrades over extended exposure to UV.
- **Acrylonitrile** (AN) for Solvent Resistance (hydrophillic)
  - Discolors under UV (unsaturation).
- **Vinyl Acetate** (VA) Low Cost
  - Hydrolyzes
  - Degrades under UV

Backbone Composition

Vinyl Monomer

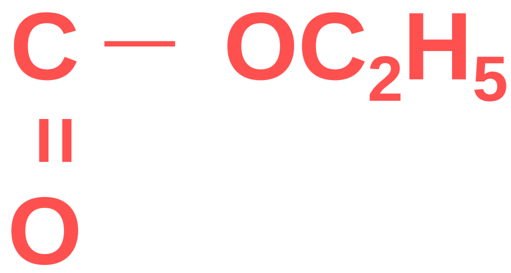


Vinyl Polymer

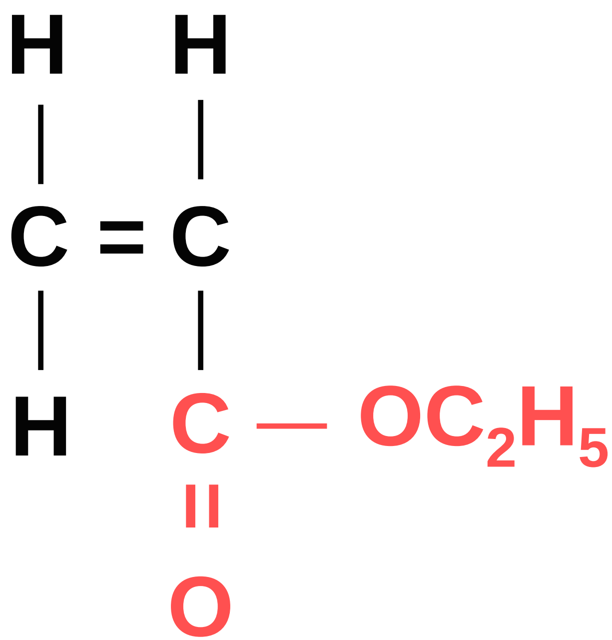


Acrylates

R:



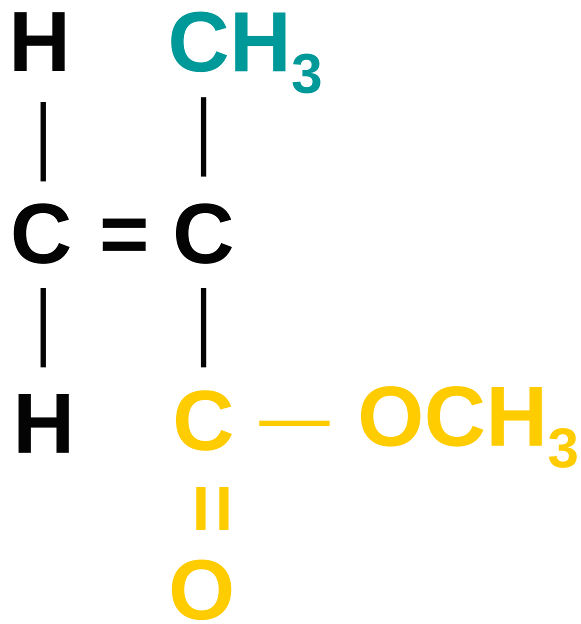
Ethyl Acrylate



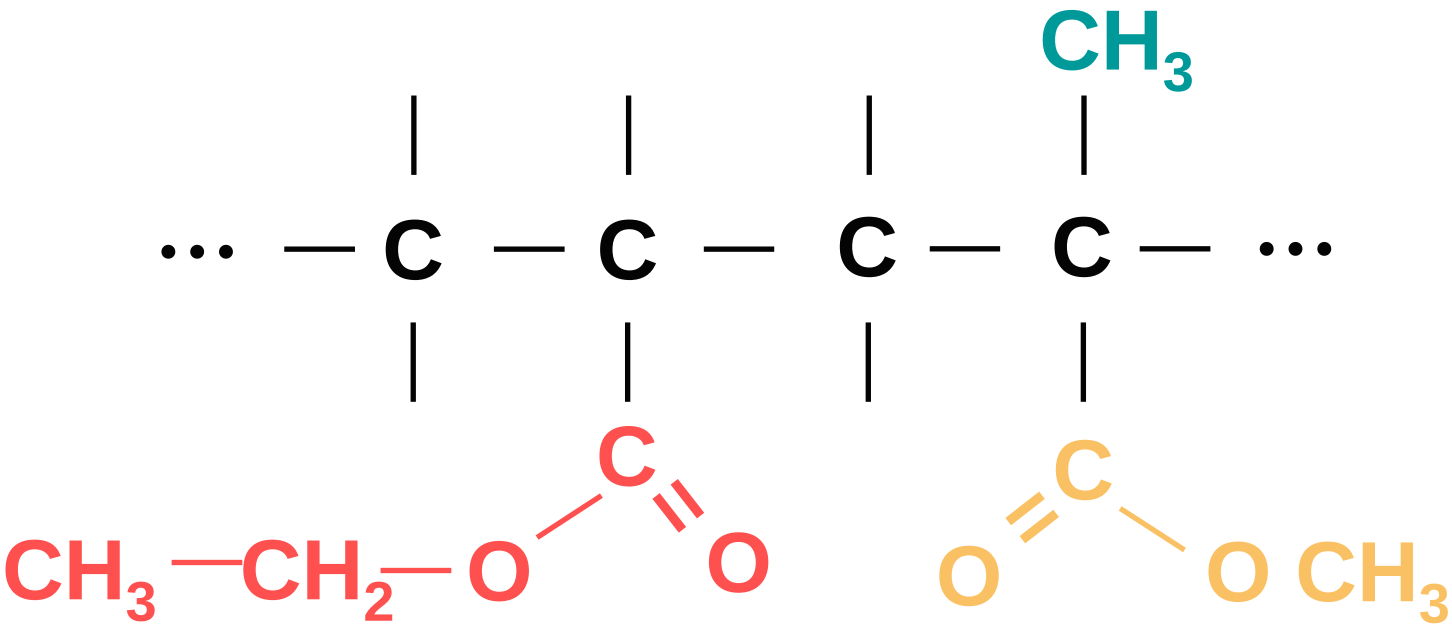
Methacrylates

H: CH_3 **R:**

Methyl Methacrylate



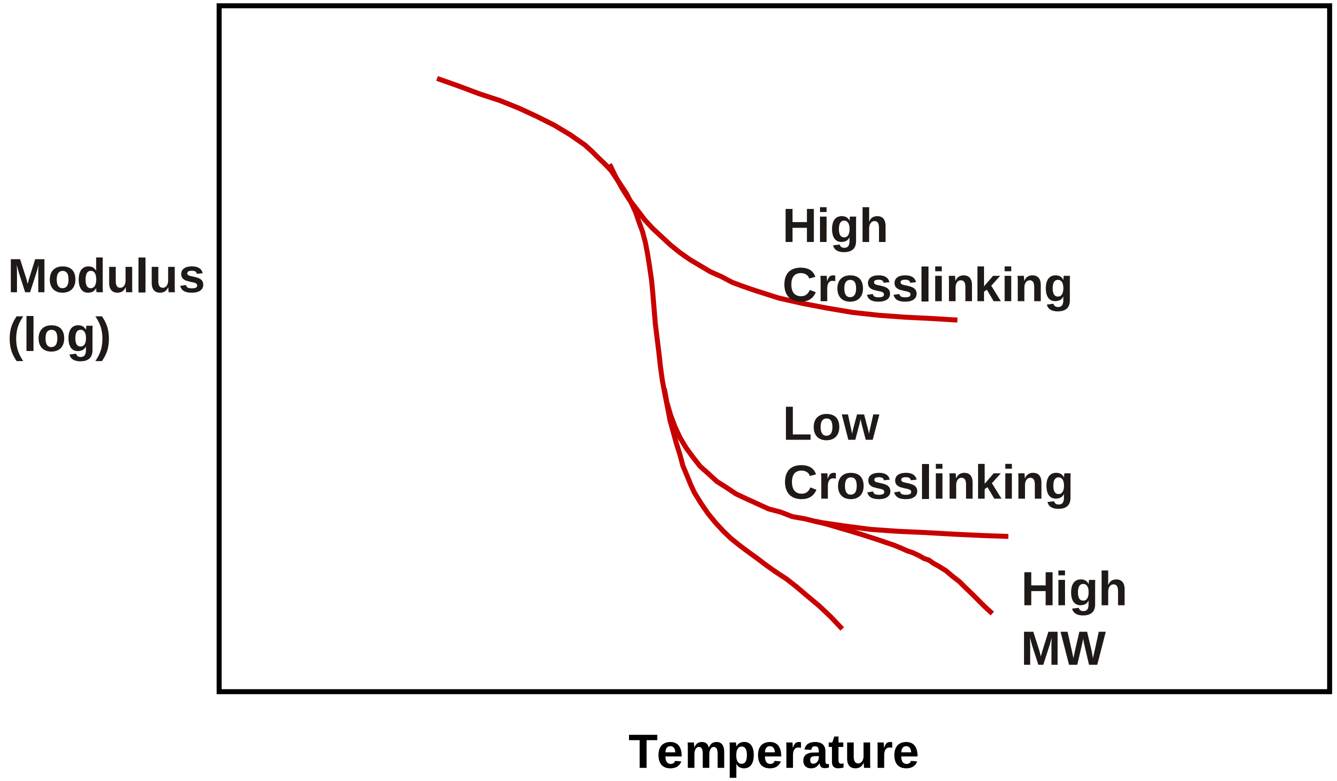
Acrylic Copolymer



Ethyl Acrylate/Methyl Methacrylate Copolymer

<u>Rigidity:</u> affected by Tg

Tg = f(monomer choice, crosslinking)



Thermoset:
Rigid, No creep

↑

Latex

↓

P.M. Lesko and P.R. Sperry, Emulsion Polymerization and Emulsion Polymers, P.A. Lovell and M.S. El-Aasser (Eds), John Wiley and Sons, p 641,1997.

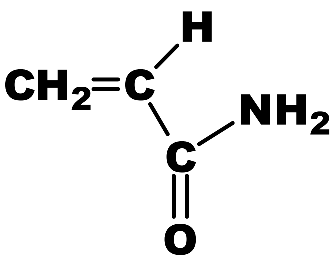
G'(rubbery plateau) ~ 1/Me ~ Crosslink density

Monomer Choice – Guidelines

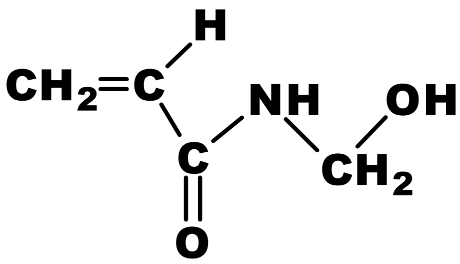
Hydrophobicity independent of Rigidity

Monomer		Tg (°C)
2-EHA	Most Hydrophobic	- 85
Styrene	↓	+ 105
Butyl Acrylate	↓	- 52
Methyl Methacrylate	↓	+ 105
Ethyl Acrylate	↓	- 21
Methyl Acrylate	↓	+ 8
Acrylonitrile	↓	+ 130
Vinyl Acetate		+ 29
Acrylic Acid	Most Hydrophilic	+ 103

Crosslinking Chemistry #1: Amides

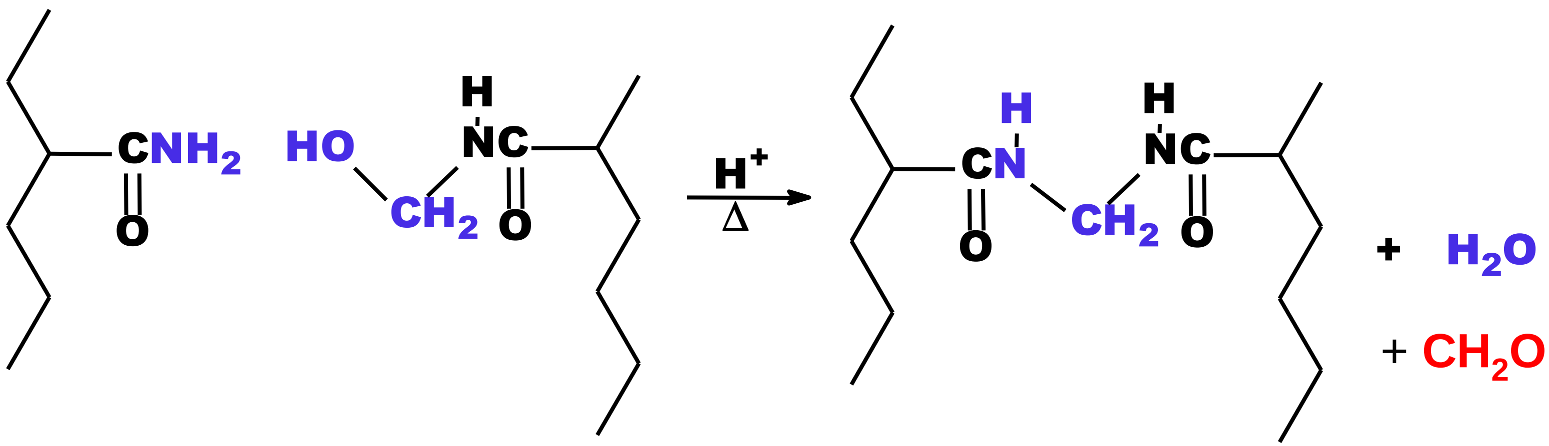


Acrylamide (AM)

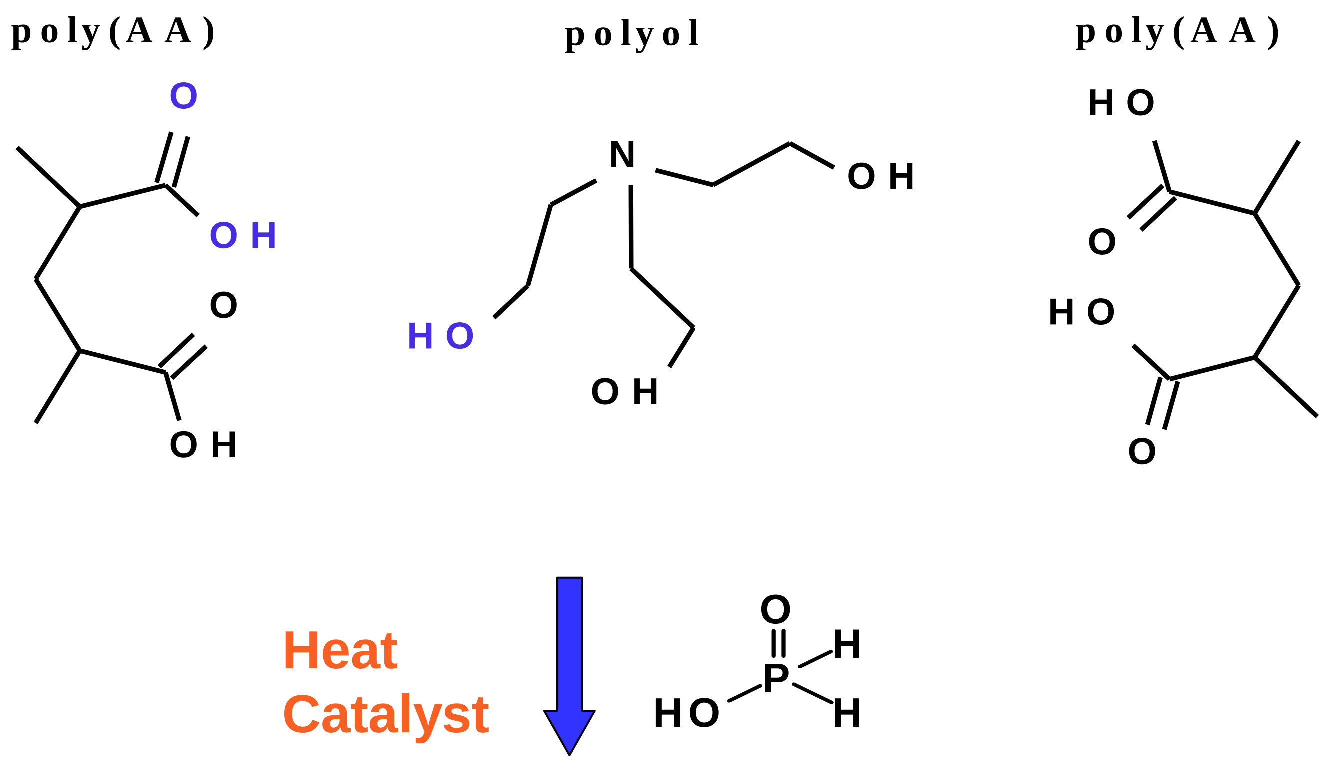


N-Methylol Acrylamide (NMA)

