EQUITECH

IN-LINE PROCESS MEASUREMENT

Optimizing Processes • Maximizing Quality • Minimizing Waste

Outline

- Why Equitech?
- Background
- In-line process measurement
- Production vs. lab data
- Benefits we offer
- Industries
- Applications
- Payback/ROI

“Pharmaceutical industry wastes $50 billion a year due to inefficient manufacturing”
theSource *By Shula Neuman October 9, 2006*

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In the Plastics Industry the Conversation has Changed

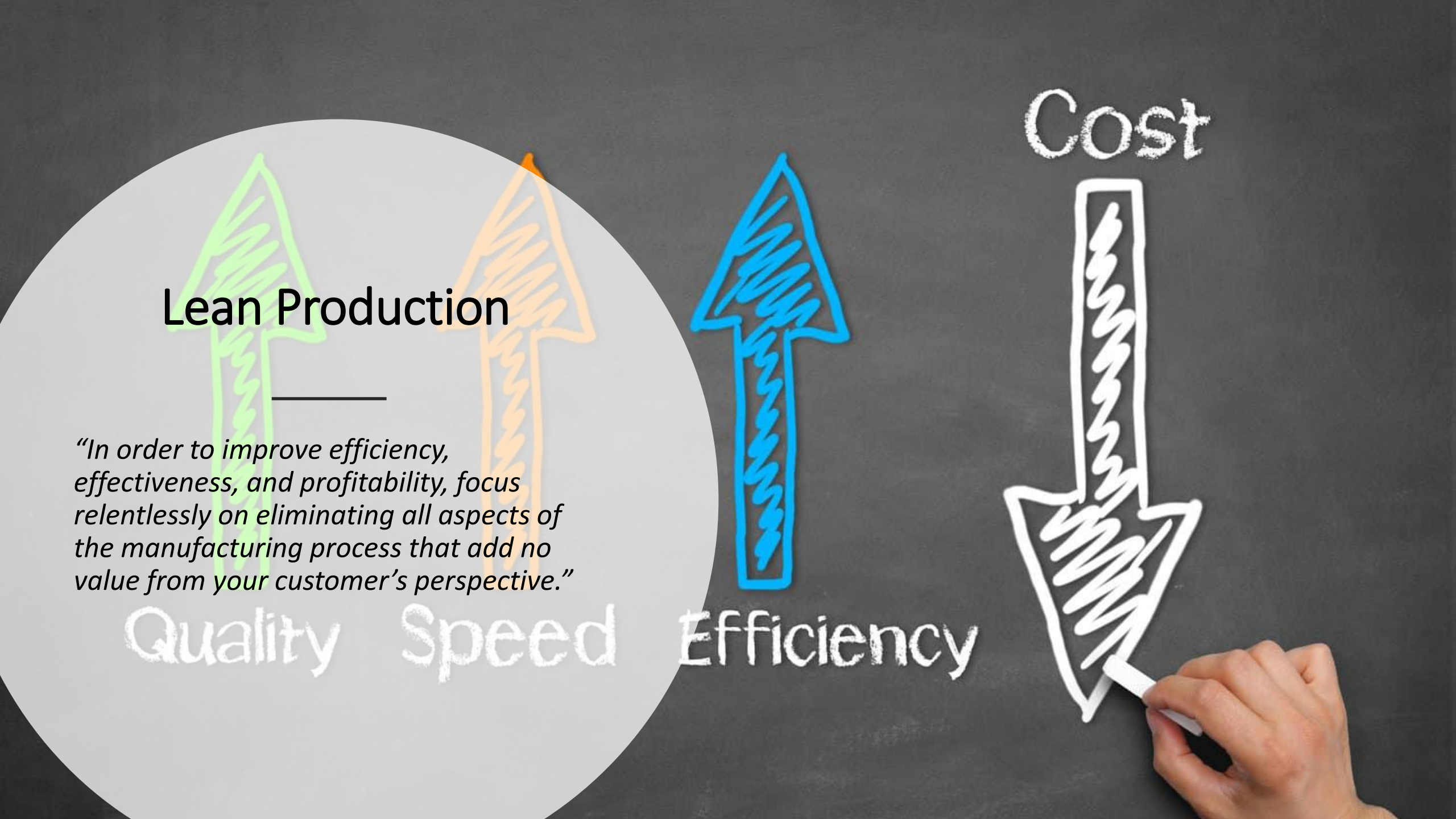
- Plastics have made modern life possible
- Most plastics are only used once
- Plastics are polluting our waters
- Significant growing pressure to address plastics waste in all forms