- Acid/Heat-catalyzed Crosslinking → methylene bridge



Crosslinking Chemistry #2: Acid/Polyol



Ester Crosslinks + H_2O

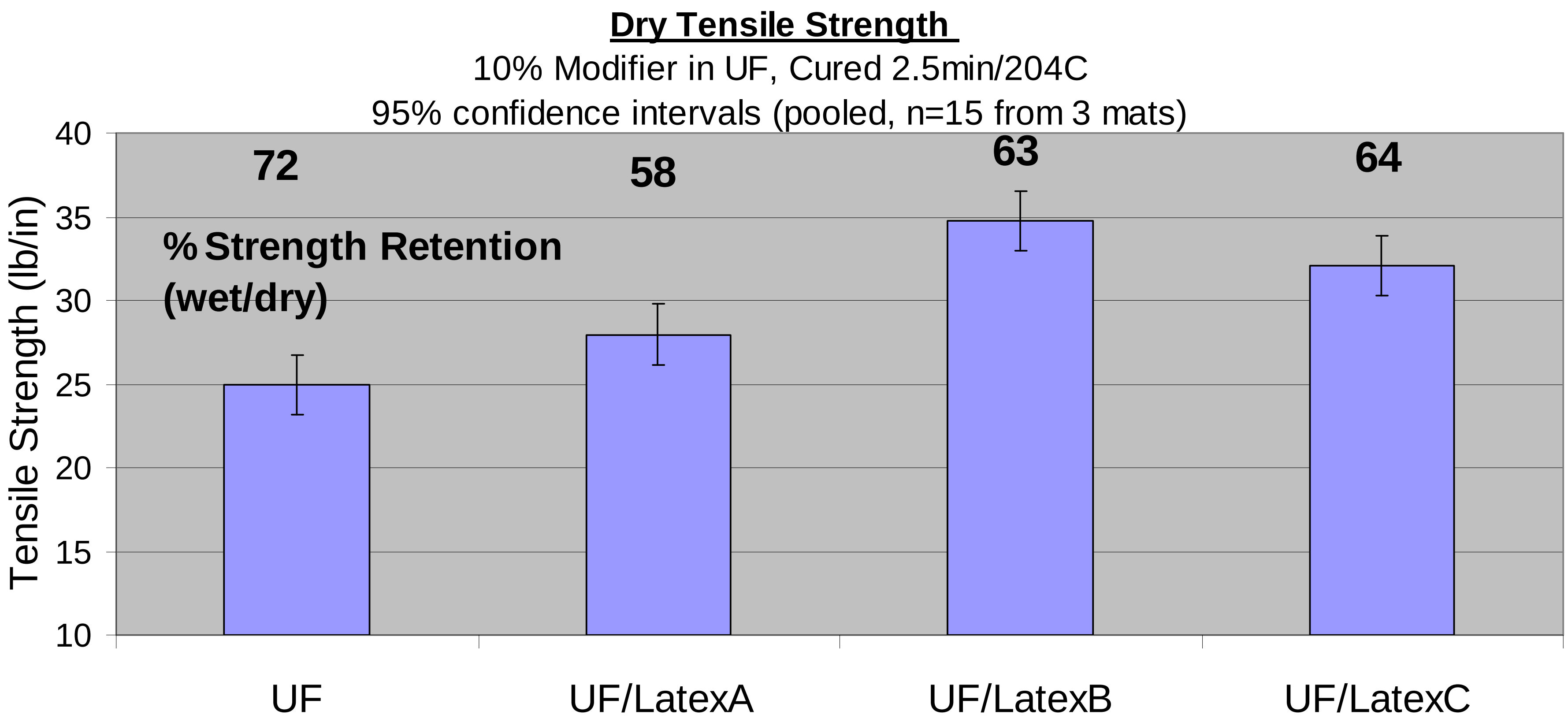
CH_2O-free

Aquaset LT™

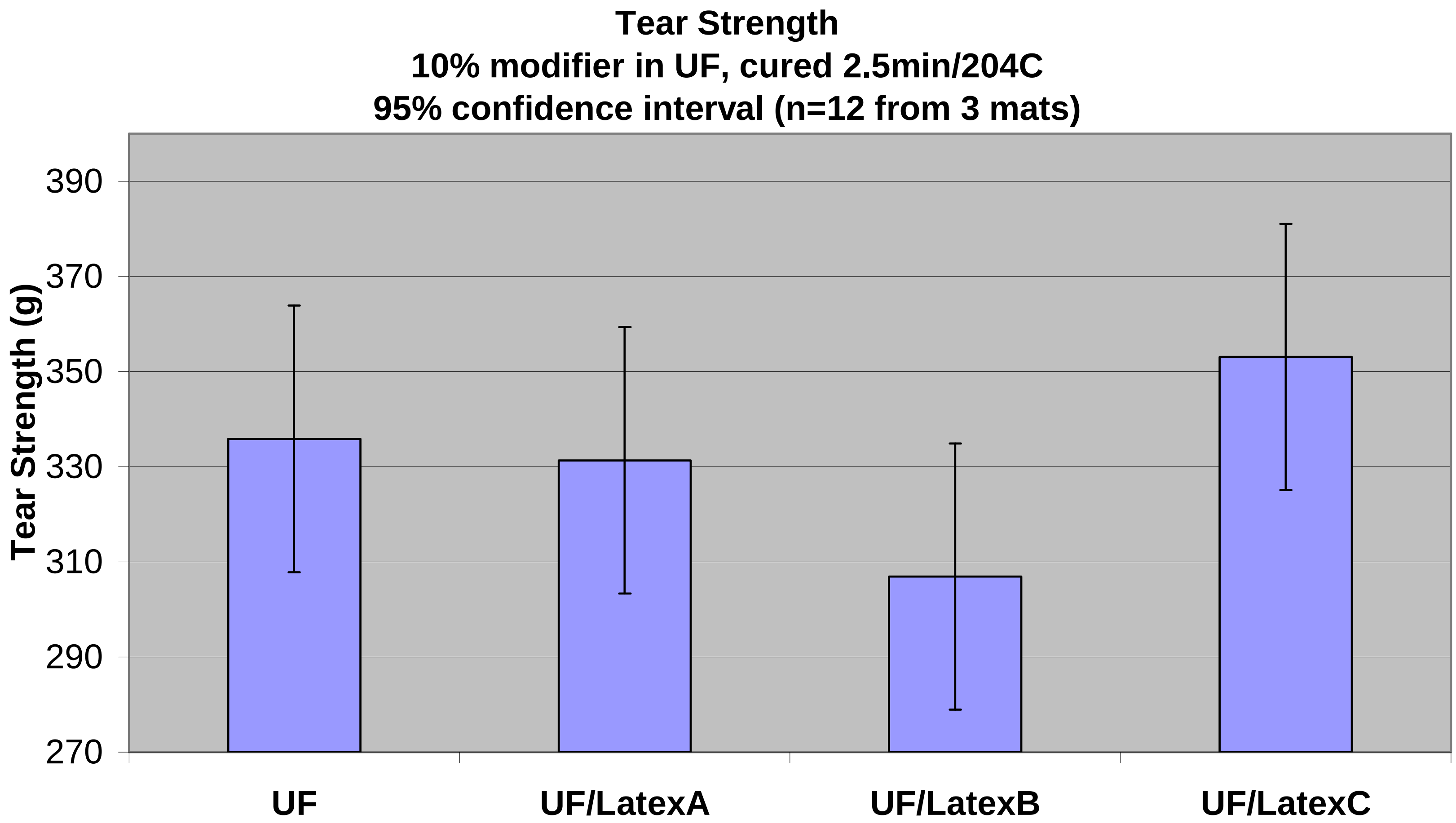
Nonwoven Performance:

- Tensile Strength (rigidity)
- Tear Strength
- "Elasticity" (extensability)
- Hand or "feel"
- Hydrophobicity

Tensile Strength: Latex-Modified UF

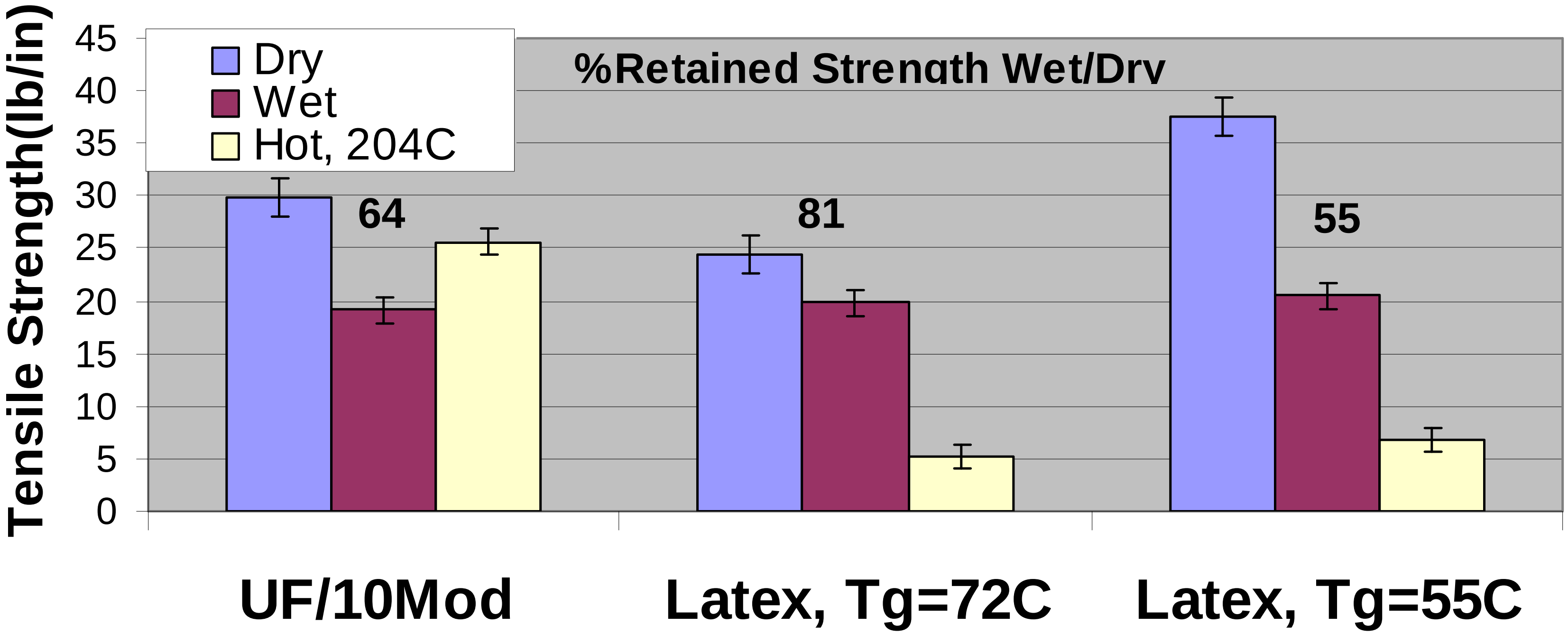


Tear Strength: Latex-Modified UF



Crosslinked Latex (sole binder):

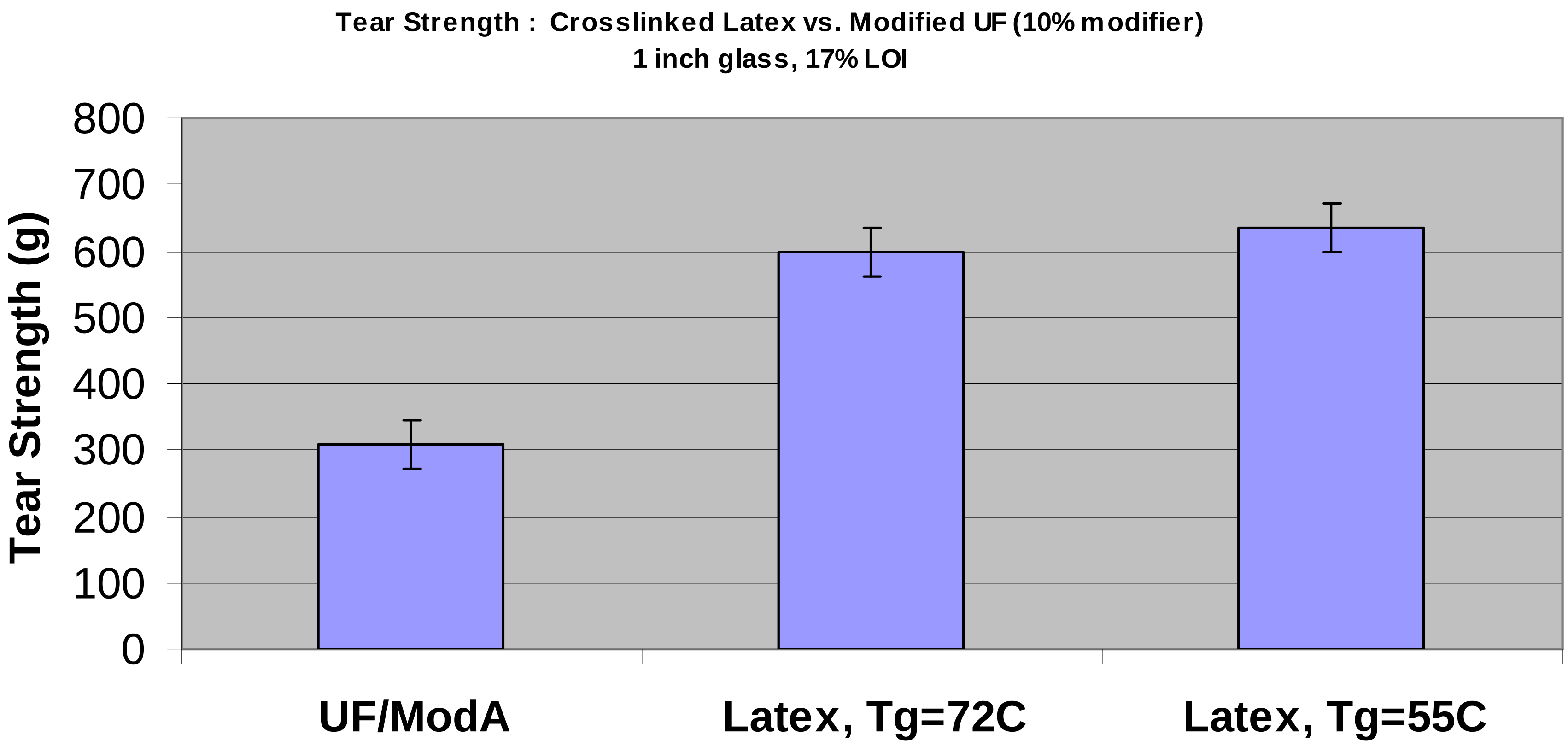
High strength & high temperature flexibility



17% LOI on glass mat, cured 2min/200C (no pre-dry)

Crosslinked Latex (sole binder):

Excellent Tear Strength



Construction Chemicals

THANK YOU

Jean Brady
The Dow Chemical Company
Spring House, PA 19477
215-619-5438

Novel Formaldehyde Free Technology For Glass Fibers: Hycar® FF 26920 & Hycar ® FF26921

Building and Industrial Mat Meeting 5/19-5/21

Dennis P. Butcher – Technical Market Manager
Lubrizol Advanced Materials

Formaldehyde Free Technology For Glass Fibers

Drivers for Formaldehyde Free Technology

- **The Clean Air Act**
- **California Proposition 65**
- **ACGIH lists formaldehyde as suspected human carcinogen**
  - **American Conference of Governmental Industrial Hygienists**
- **IARC Group 1 Human Carcinogen**
  - **International Agency for Research on Cancer**
- **Free formaldehyde level permissible is continuously being reduced by various regulations globally**
- **European Union, California, New England States are forefront in reducing the limits on free formaldehyde on various substrates**
  - **California Air Resources Board – Wood Products**
- **Reducing formaldehyde may allow <u>potential</u> of "Green Branding" for products using alternative technologies**
  - **US Green Building Council – LEED Certification**

What does a binder need to do in industrial mat applications?

- Bind fibers
- Provide structural integrity
  - Dimensional stability and strength
    - Initially during manufacturing of mat product
    - In final composite
- Provide processability and product integrity
  - Resistance to:
    - Solvents
    - Plasticizers
    - Petroleum based materials
- Provide application appropriate feel
  - Stiffness
  - Flex

How do we measure binder performance?

- Dry Tensile Strength
- Hot Dry Tensile Strength
  - Thermal Stability
- Hot Wet Tensile Strength
  - Wet Strength
- Plasticizer Resistance Tensile Strength
  - Mat Chemical Resistance

Overall Physical Performance Targets

Achieve similar or improved properties of crosslinked industry leading acrylic with a formaldehyde free system.

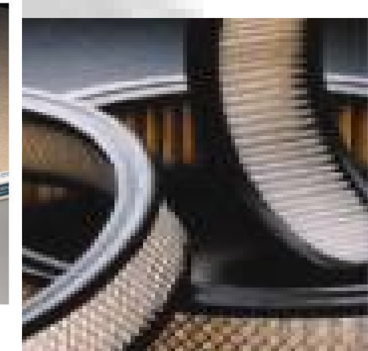
Overall Performance of leading acrylic + 2.5 pph melamine formaldehyde

- **High Dry Tensile Strength**
- **Good Hot-Dry Tensile Strength**
- **Hot-Wet Tensile Strength**
  - **Good wet/dry ratio**
- **Plasticizer Resistance Tensile Strength**

Conventional Benchmark

Product	Tg°C	Solids	pH	Viscosity	Comment
Leading Acrylic	+29	49.0	5.5	60 cP	Can Modify with MF or UF Resin to Improve: Hot Dry Tensile Strength Hot Wet Plasticizer Resistance

Product commonly used in construction products alone and with crosslinking resins



Key Properties

- Dry Tensile
- Hot Dry Tensile Strength
- Hot / Wet Tensile

Procedures for Testing Binders

Substrate: Whatman® Microfiber GF/A

Test Conditions:

- Target LOI: 25%
- Dry/Cure Conditions: 2 minutes at 375°F
- Sample Conditioning: Samples conditioned for 24 hours at 70±1°F and 50%±2% RH
- Crosshead speed for tensiles- 1”/min.
- Avg. of 4 specimens
- Tensiles recorded in lbs./in.