Disposal of Paints, Solvents & Chemicals

- Potential Classification as Hazardous Waste
- Expensive to dispose
- Ignitability
- Toxicity
- Reactivity
- Corrosivity

Lean Production

“In order to improve efficiency, effectiveness, and profitability, focus relentlessly on eliminating all aspects of the manufacturing process that add no value from your customer’s perspective.”



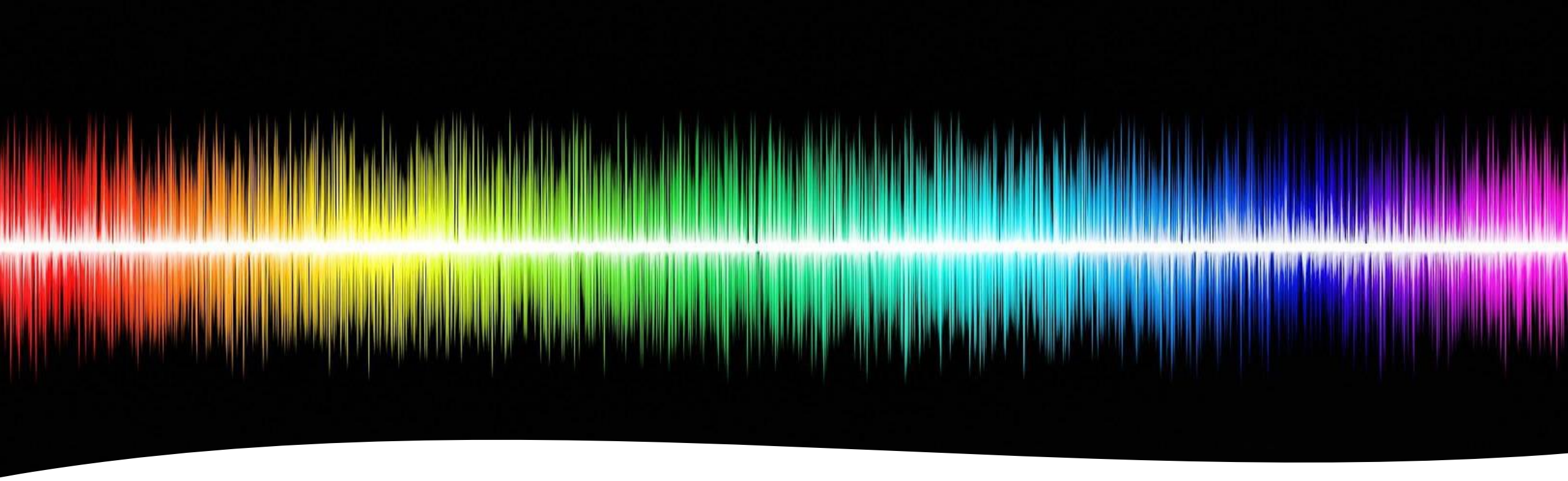
Industry 4.0

"Industry 4.0 refers to a new phase in the Industrial Revolution that focuses heavily on interconnectivity, automation, machine learning, and real-time data"

Real-Time Data

"Real-time data is a necessity to stay relevant for today's business and it needs to be delivered by sophisticated electronic communications tools such as digital signage and data dashboards, to remain appealing to today's 'tech-savvy' workforce from call centers to retailers, to manufacturing plants."