Dry Tensile

- 1x 6 Sample
- Gauge length – 4”

Hot-Dry Tensile

- 1"x9" Sample - die cut
- Gauge length - 7"
- Samples placed in hot slot and tested after 1 minute at 375°F

Hot-Wet Tensile

- Samples immersed 10 minutes in H_2O at 180°F
- Tested using same parameters as dry tensile

Plasticizer Soak

- Samples immersed 2 minutes in Diisononyl Phthalate (DINP) at RT
- Tested using same parameters as dry tensile

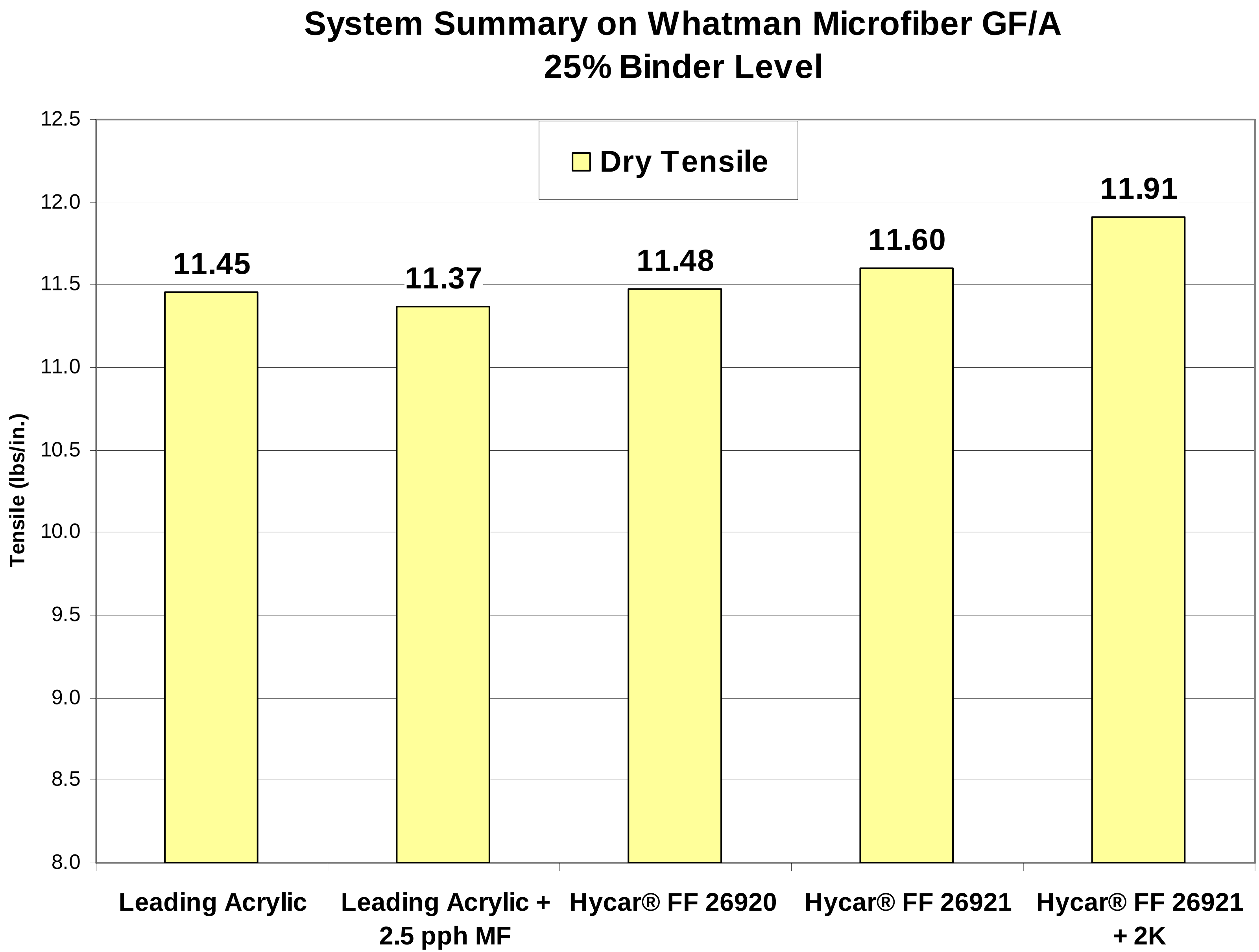
Glass Fiber Saturation Test Procedure

- Substrate- Whatman Microfiber Grade:GF/A
- Saturate substrate sheets with latex on Padder
- Dry sheets in oven at 190°C/ 2 min.
- Cut sample into strips and measure tensile properties

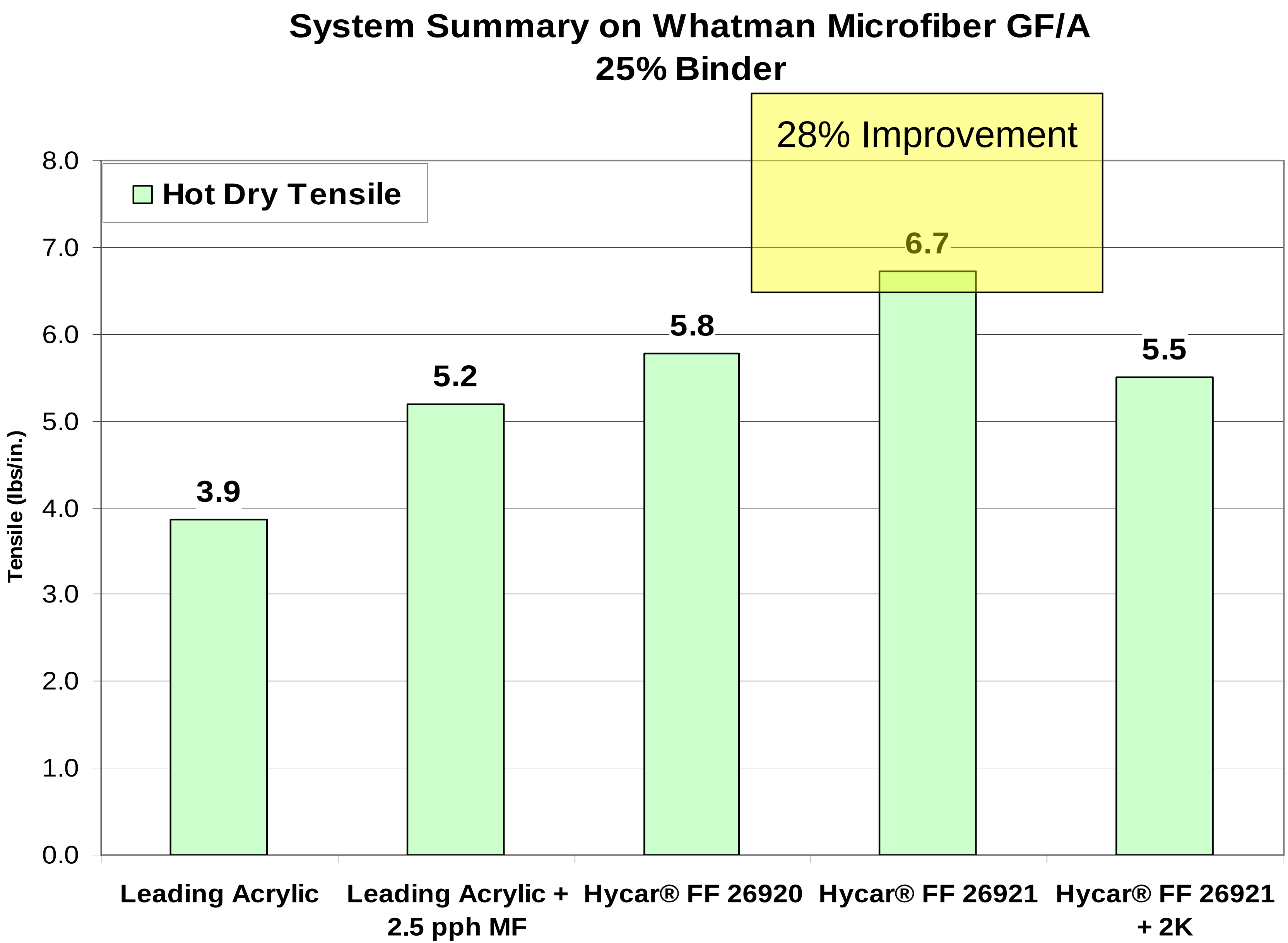
Padder

Tensile Test

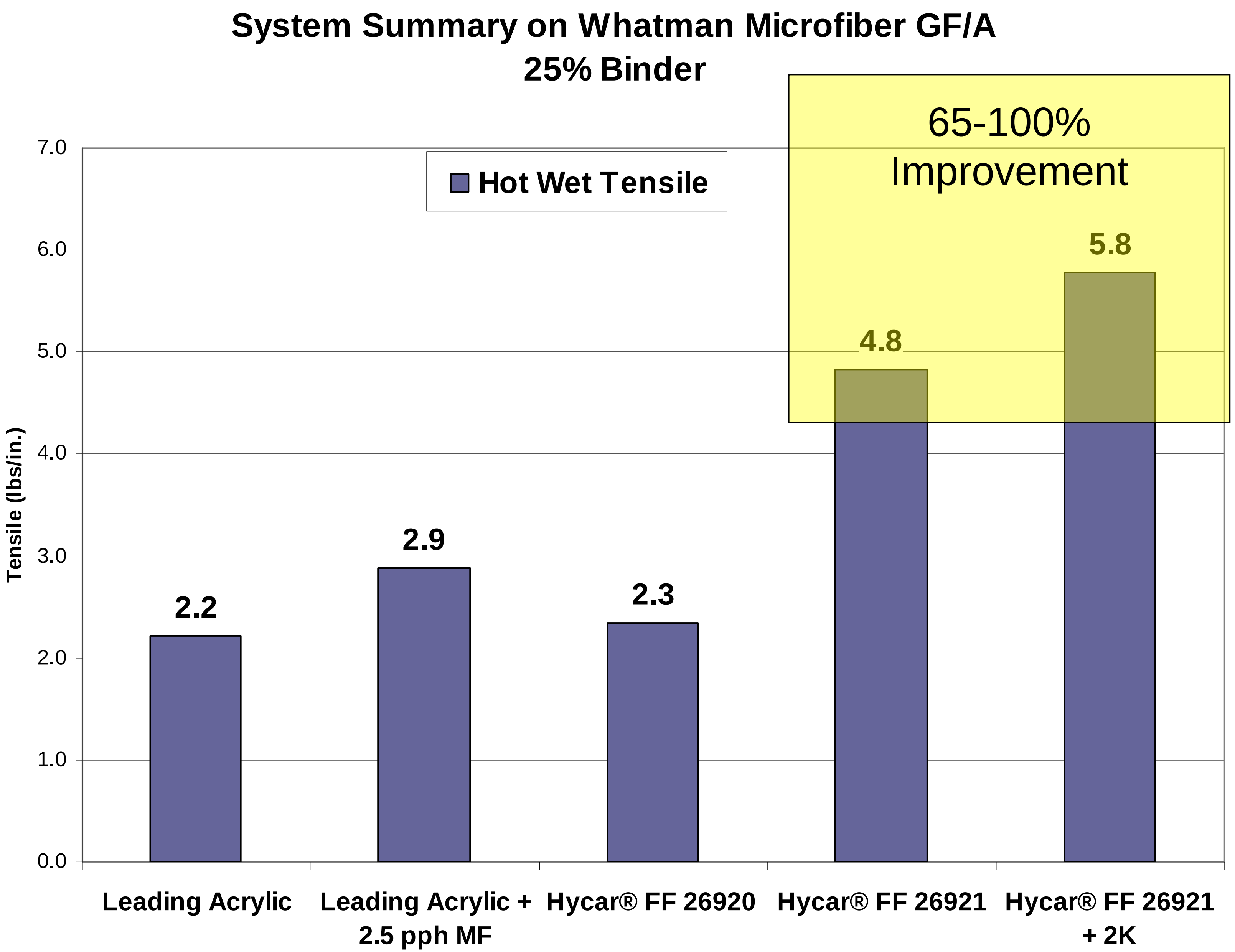
Dry Tensile


System Summary on Whatman Microfiber GF/A
25% Binder Level
Dry Tensile
Tensile (lbs/in.)
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
11.45
11.37
11.48
11.60
11.91
Leading Acrylic
Leading Acrylic + 2.5 pph MF
Hycar® FF 26920
Hycar® FF 26921
Hycar® FF 26921 + 2K

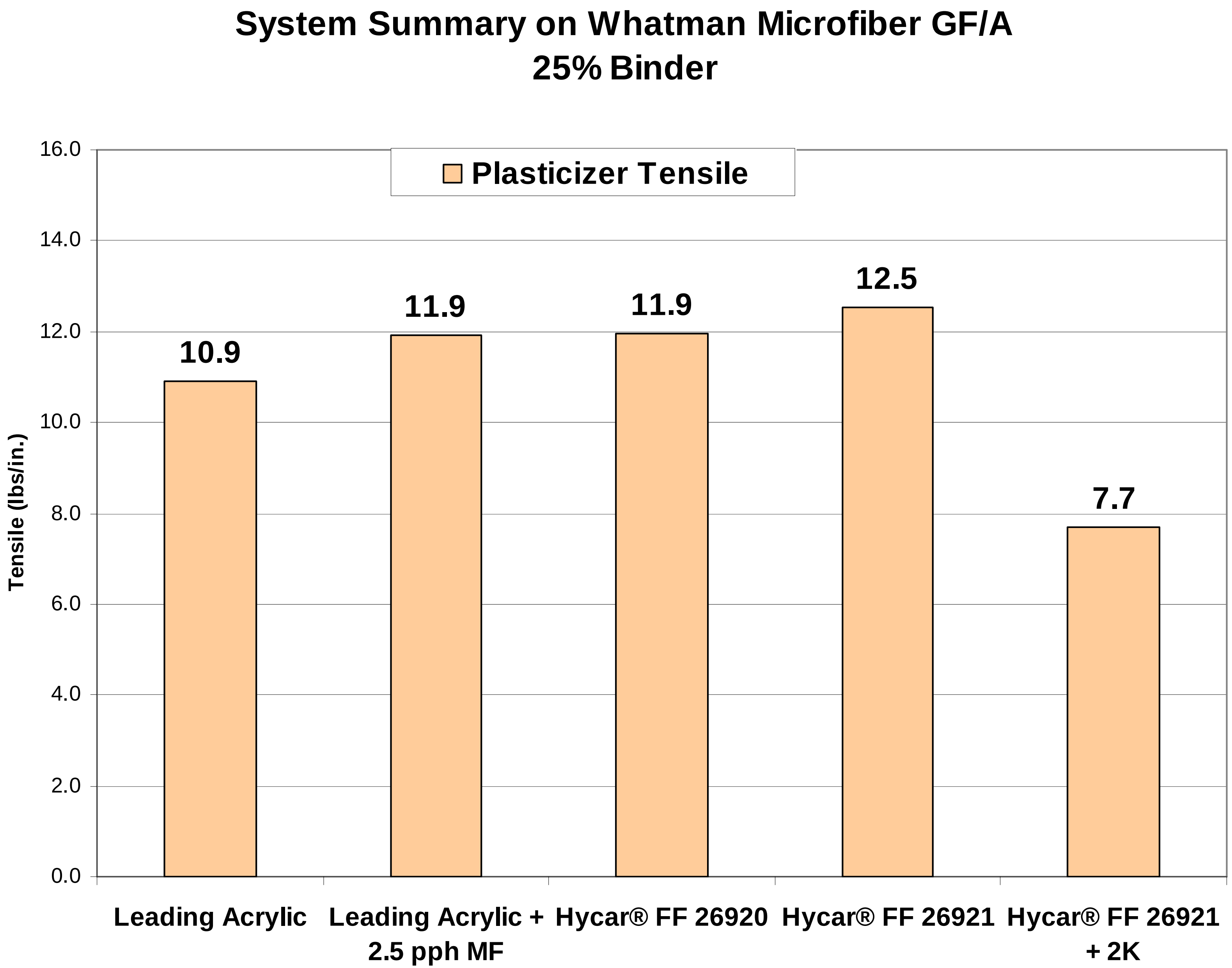
Hot Dry Tensile



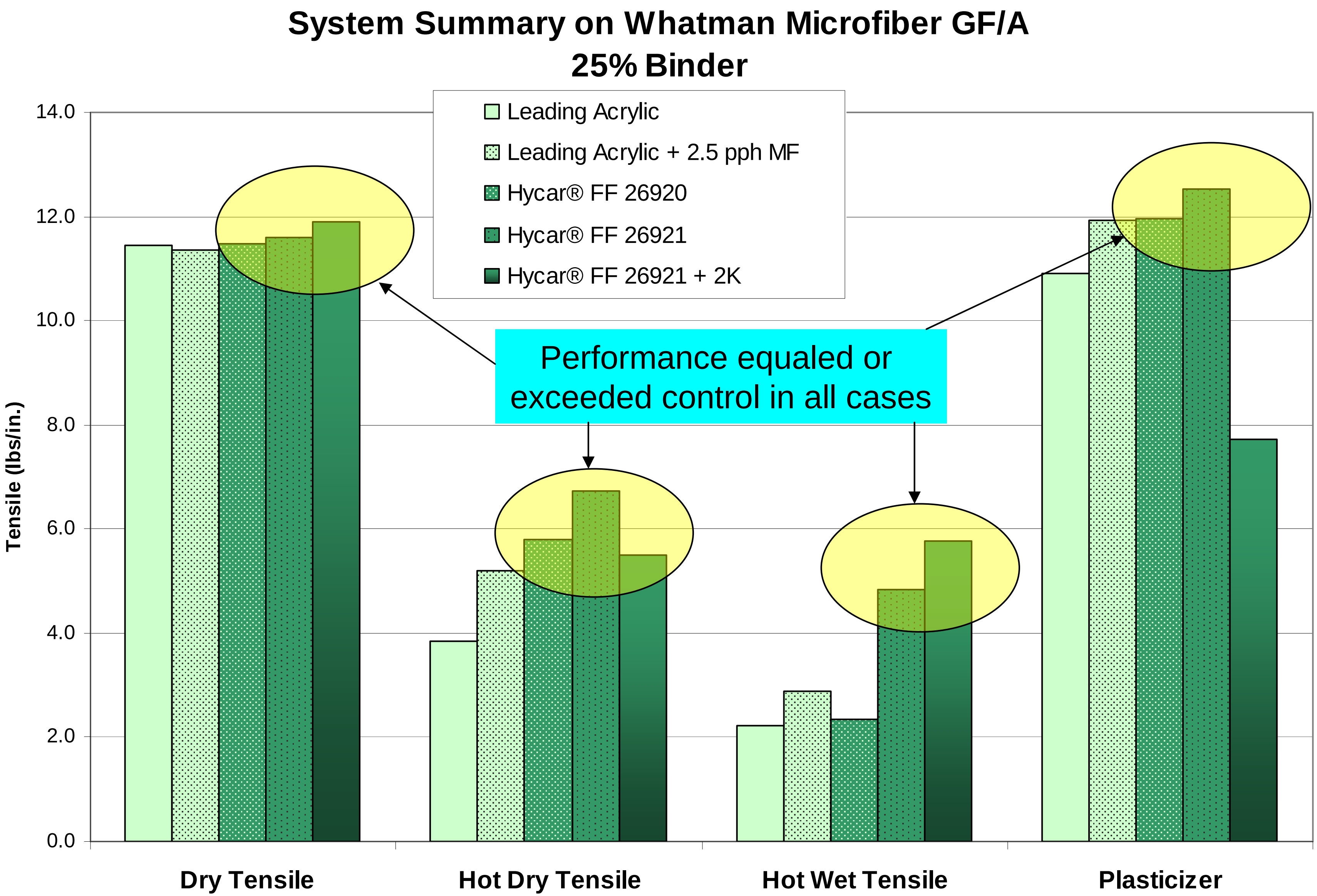
Hot Wet Tensile



Plasticizer Soak Tensile



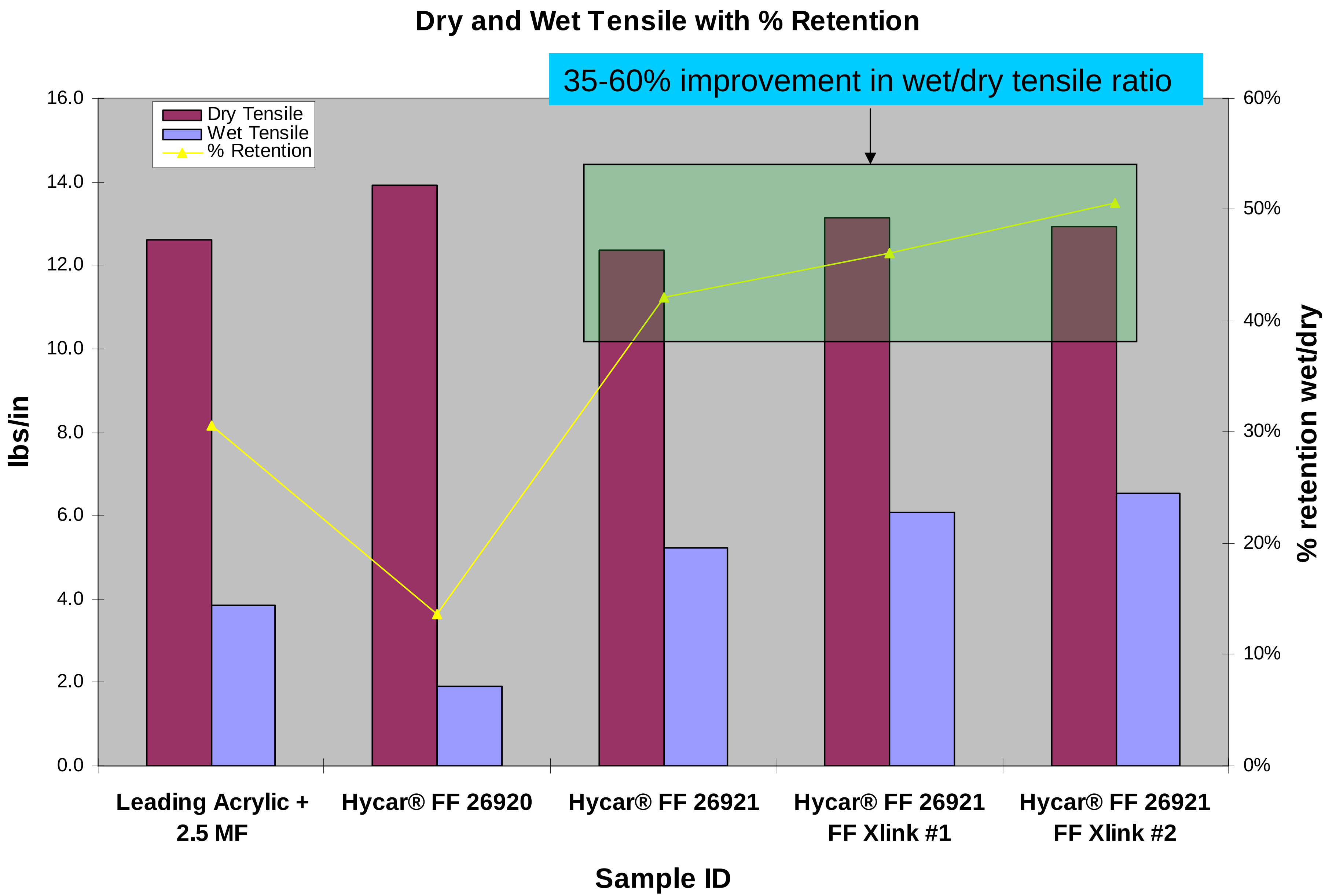
Composite Tensile Results



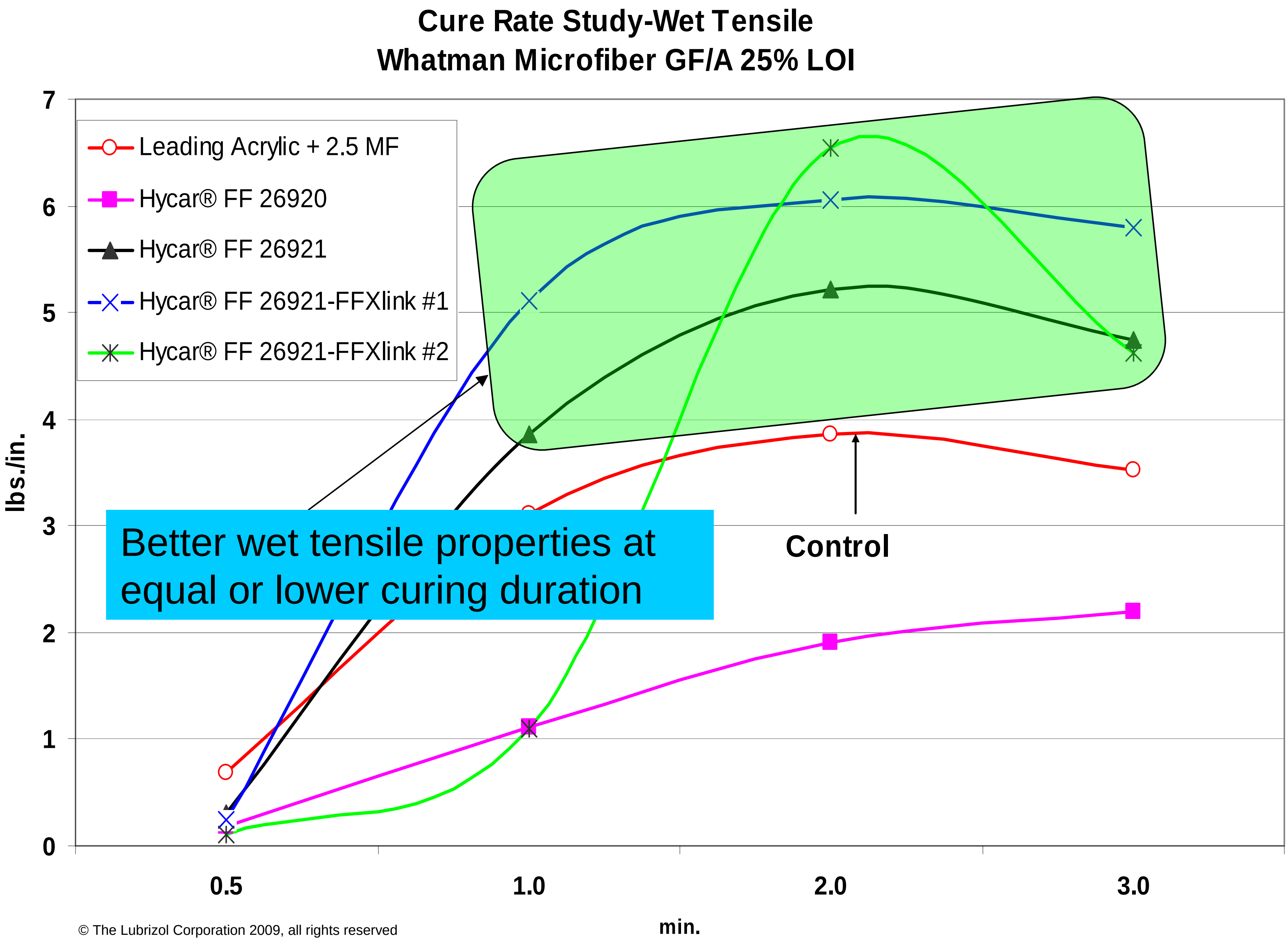
Based upon initial development work, additional studies were performed to better understand application properties and property development

1. Attempt to better quantify wet tensile improvement
2. Examine wet tensile strength development as a function of time
3. Examine tensile strength development as a function of temperature

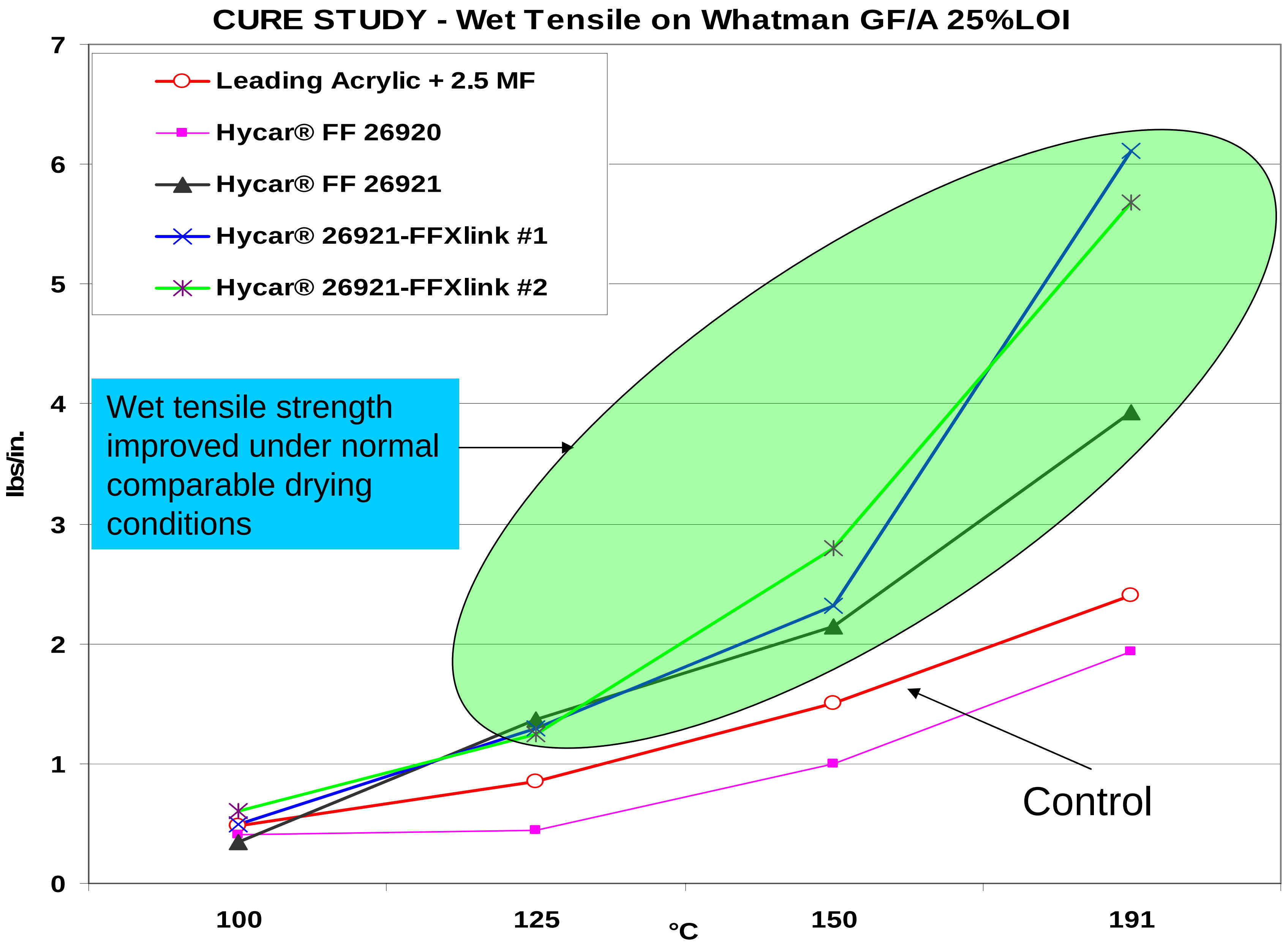
Wet and Dry Tensile – 2 min cure @ 190ºC



Cure Rate Study - 190º



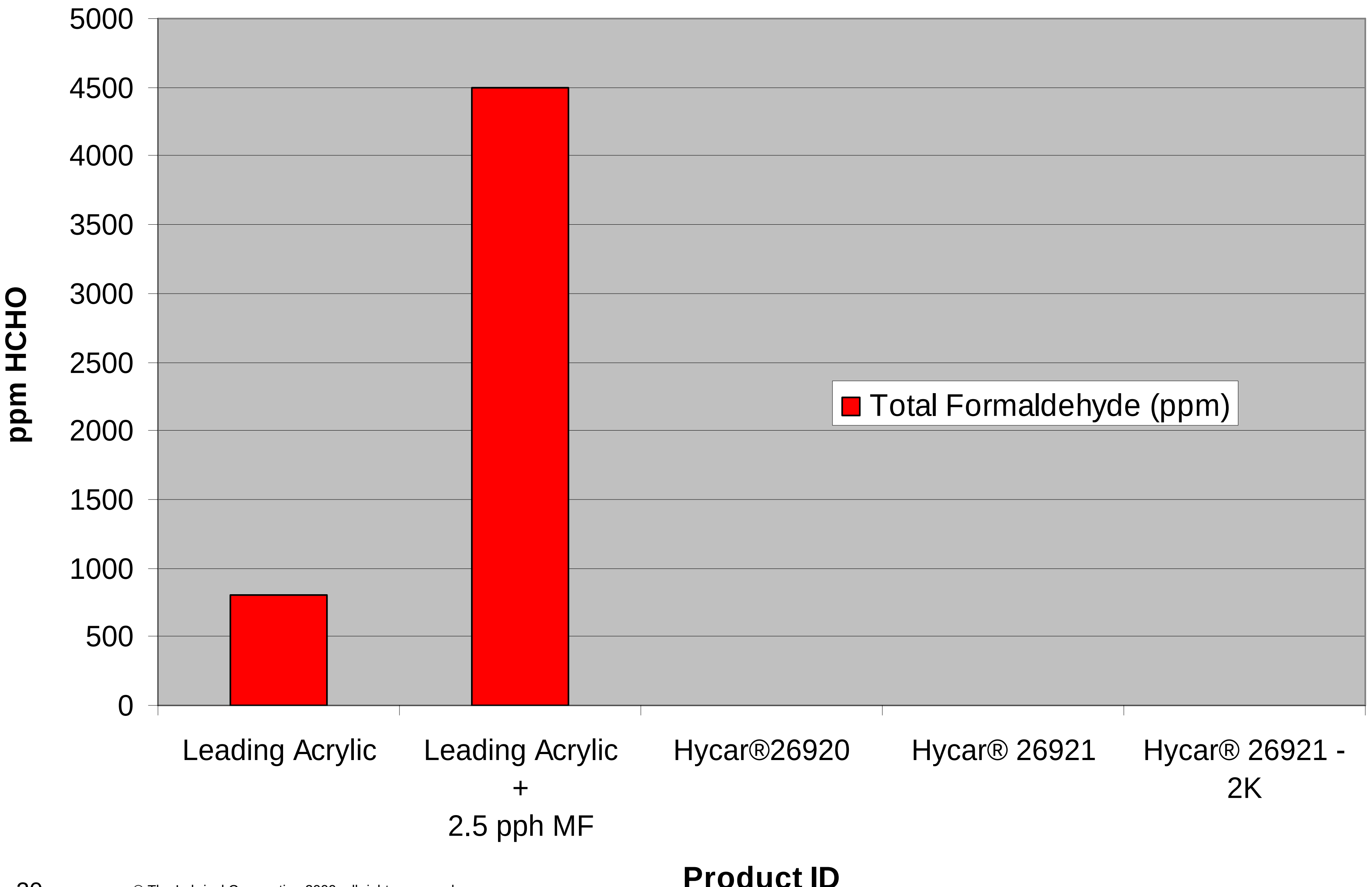
Cure Temperature Study – 2 min.



Findings ………

1. Formaldehyde free products showing improved tensile properties on microglass over MF crosslinked Leading Acrylic system
   - Hycar® FF 26920 compared to control
   - Hycar® FF 26921 shows improved hot and wet tensiles compared to control
2. Hycar® FF 26921 demonstrates improved cure response compared to control
   - Opportunity for energy savings?

Total Formaldehyde (ppm)



HYCAR® FF-26920 Formaldehyde Free System

Solution Description:

Hycar FF-26920 is a one component system replacing the use of traditional acrylic emulsion binder and melamine-formaldehyde cross-linker for a non-yellowing binder for most industrial use fiberglass nonwovens.