(Fourth Source, August 1, 2017)



Background

- Leaders in fiber-optic spectroscopy
- Recognized need for in-line process control in UV-VIS region of EM spectrum
- Developed a fully vertical integrated solution (hardware & software)
- Established recognized references in the market

In-Line Process Measurement

- It’s about getting real-time data
- Applicable for both batch & continuous manufacturing
- Positively affects company’s bottom line

General Process Diagram

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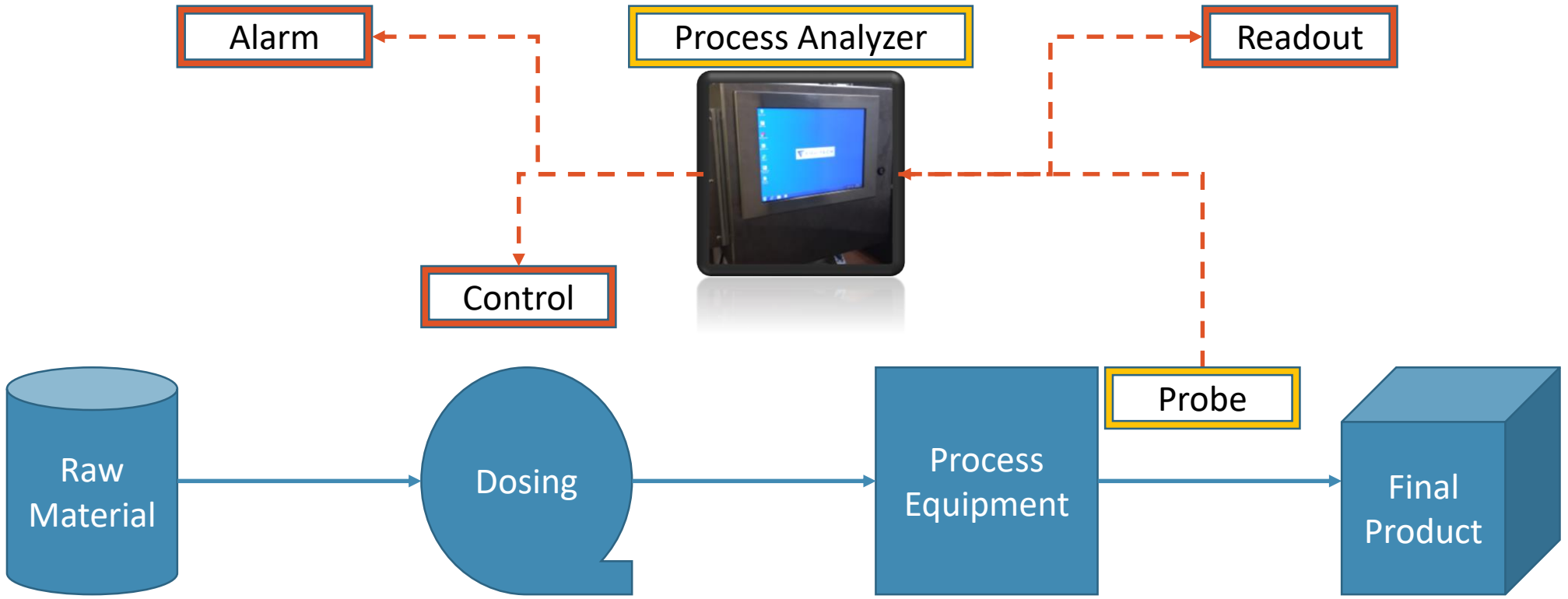
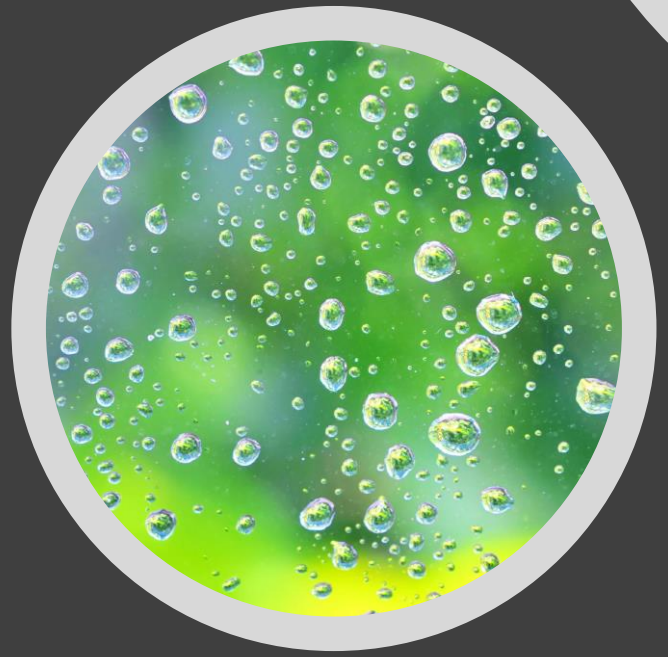