Unique Benefits:

- *Formaldehyde Free System*
- *Unsurpassed Hot Dry Tensile Strength*
- *Self Cross-linking*
- *1K solution to a typical 2K system*

Potential Applications:

- *Wet-laid*
  - *Fiberglass/ Industrial Mats*
  - *Duct Liner*
  - *Carpet Tiles*
  - *High Tech Filtration*

Value Creation:

- *"Green" implications because of Formaldehyde Free system*
- *Reduced emissions at substrate manufacturing process*
- *Extended durability and usage life of substrate because enhanced hot dry tensile strength*

Fiberglass Building Mat

General Specs

Tg: *+29°C*
Viscosity: *105 cps (#2 @ 60rpm)*
pH: *8 – 9*
Solids: *44%*

Hycar FF

HYCAR® FF-26921 Formaldehyde Free System

Solution Description:

- *Hycar FF-26921 is a one component system replacing the use of traditional acrylic emulsion binder and melamine-formaldehyde cross-linker to be used as a binder for most industrial use fiberglass nonwovens.*
- *For unsurpassed performance, additional non-formaldehyde component can be added*

Unique Benefits:

- *Formaldehyde Free System*
- *Unsurpassed Hot Wet Tensile Strength*
- *Self Cross-linking*

Potential Applications:

- *Wet-laid*
  - *Fiberglass/ Industrial Mats*
  - *Duct Liner*
  - *Carpet Tiles*
  - *High Tech Filtration*

Value Creation:

- *"Green" implications because of Formaldehyde Free system*
- *Reduced emissions at substrate manufacturing process*
- *Extended durability and usage life of substrate because enhanced hot wet tensile strength*

Fiberglass Building Mat

General Specs

Tg: +29°C
Viscosity: 65 cps (#2 @ 60rpm)
pH: 8 – 9
Solids: 44%

Hycar FF

Thank You!

Acknowledgements

Ashok Makati

Jamel Lawrence

Matt Sciulli

Prachur Bhargava

Gary Anderle

The Impact of Product Variability on Profitability

B&IM Spring Meeting 2010

Paul Frost

P J Associates

Product Variability

- The term “product variability” refers to both the amount of variability in product that meets specification along with out-of-spec product.

- This characteristic is also important in hidden, or non-delineated specifications.

A Fundamental Problem

- Most roll goods manufacturers use the concept of product “in-spec” as compared with product “in control.”
- There are several problems with this philosophy:

Internal Problems

1. The entire spec (and more) is used to ship product to customers.
2. Assignable causes are not usually recognized until bad product is made.
3. Current inspection acceptance procedures assure that some level of out-of-spec product will be shipped.
4. Current inspection techniques are nearly always statistically invalid.

External Problems

1. Shipment-to-shipment variability
2. Doff-to-doff variability
3. Within doff variability
4. Out-of-specification product

Key Drivers of Profitability

1. Customer satisfaction and loyalty
2. Internal costs

Hidden Customer Factors

- Product/Service dissatisfaction not communicated
- Hidden specifications
- Changing markets/processes
- 2nd sourcing

Customer Communication

Dangerous perceptions

1. If I deliver product that meets specification, my customers will be happy.

2. If I provide poor product or poor service, my customers will tell me.

Customer Complaints

- 50% of all customers experiencing a problem never complain to anyone.

- Of those who complain, 45% complain only to frontline personnel who either fail to escalate the problem up to management and/or mishandle solving the problem.

- Only 5% voice the problem to management

❖ TARP & Goodman and Ward

Hidden Specifications

- Virtually every customer has product expectations that are not covered in the specification; however, “they know it when they see it.”

- Nearly every manufacturer is capable of producing a “new and exciting” defects with potential “Shut Down” capabilities.

Changing Markets/Processes

- New or modified production processes at the customer/supplier facility may impact product quality perceptions.

- Changing markets and/or consumer needs may impact product specifications.

2nd Sourcing

- SOP for many customers
  - Raw material costs
  - Quality
  - Unions
  - Good business practice
  - Shutdown Hedge

Hidden Manufacturing Factors

- Operator variability
- Machine variability
- Critical Raw materials
- Changeovers
- Operating procedures
- Bottlenecks
- Lean Waste
- Environment

Operator Variability

- Training
- Habit
- Attitude
- Union
- Operating procedures
- Maintenance
- Communication

Machine Variability

- Design
- Maintenance
- Wear
- Set-up
- Start-up
- Steady state variability
- Effect of environment
- Comparisons

Critical Raw Materials

- Within lot
- Lot-to-lot
- Environment
- 2nd source comparisons

Changeovers

- Time
- Frequency
- Product effect
- Standardized procedures

Cost of Quality

- Reports
- Calculations

Non-Traditional Reports

- Effect of variability on product quality
  - Process average location & range
  - MD/CD patterns of variability
- Intangibles
  - Covert customer dissatisfaction
  - Poor company image
  - Unknown/underestimated competitor advantage
- Impact of quality & service on revenue
- Taguchi Quality Loss Function

Roll Goods vs. Piece Parts Overview

1. **Product variability is *integrated* in both the cross and machine directions.**
2. **Test values may be correlated in the cross and/or machine directions.**
3. **Multiple populations may well be manufactured over time.**

Where Does Roll Variability Analysis Add Bottom Line Value?

- **The Entire Supply Chain**
  - **Raw Materials**
  - **Mat**
  - **Coating**
  - **Converting**
  - **Customer**

Conclusions

- Profitability is more important than ever.
- There are many <u>hidden</u> factors influencing profitability.
- Controlling overall product variability and patterns of variability is critical to minimizing cost.
- There are a number of specialized tools to help us.

Contact Information

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Web Site: www.pjassociates.com

Glass Fiber Mat Reclamation Process

- Patent Information
- Process Highlights/Summary
- Process Footprint
- Fiber Reuse
- Trial Work
- Savings

Patent Information

- **Patent Number**
- 6,793,737

- **Plant Location**
- Aiken, South Carolina

Process Highlights

- Material Handling

J. W. Yount Fiberglass Reclaimers Corporation

Process Highlights

- Process Washer Unit

Process Summary

- 200 Degree Wash Cycle
- Rinse
- Dry/Spin – approximately 15% moisture
- Packaged

Process Footprint

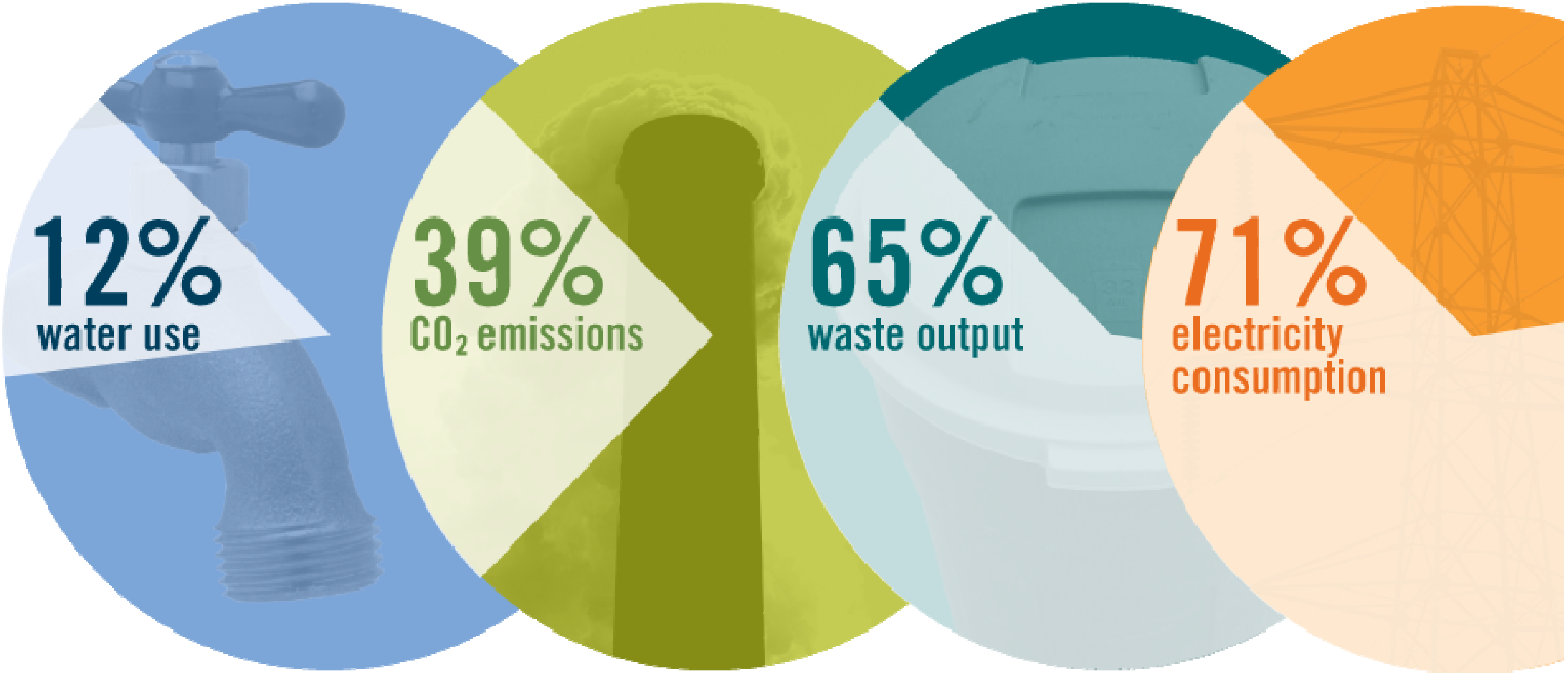
- Relatively Small Footprint
- Range from Inexpensive Batch Equipment to Automated Continuous Washer Unit
- Training

Glass Fiber Mat Reclamation

- Fiber Reuse
  - Glass Fiber Mat
  - Other Glass Fiber Products
- Trial Work
- Savings
  - Economic – Raw Material Costs
  - Environmental – Landfill Issues

COMMERCIAL REA
GOING GREEN
Environmental efficiency is actually the hottest trend in
The challenge is creating demand among te
Special Reprint Edition
USA TODAY
NO. 1 IN THE USA
As seen in USA TODAY Money
July 26, 2006
Building 'green' reaches a new level
REAL ESTATE FINANCE
Real Estate's Latest Movement
green by DESIGN
The Gre
in A
Adobe has turned its headquarter
and is saving millions of d
The New York Times
Editorial
FRIDAY, AUGUST 11, 2006
Build Green,
Make Green
ew York Times
ucation Life
The Greening of America's Campus
cling anymore. The sustainability movemer
w campuses are built, and how students live
CONDOLiving
It's Easy Being Green
The Washington Post
REAL ESTATE

U.S. Building Impacts:



The Average Green Building Saves:

ENERGY SAVINGS
30%

CO2 SAVINGS
35-50%

WATER USE SAVINGS
35-50%

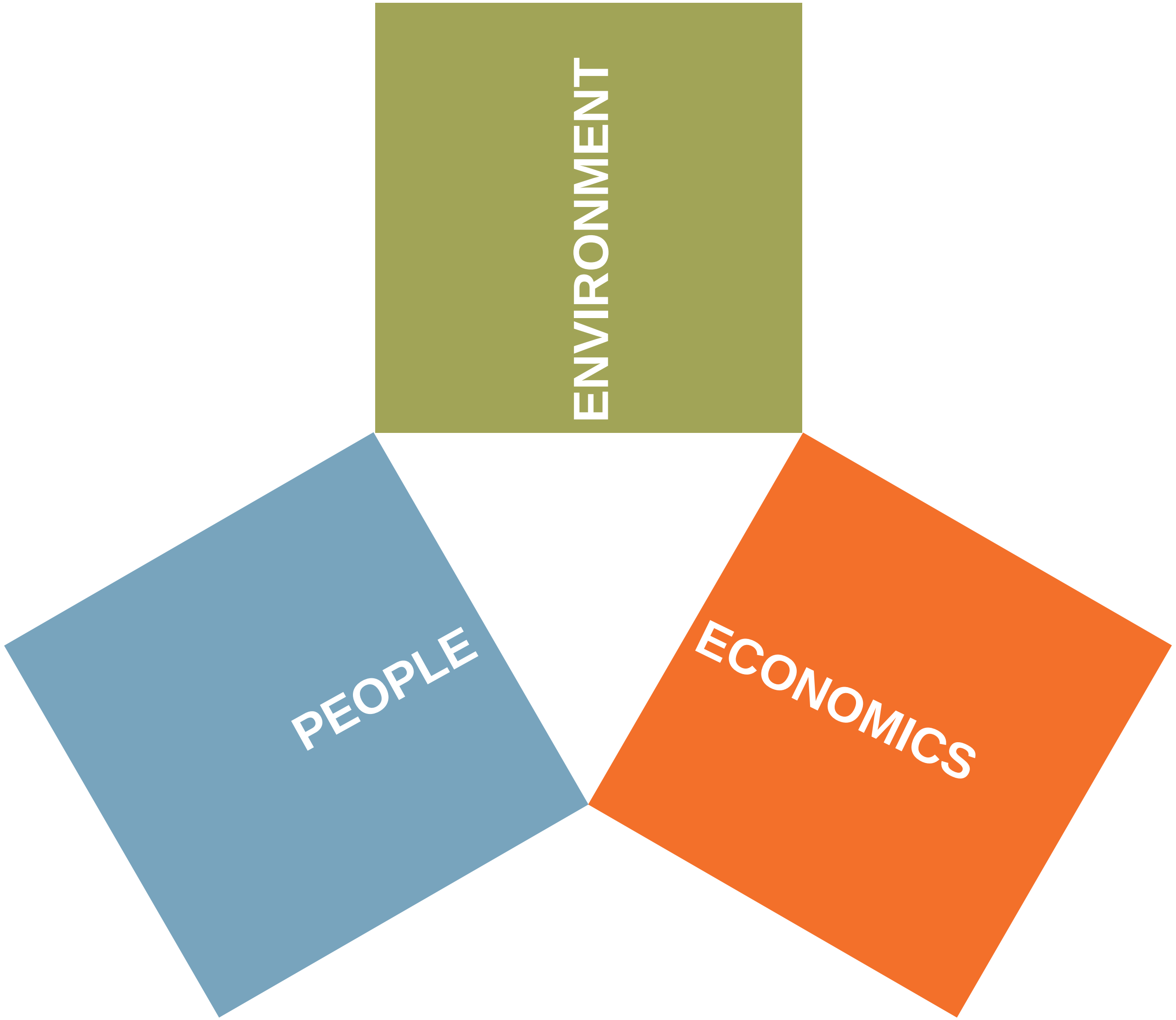
WASTE COST SAVINGS
50-90%

What is green building?

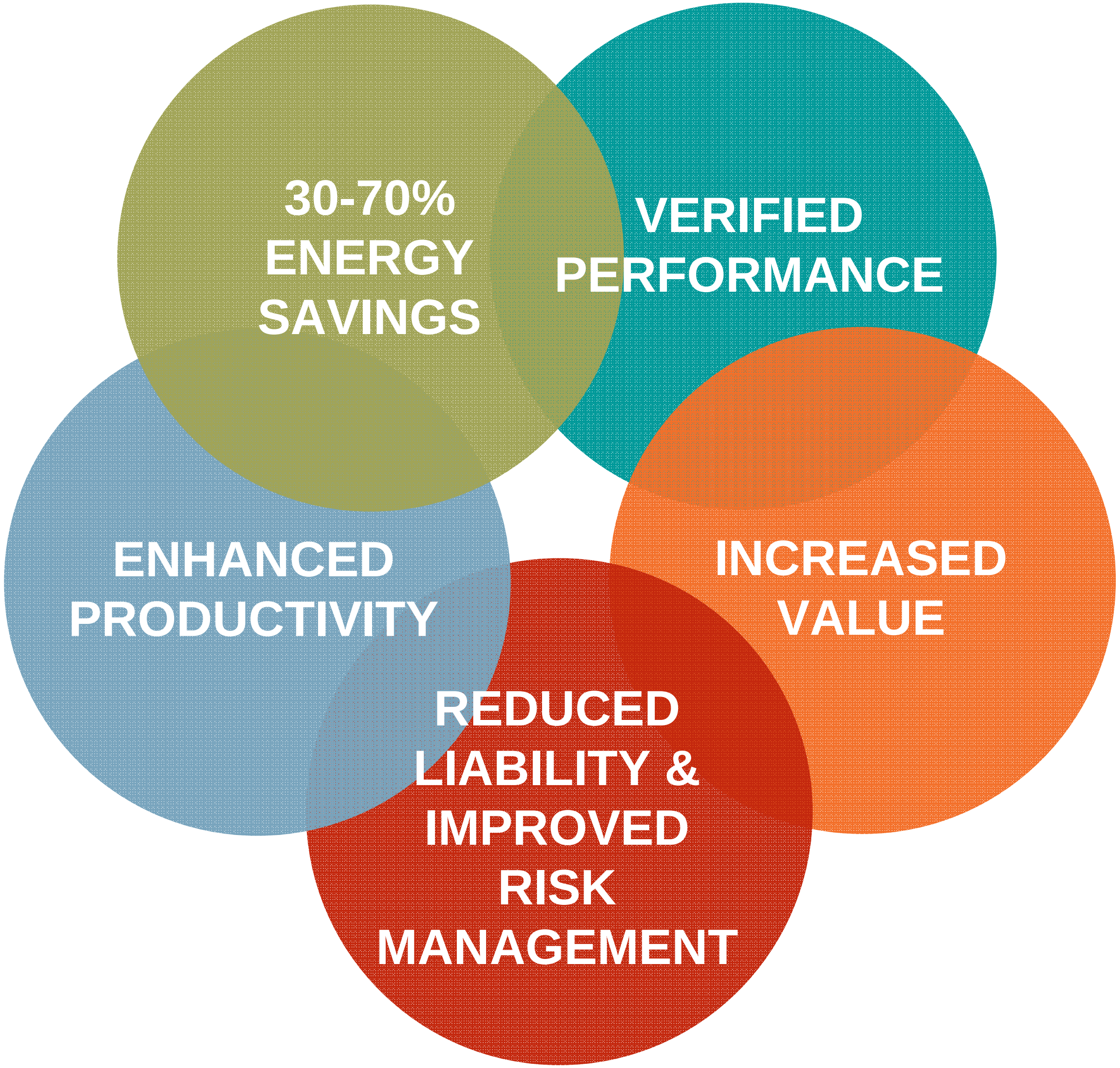
Design and construction practices that meet specified standards, resolving much of the negative impact of buildings on their occupants and on the environment.

The Triple Bottom Line

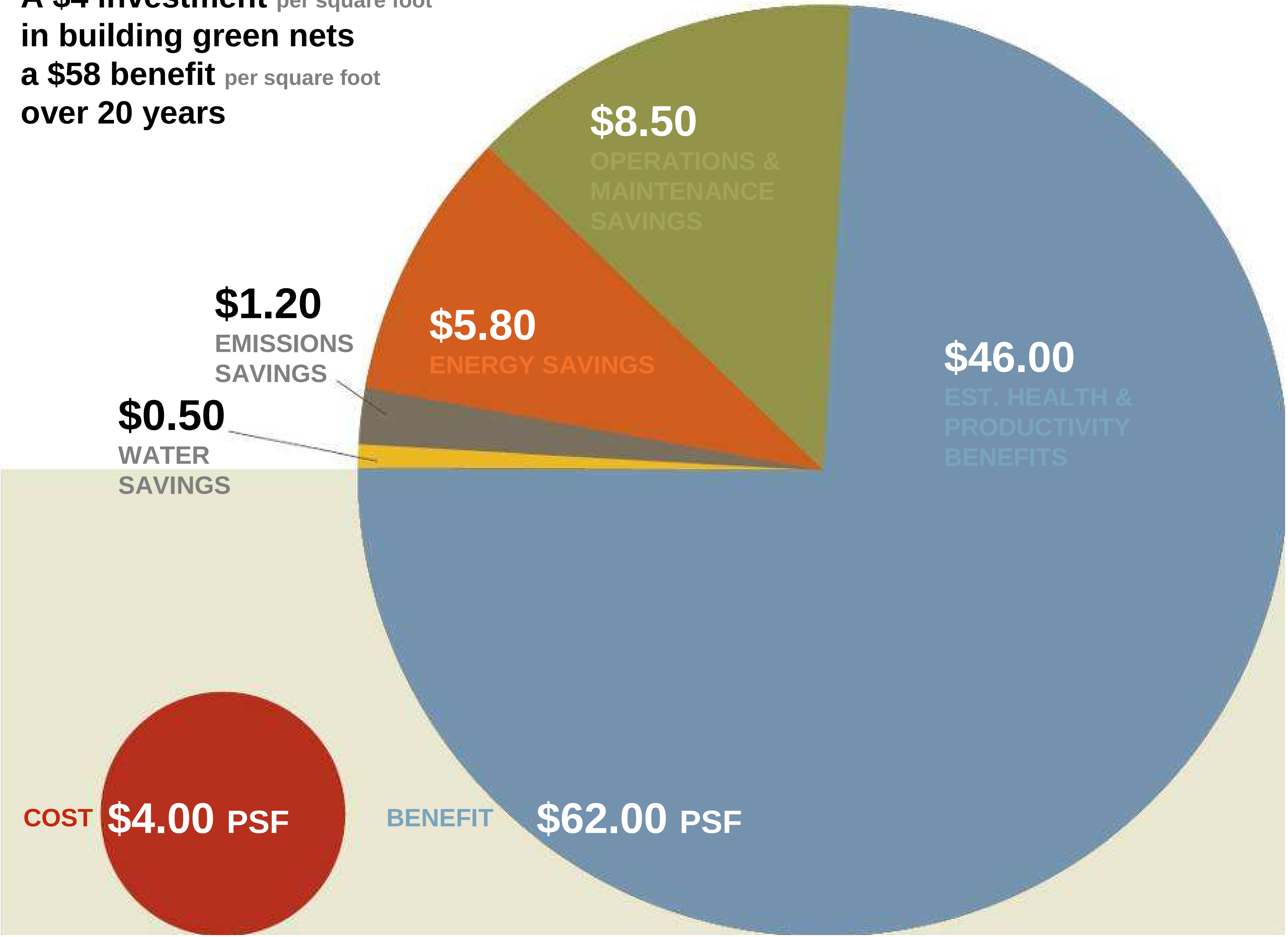
Reduced Environmental Impact. Peak Efficiency. Improved Capitalization Rates. Increased Marketability. Higher Lease Rates. Improved Productivity. Reduced Absenteeism.



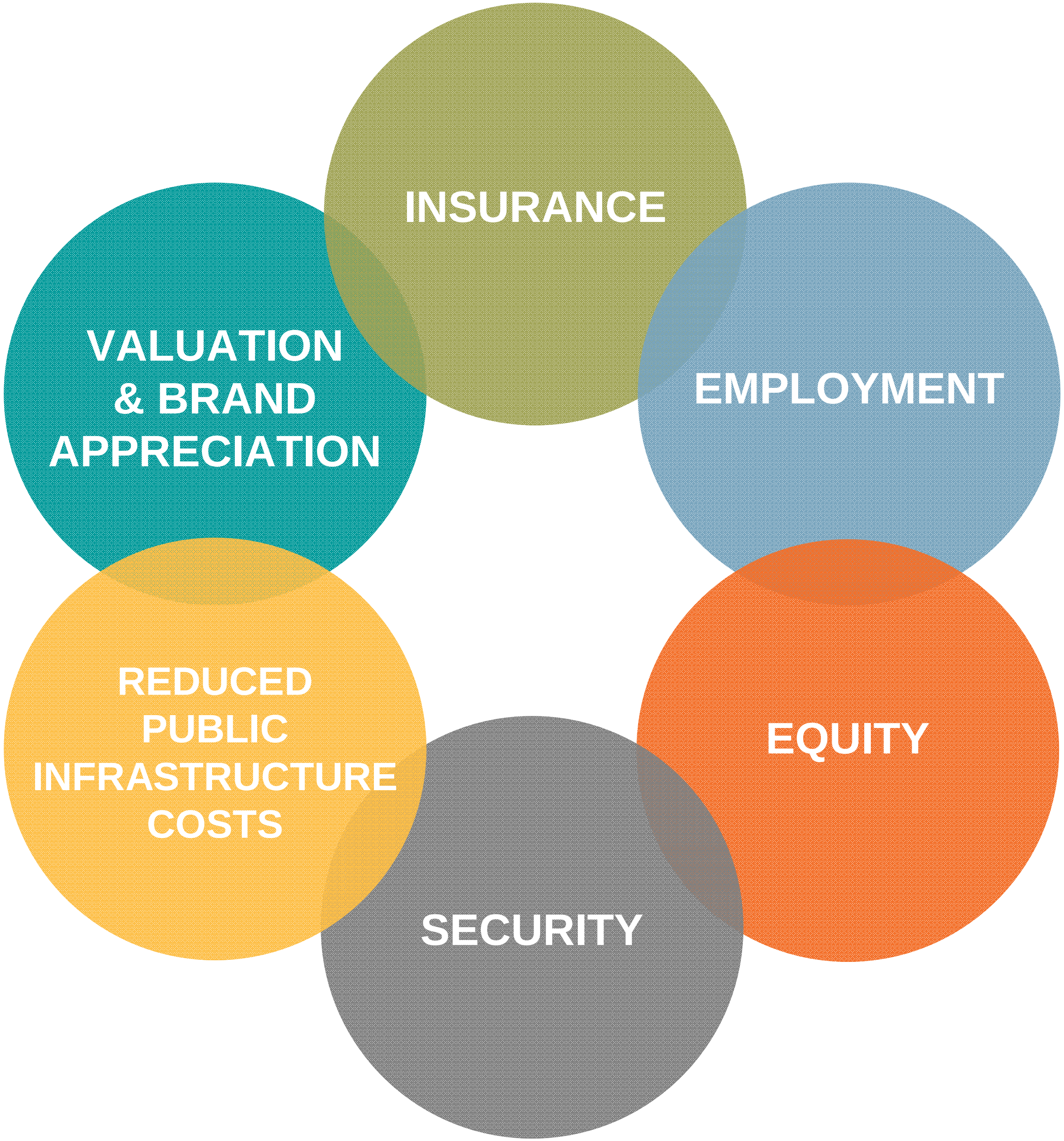
Improved Bottom Line.



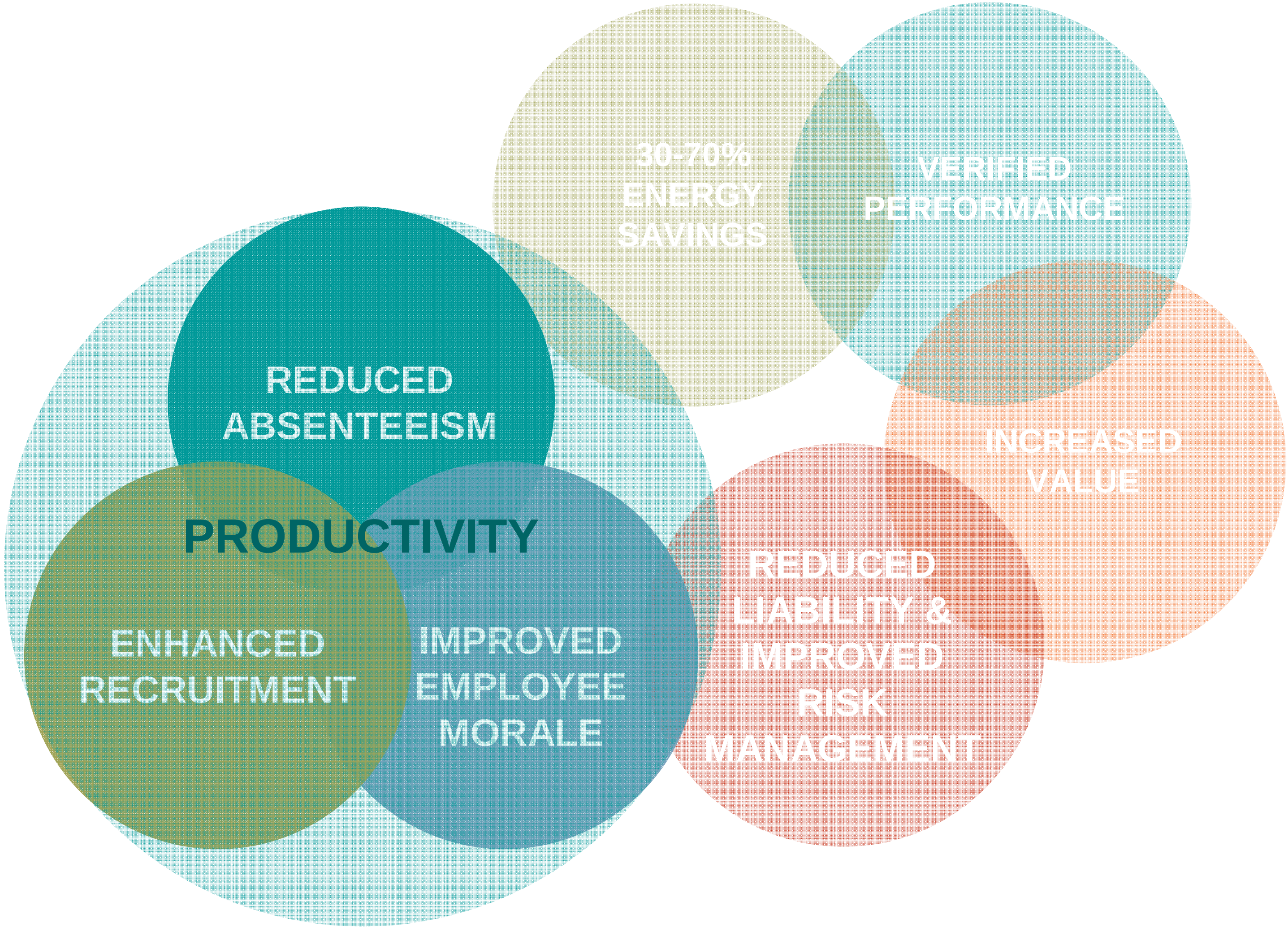
A $4 investment per square foot
in building green nets
a $58 benefit per square foot
over 20 years



Additional Benefits



Improved Bottom Line.



Average Productivity Gains

INDIVIDUAL TEMPERATURE CONTROL ENHANCES PRODUCTIVITY

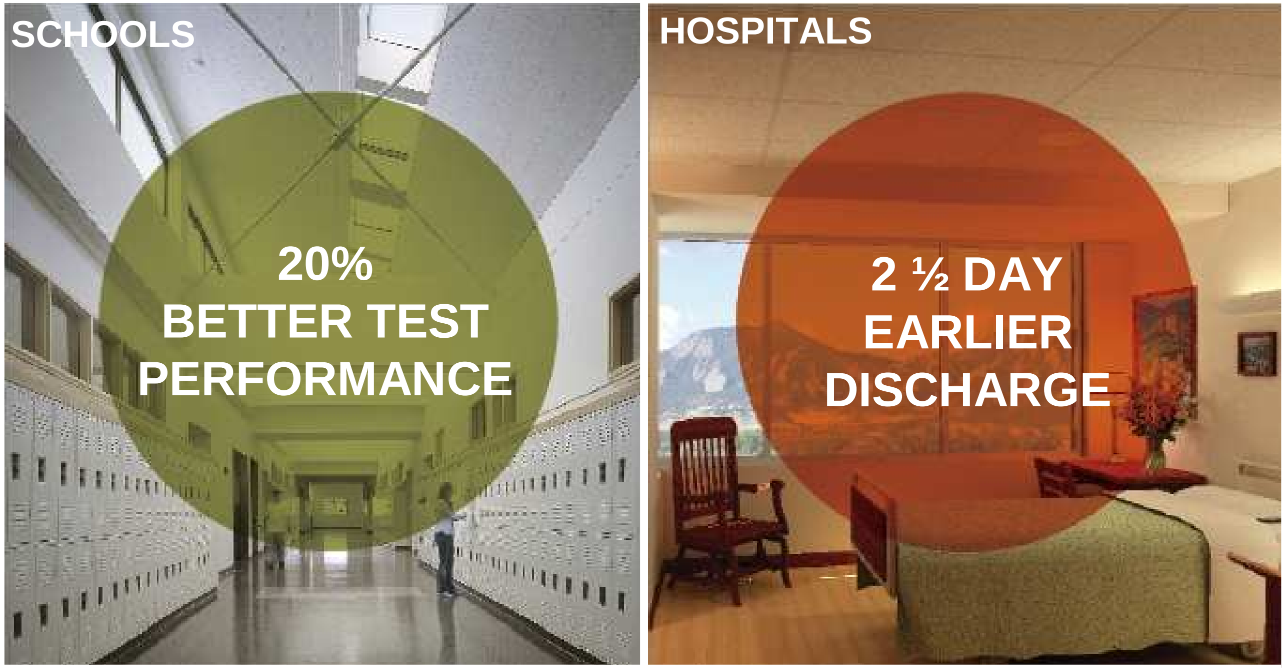
3.6%

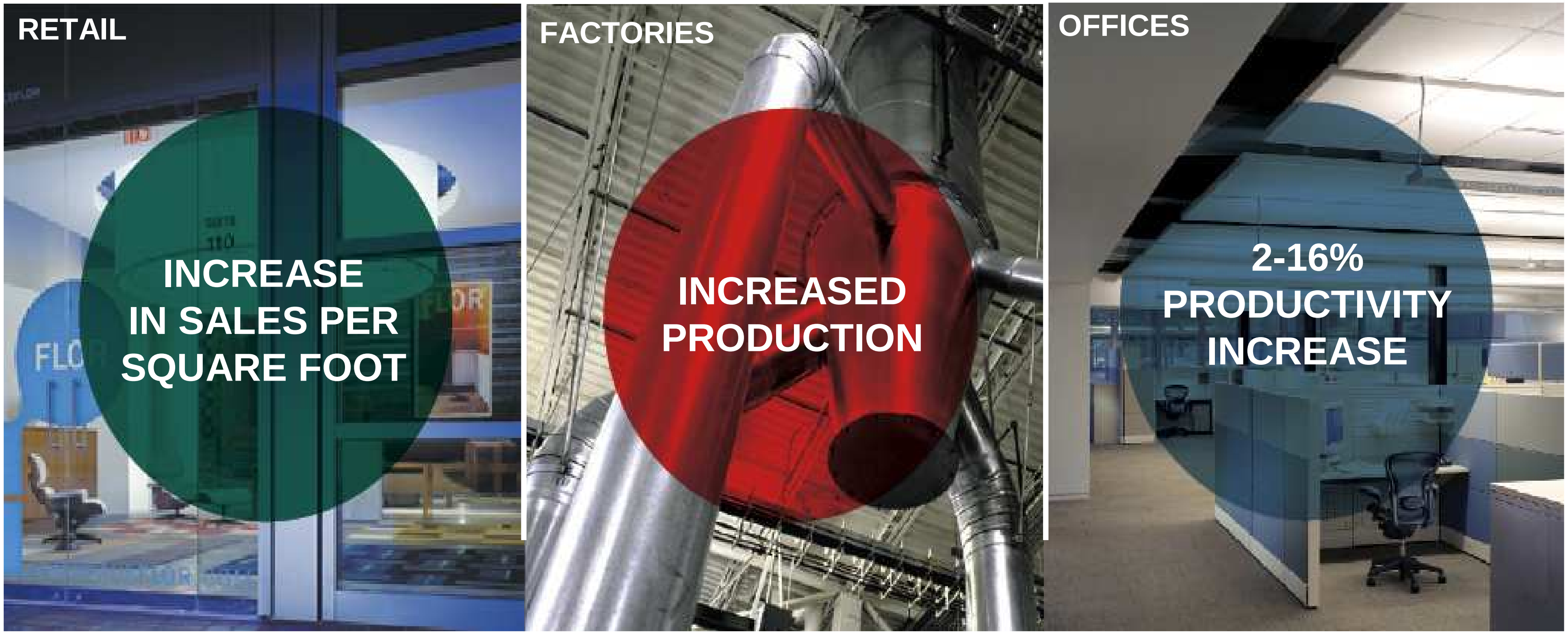
HIGH-PERFORMANCE LIGHTING ENHANCES PRODUCTIVITY