Examples of Processes Amenable to Equitech's Technology

- Plastics Extrusion
- Flow reactors
- Separations
- Crystallization
- Blending
- Granulation
- Drying
- Coating
- Sterilization

Process vs. Laboratory Measurements



Movement

Pressure

Inline Process Measurement

Temperature

Interference

In-line Process Measurements vs. Laboratory Measurements for Process Control

In-line Measurements

- Real time results
- Immediate adjustment to process
- Early detection of out-of-spec product
- Less off-spec product made
- Process correction before off-spec products are manufactured
- Improve understanding of process behavior

Laboratory Measurements

- Delayed results
- Delayed adjustment to process
- Late detection of out-of-spec product
- More off-spec product made
- Process correction after off-spec product are manufactured
- No understanding of process behavior

High-Grade Instrumentation

- Laboratory-quality performance specifications
  - Wavelength resolution, accuracy & repeatability
  - Low noise
  - Wide dynamic range
- Rugged and reliable
  - One moving part
  - Easily serviced

Sample Types

- Equitech offers fiber-optic probes for:
  - Liquids (Aqueous and Organic)
  - Slurries
  - Pastes
  - Powders
  - Coatings
  - Films
  - Polymers

Equispec™
Process Analyzers

- Chemical Process Analyzer
- In-line Color Spectrophotometer
- Film Thickness Analyzer