6.7%

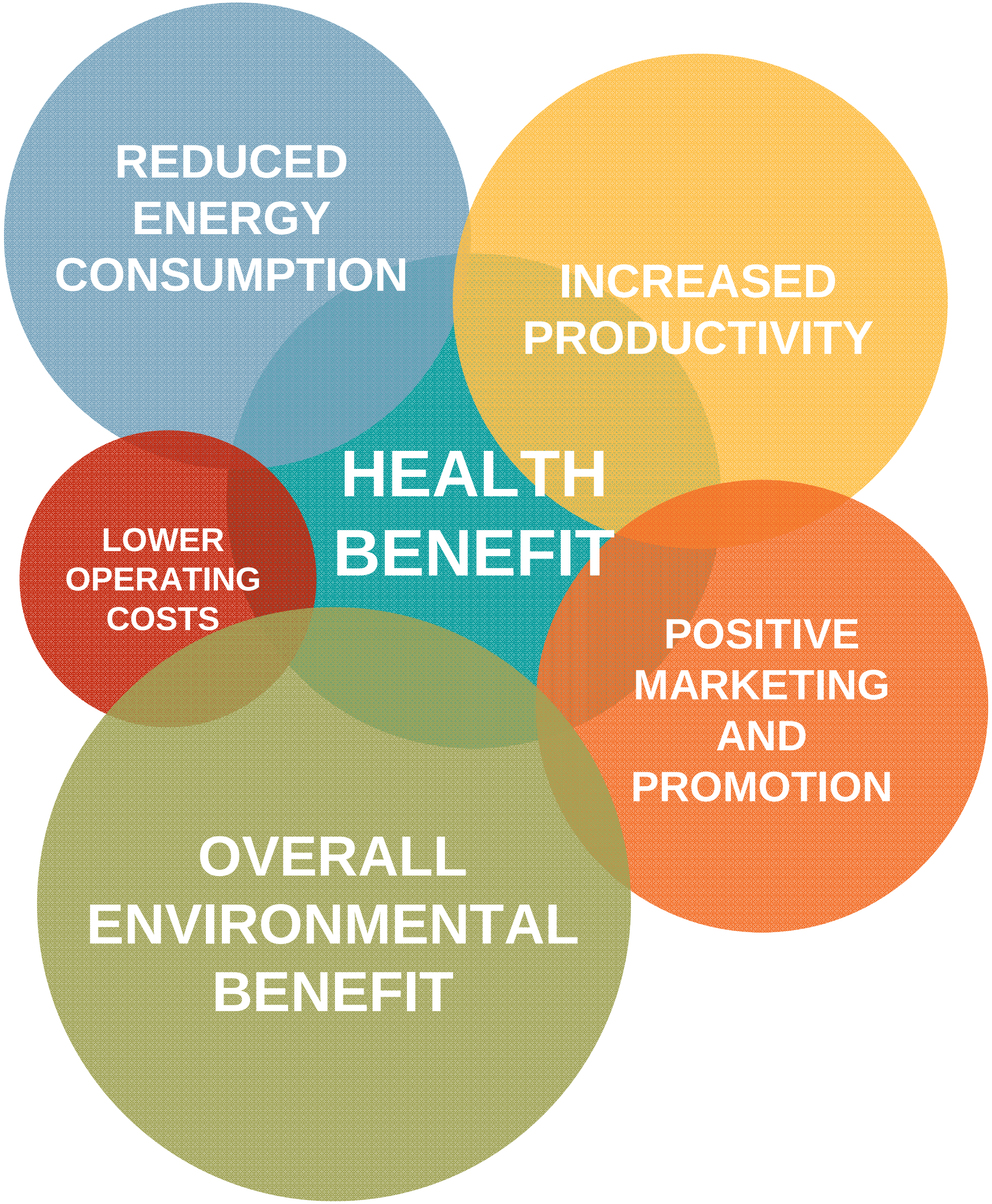
Green benefits go beyond cost savings:

Increased Productivity



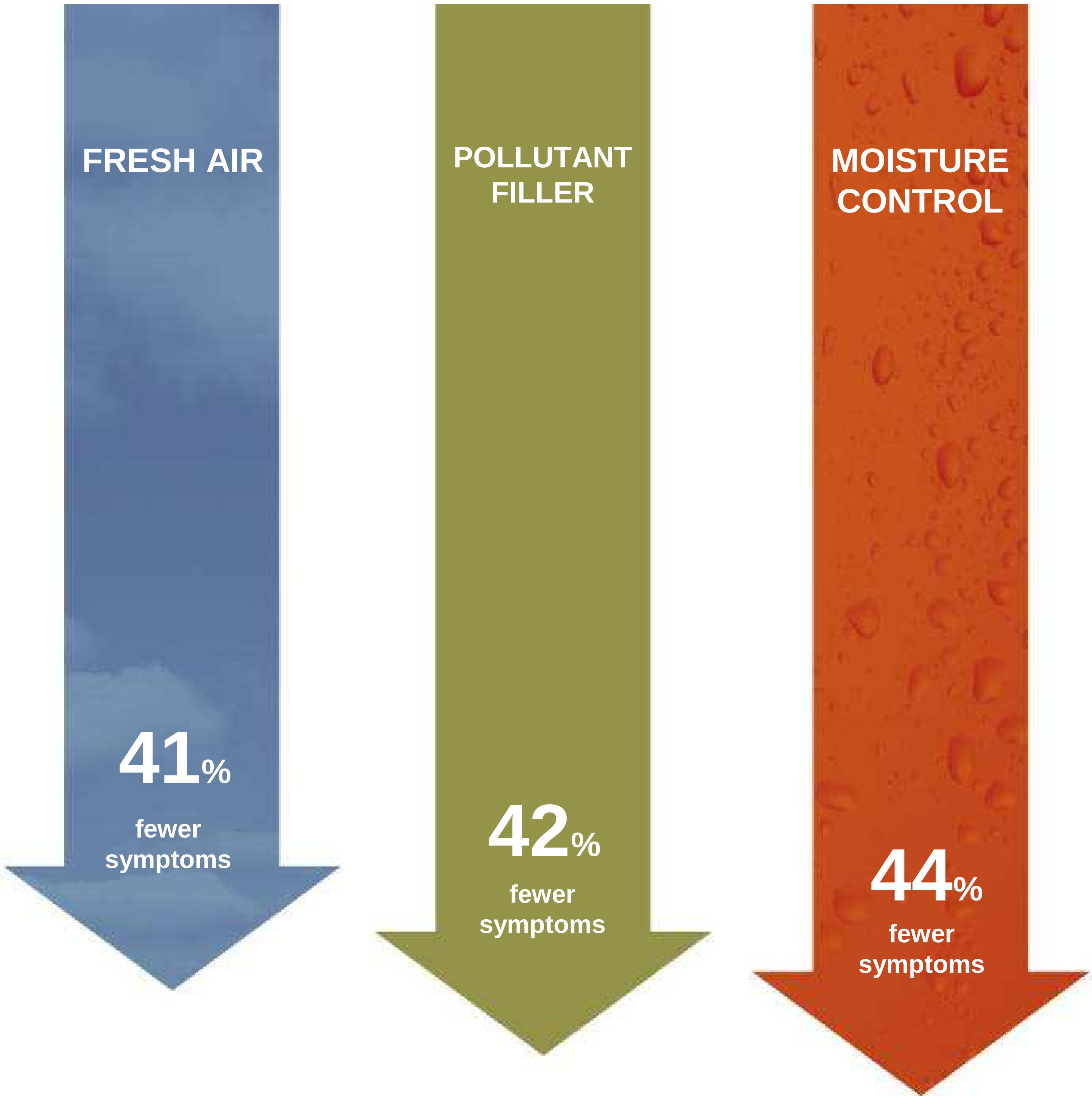


Occupants and tenants perceive value of working in a green building to be:



Health gains from improved Indoor Air Quality

As indicated by reduced symptoms for flu, asthma, allergies, respiratory infections, headaches, and colds.



An Oven Explosion – Lessons Learned on PSM Concepts (or "PSM: It's not just for breakfast anymore")

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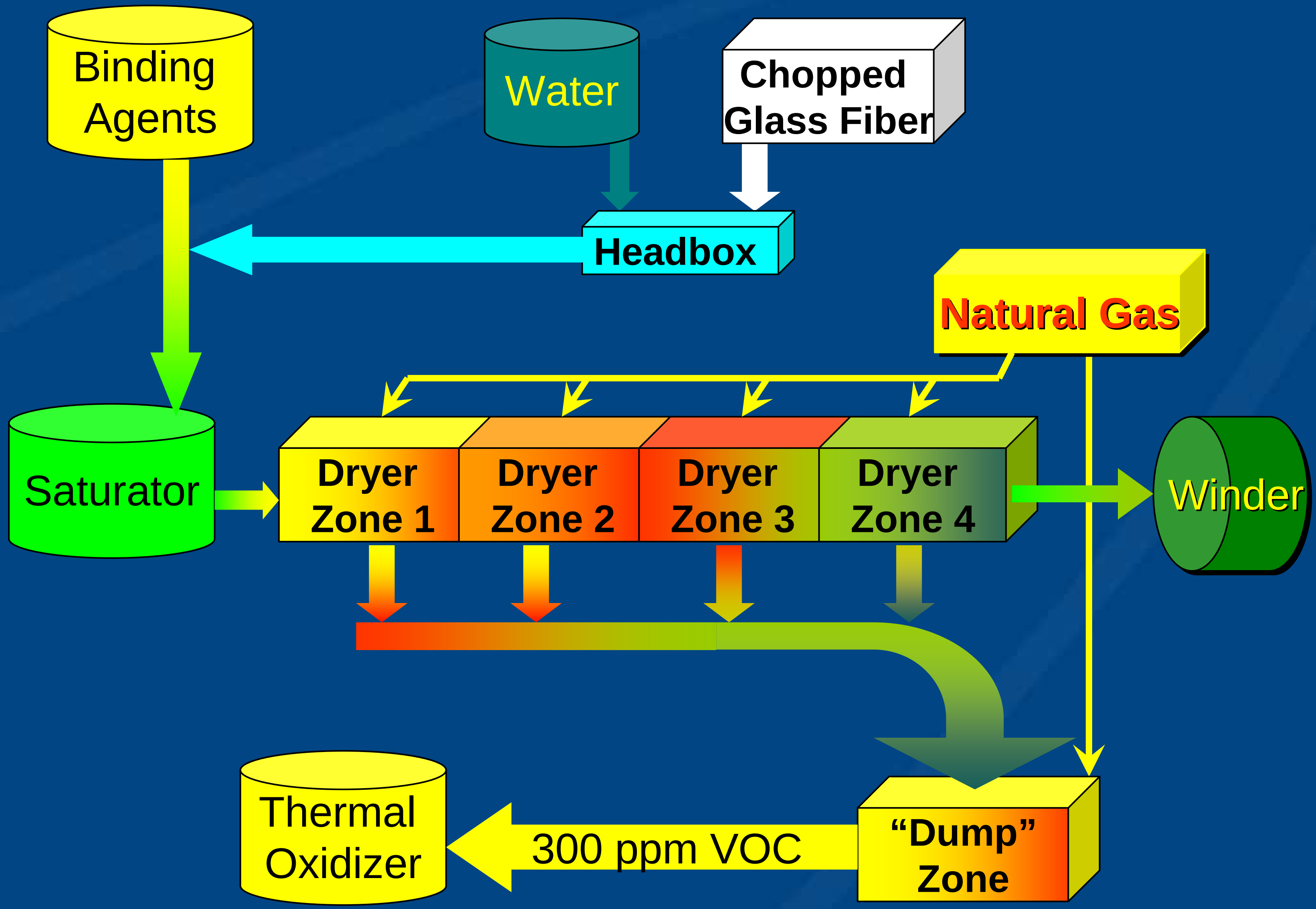
Kirby Erickson, P.E.
GAF-Elk
202 Cedar Road, Ennis, TX 75119
KirbyE@gaf.com

PSM Concepts & Applicability

- Should some concepts of PSM be applied in all industries?
- Are codes enough?
- Should we accept the notion that suppliers always know their process and equipment better than us?
- Should we view combustion as something more than a mundane, ubiquitous process?

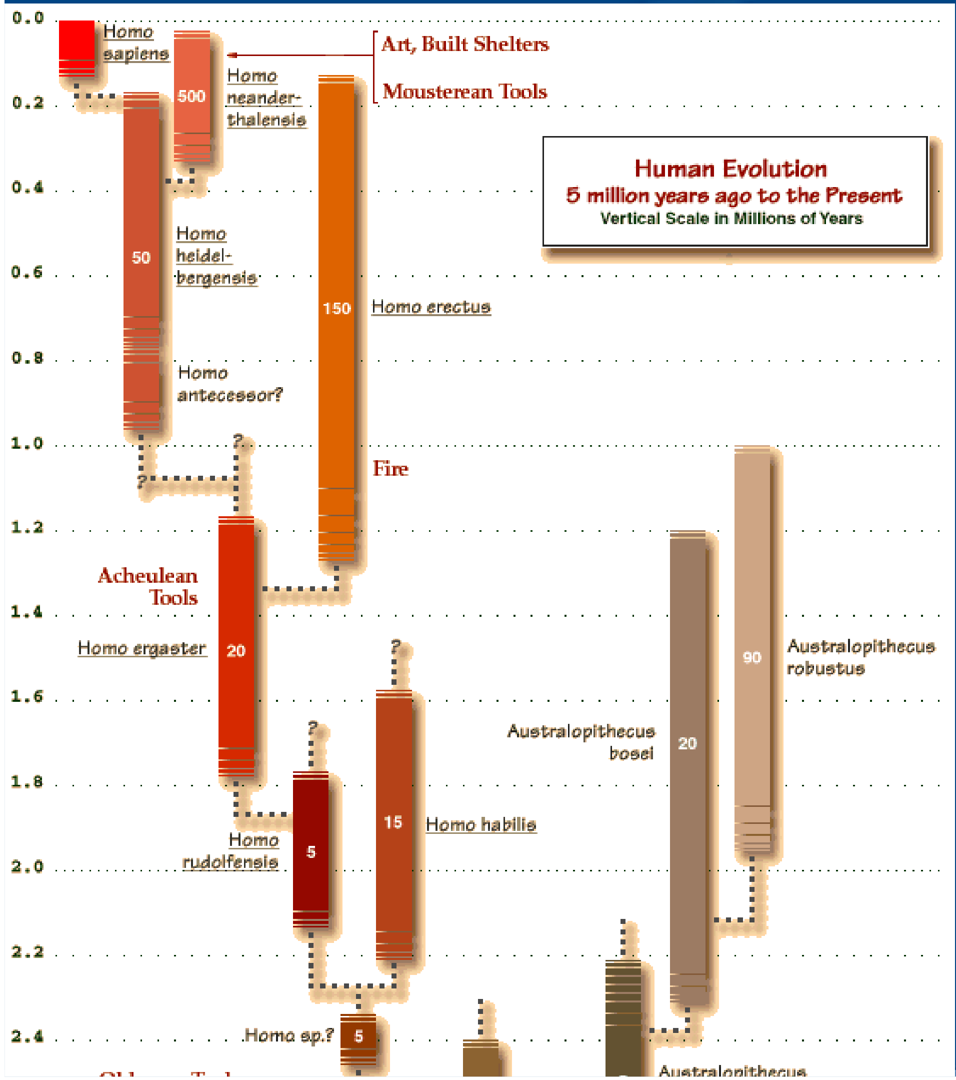
The Event

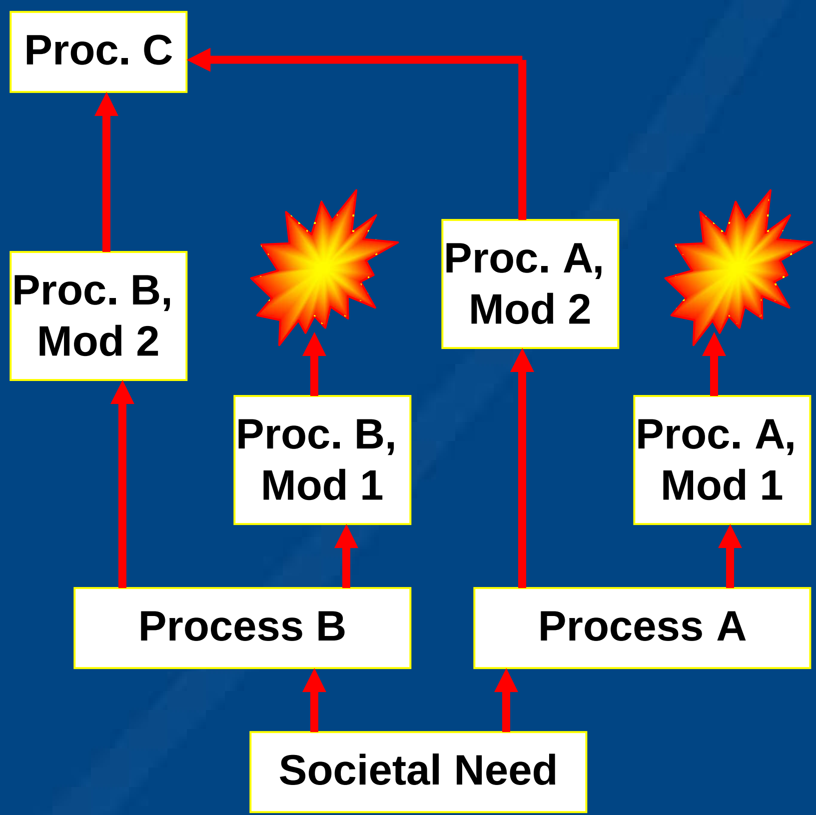
- *September 15, 1998: Difficulties starting up new line.*
- *Once started, operations ramps up to full speed. Ovens ramp up to high fire settings.*
- *Within 12 minutes of ramp initiation, an explosion, heard for 6 miles, takes place.*


Binding Agents
Water
Chopped Glass Fiber
Headbox
Natural Gas
Saturator
Dryer Zone 1
Dryer Zone 2
Dryer Zone 3
Dryer Zone 4
Winder
Thermal Oxidizer
300 ppm VOC
"Dump" Zone

Evolution or Managed Change?

Evolution or Managed Change?