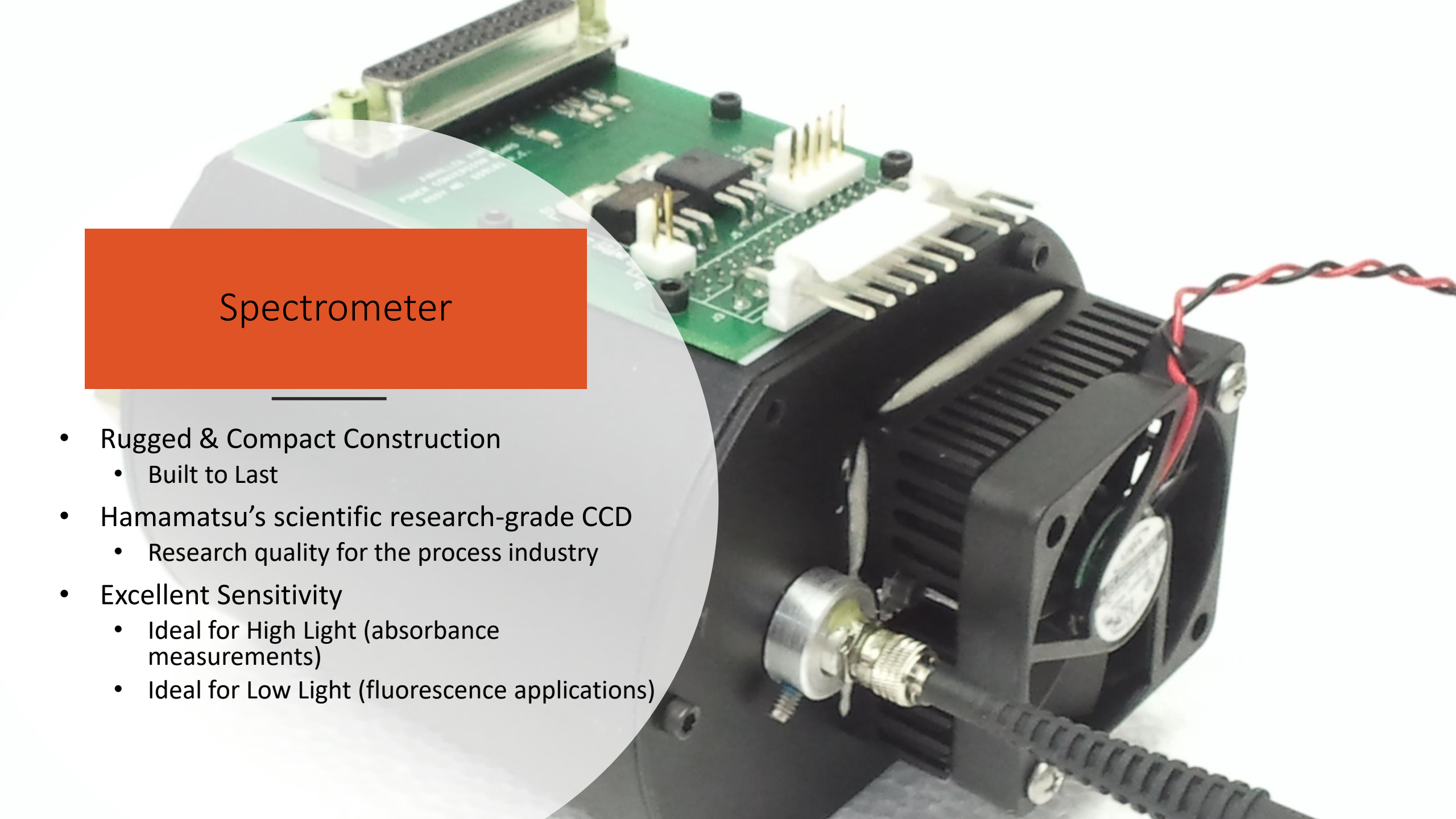
Components

- Illumination Source
- Spectrometer
- Probe(s)
- Industrial Computer w/ Touch Display
- Software
- NEMA Box

Illumination Source

- Xenon
- Deuterium
- Tungsten – Halogen

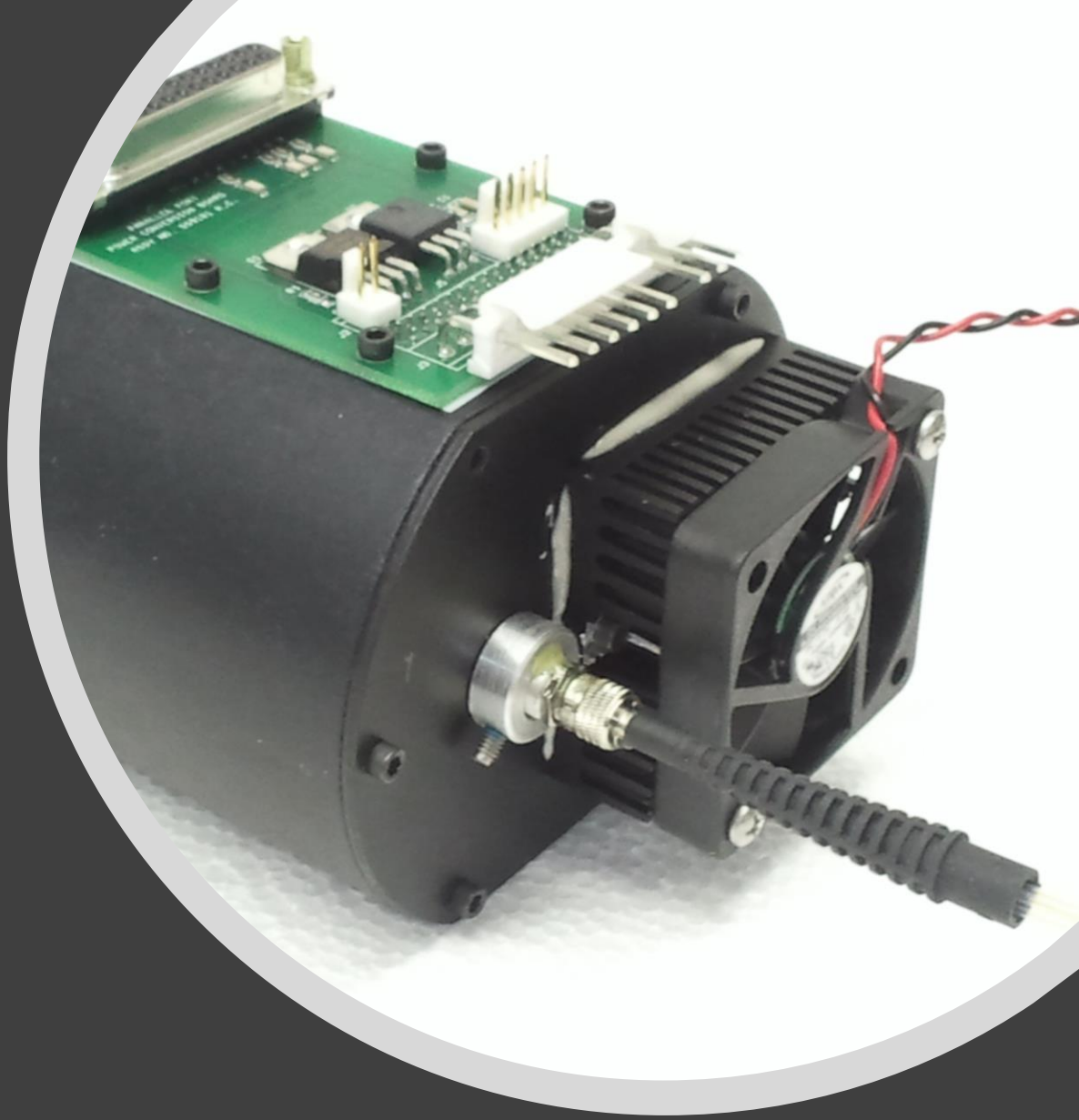
Spectrometer



- Rugged & Compact Construction
  - Built to Last
- Hamamatsu’s scientific research-grade CCD
  - Research quality for the process industry
- Excellent Sensitivity
  - Ideal for High Light (absorbance measurements)
  - Ideal for Low Light (fluorescence applications)