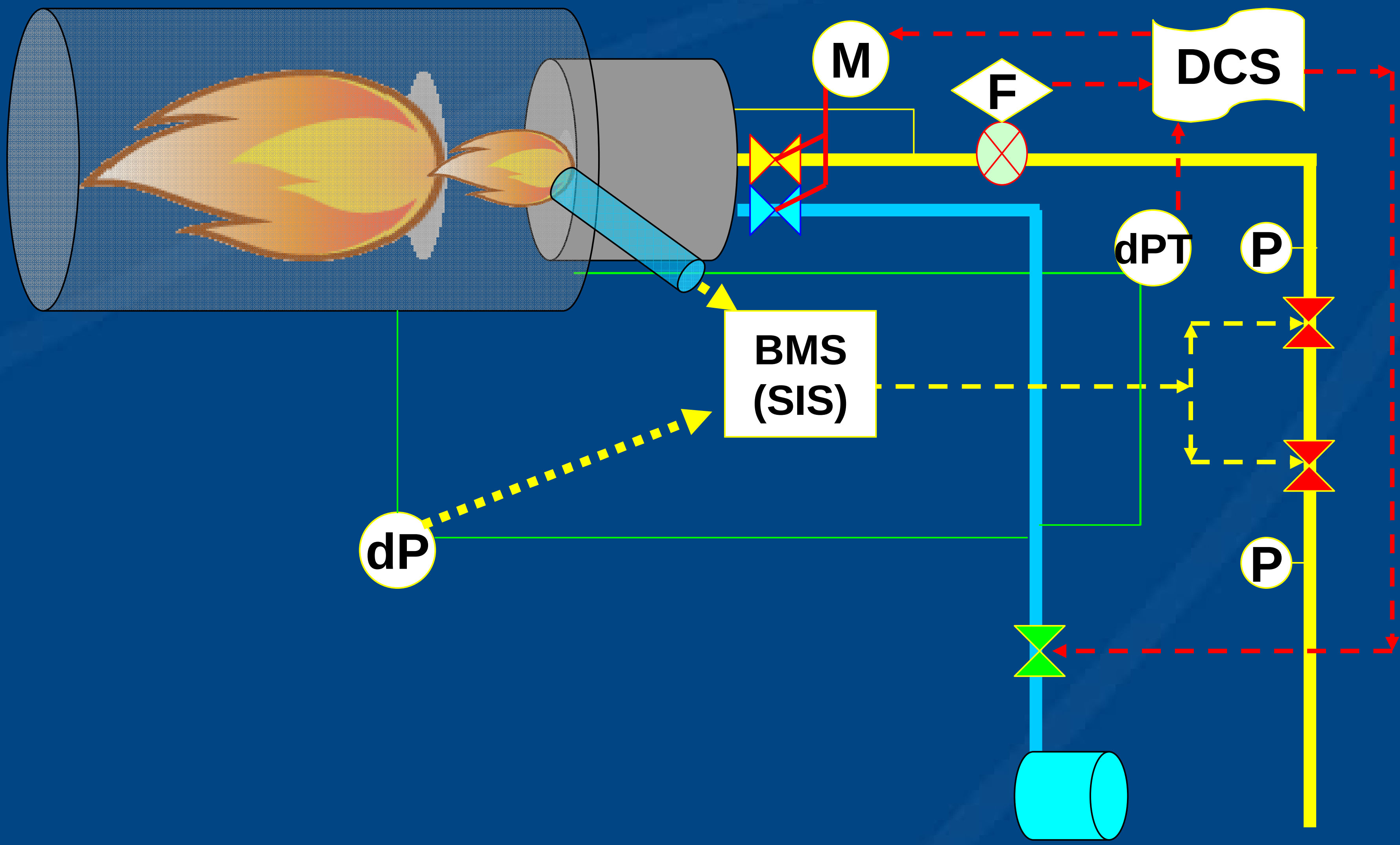


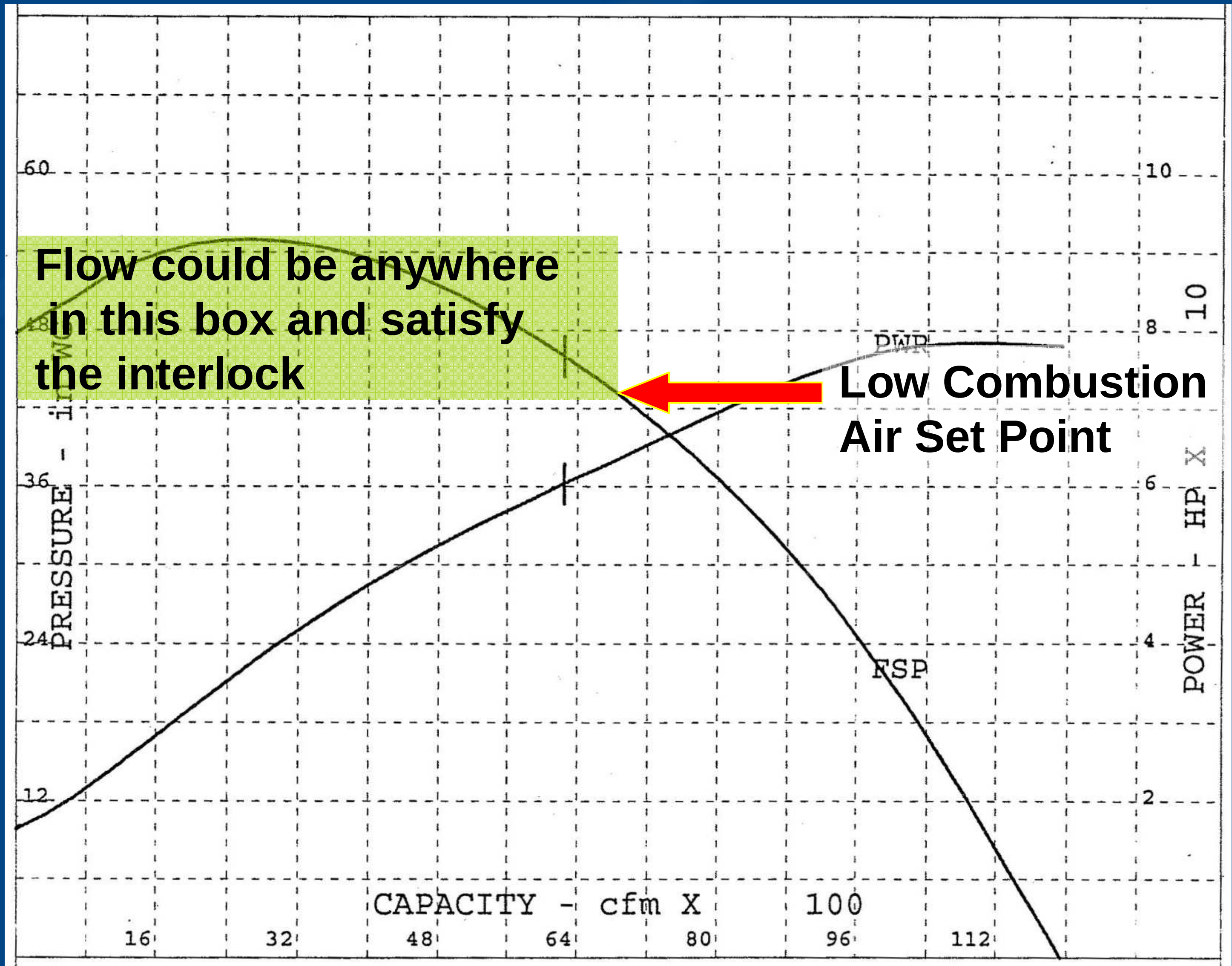
Sequence of Changes

- *Orders a machine capable of X feet/minute*
- *Changes order to 1.5 X feet/minute*
- *Machine manufacturer changes burner requirements*
- *Burner manufacturer uses same burner, but increases gas flow to get higher rating*
- *No one changes combustion air fan capability*

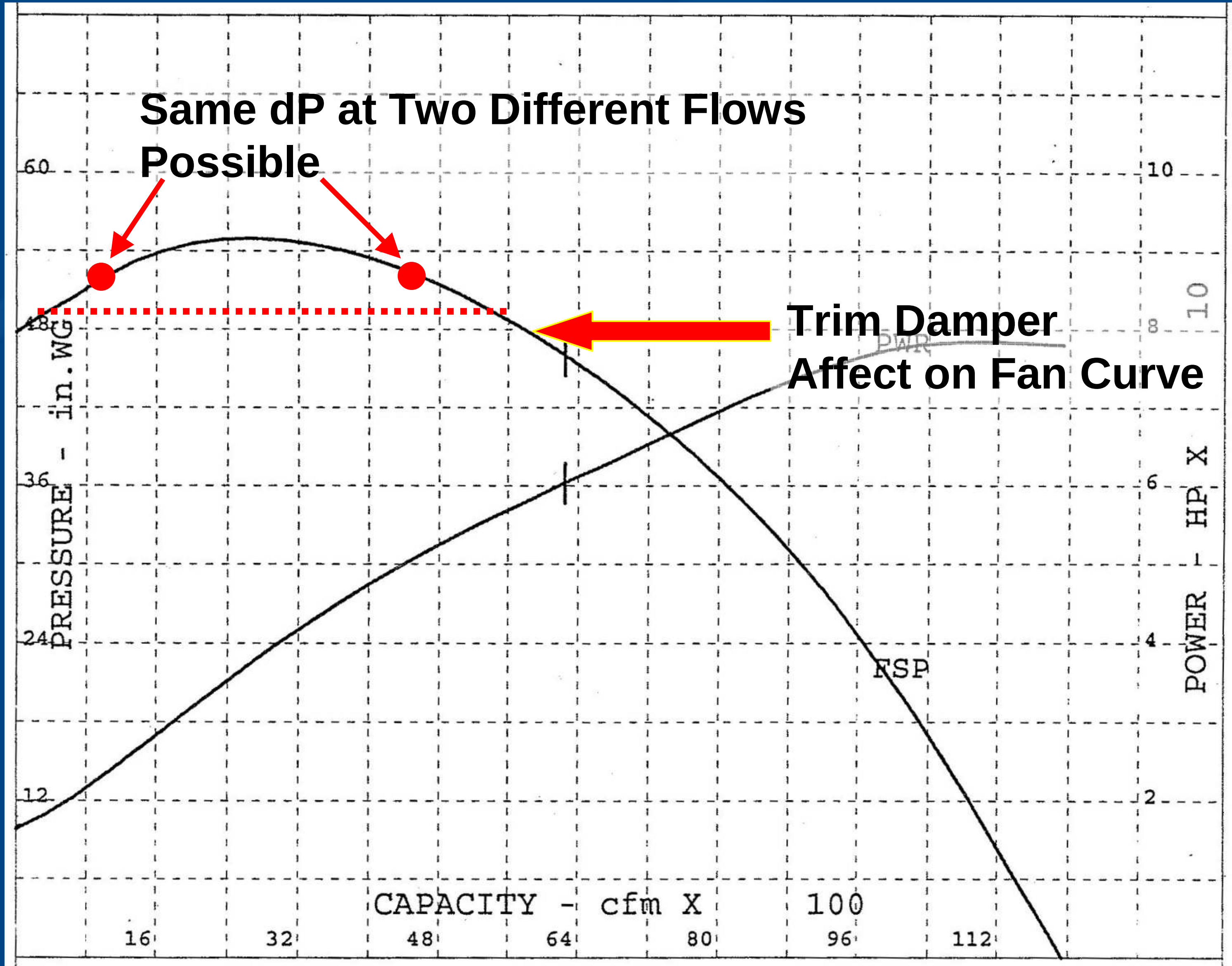
Sequence of Changes

- ***Start up problem: Unstable low fire flame***
- ***First Solution: Weighted Pressure Relief Valve on Combustion Air – Too Noisy!***
- ***Second Solution: Combustion Air Trim Damper***


M
F
DCS
dPT
P
BMS
(SIS)
dP
P



Flow could be anywhere in this box and satisfy the interlock
Low Combustion Air Set Point
PRESSURE - in WC
POWER - HP X 10
CAPACITY - cfm X 100
PWR
FSP
60
48
36
24
12
10
8
6
4
2
16
32
48
64
80
96
112


Same dP at Two Different Flows Possible
Trim Damper Affect on Fan Curve
60
48
36
24
12
PRESSURE - in.WG
10
8
6
4
2
POWER - HP X
PWR
FSP
CAPACITY - cfm X 100
16
32
48
64
80
96
112

The Burner

The Incident

21:15 Line shut down due to quality; burner at low fire

21:34 Line re-started, 12 minute ramp up to maximum speed. Burner demand set to high-fire

21:39 Leakage alarm – calculated number indicating pressure is high within oven. Operators should smell binder fumes. No smell reported. Thermal oxidizer temperature begins rising

The Incident

21:41	*Thermal oxidizer shuts down on high temperature. Machine shutdown initiated, atmospheric bypass opened.*
21:41:58	*Last of product leaves oven, triggers "sheet break" alarm.*
21:45:33	*Operator clears alarm*
21:46:04	*Explosion occurs (pressure disturbance in Zone 1)*

Explosion Venting

- ***Recommended by FM & NFPA***
  - Only for ovens regardless if flammable vapors are generated or not
  - Does this mean we do not trust combustion safeguards?
- ***Venting not provided***

Investigation

- *Identified, secured and tested the low combustion air pressure switch*
- *Confirmed valve positions and determined failure mode – Combustion air trim damper was “fail last”*
- *Found water in instrumentation lines*
- *Preserved lines and tested for effect of water on dPT*

Affect of Water in the Instrumentation Line

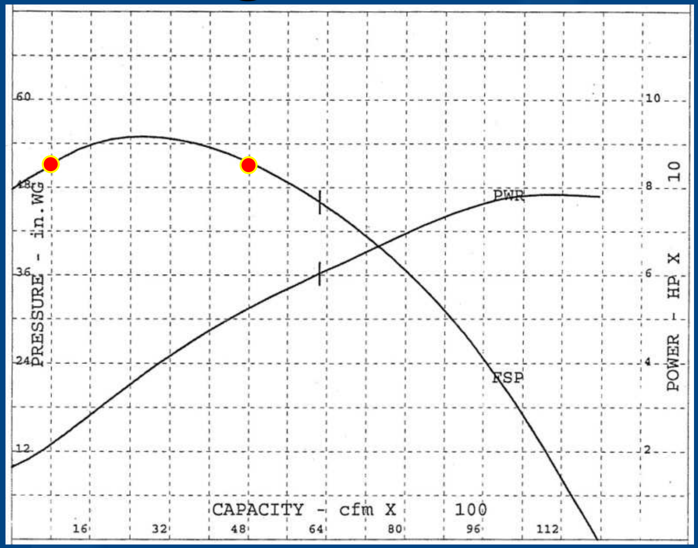
Test No.	Amount of Water	dP Applied (in. WC.)	dP from DPT (in. WC.)	Error (in. WC)
1	0 ml.	4.1	4.1	0
2	5 ml.	4.8	6.0	1.2
3	10 ml.	4.1	5.9	0.8
4	15 ml.	4.12	6.17	2.05
5	20 ml.	4.3	5.1	0.8

Conclusions

- ***Failure to manage change:***
  - ***Upsized burner from 30 MM to 40 MM BTU***
  - ***Never increased fan rating***
  - ***Original specification of 14:1 air/fuel ratio***
  - ***Actual ability at high fire was 10:1***

Conclusions

- ***Failure to manage change:***
  - ***Due to flame instability at low fire, dP was reduced first by relief valve, then by trim damper***
  - ***Fan curve truncated resulting in multi-point dP***
  - ***Allowed trim damper to seek low flow position***



Conclusions

- *Failure to properly install:*
  - *Instrument locations changed to become accessible without building ladders/platforms*
  - *Tap points were higher than instruments*
  - *Condensate filled lines*
  - *Induced error*
  - *Corroded switch contact closed*

Conclusions

- ***Questionable design of burner***
  - Seemed to meet code, but high fire flame was not monitored
  - Low fire flame monitored and stayed lit
  - Became ignition source of explosion

Conclusions

- *We are not measuring meaningful parameter*
  - *Combustion air pressure limits do not mean we have sufficient air for combustion!*
- *We assume linkage will not slip or bind*
  - *Linkage slip has happened!*

Conclusions

- *Should we measure air and fuel flow instead?*
  - *Ratio control and interlock systems?*
- *How about measuring combustibles in the exhaust?*
- *Can we make them reliable enough to preclude the need for venting?*
  - *ASME Code Case 2211?*
  - *SIL 1 or 2 needed?*

Glass Mat Industry Safety Group

Phil Halpin, GAF-ELK
Glass Mat Industry Safety Group Member

TAPPI Building & Industrial Mat Meeting
May 28, 2010

Johns Manville

Malarkey

Fiberteq

Owens Corning

Glass Mat Industry Safety Group

GOAL

Keep anyone from getting hurt in our plants

St. Gobain

TAMKO

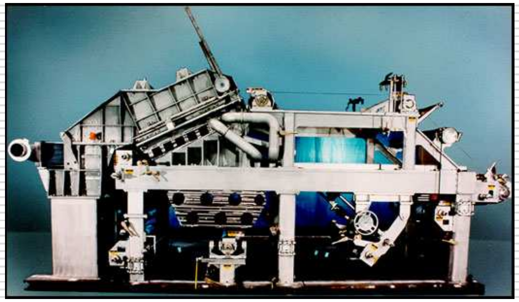
Conglas

GAF-ELK

Background

- Followed a fatal accident at a member company
- Appeal to join forces to eliminate injuries
- 2007 Ashley Safety Summit
- Website Developed: www.glassmatsafety.org
- 2008 Benchmarking visit Verso Paper
- Monthly Conference Calls

Monthly Calls



- Safety Shares
- Best Practices
- Equipment
- Safety Training & Systems
- Post on www.glassmatsafety.org

Ladder Rung Covers

Tufco Flooring

Next Steps & Future Focus

- "Future Focus" sub-team developed and plans to meet in Q3 to work on the following:
  - Structure of the group to ensure effectively meeting the original vision of the safety group
  - Development of a rotational leadership plan
  - Development of a strategy that will ensure this group stays together and committed to providing the glass mat industry an avenue for sharing safety best practice, etc., as company representatives change
  - Development of a plan to increase involvement / participation to include a plan to get Senior Leaders in the industry to assure their companies' commitment to this Group's purpose.

Glass Mat Industry Safety Group

Please join us……

Send your contact information to: PHalpin@GAF.com