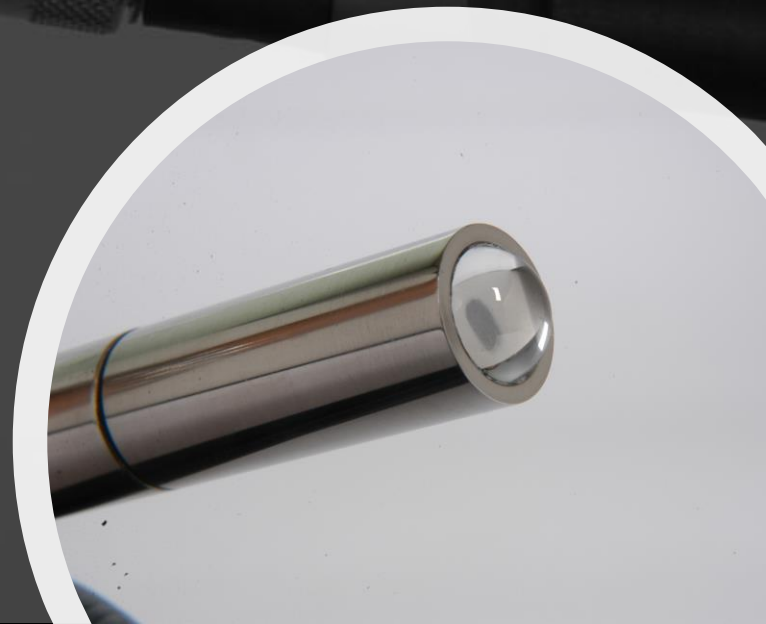
Spectrometer

- Low noise (5 x 10^{-5} au rms)*
- High signal-to-noise ratio (20,000:1)*
- Wide dynamic range (> 50,000)*
- High sensitivity (10 electrons / count)
- High resolution (< 0.75 nm @ 580 nm)
- Broad spectral coverage
  - Chemical, Color: 200-800 nm
  - Film Thickness: 375-975 nm
- Integration times from 10 ms to 60 s
- *100 reads of 10 ms exposures = 1 second acquire time



Probes

- **Measurement Type**
  - Transmittance
  - Reflectance
- **Probe Construction**
  - Process pressure and temperature
  - Chemical compatibility
- **Path Length**
  - Addresses sample concentration
- **Allowance**
  - Addresses particles, bubbles, etc.
- **Type of Sample**
  - Contact
  - Non-contact



Probes Technical Specs

Probe	Type	Optics Choices			Optical Path Length (mm)	Temperature Range (C)	Pressure (psi)
		UV Fused Silica	NIR Fused Silica	Sapphire			
Reflection Polymer Melt Probe	Reflection			Yes	0 (Contact)	10 - 500	5000
Transmission Polymer Melt Probe	Transmission			Yes	5 - 12, custom	10 - 500	5000
Retro-Reflection Probe	Transmission	Yes	Yes	Yes	2, 5, 10, 20, 50	0 - 260	3000
Transmission Cell	Transmission	Yes	Yes	Yes	1, 2, 10, 20, 50, 100, custom	0 - 260	3000
Micro-Path Transmission Cell	Transmission	Yes	Yes	Yes	.5 - 1	0 - 260	3000
Attenuated Total Reflection Probe	Transmission	Yes	Cubic Zirconia	Yes	1.5 microns	0 - 260	1200
Color Probe	Reflection			Yes	0 - 2	0 - 260	2000
Large-Area Surface Probe	Reflection	Yes			20 (standoff distance)	0 - 50	15
Transmission Lenses	Transmission	Yes	Yes		25 - 1000	0 - 50	15
LASP/Integrating Sphere	Transmission	Yes			150 - 200 (standoff distance)	0 - 50	15

Probe	Diameter (in)	Body	Seals	Fiber Type		Fiber* Length, standard (m)	Extension tube length (in)
				UV Silica Core/Silica Clad	NIR Silica Core/Silica Clad		
Reflection Polymer Melt Probe	0.5	SS, Hastelloy	Metal to sapphire	Standard	Optional	5	N/A
Transmission Polymer Melt Probe	0.5	SS, Hastelloy	Metal to sapphire	Standard	Optional	5	N/A
Retro-Reflection Probe	0.5	SS, PEEK, Ti	Kalrez	Yes	Yes	3	4, custom
Transmission Cell	1.25	SS	Kalrez	Yes	Yes	3	2
Micro-Path Transmission Cell	1.125	SS	Kalrez	Yes	Yes	1	N/A
Attenuated Total Reflection Probe	0.5	SS, PEEK, Ti	Kalrez	Standard	Optional	3	4, custom
Color Probe	0.75	SS, Ti	Kalrez	Standard	Optional	5	8
Large-Area Surface Probe	N/A		N/A	Standard	Optional	3	N/A
Transmission Lenses	N/A		N/A	Yes	Yes	3	N/A
LASP/Integrating Sphere	N/A		N/A	Standard	Optional	3	N/A

*PVC-coated steel monocoil; PTFE sleeve optional

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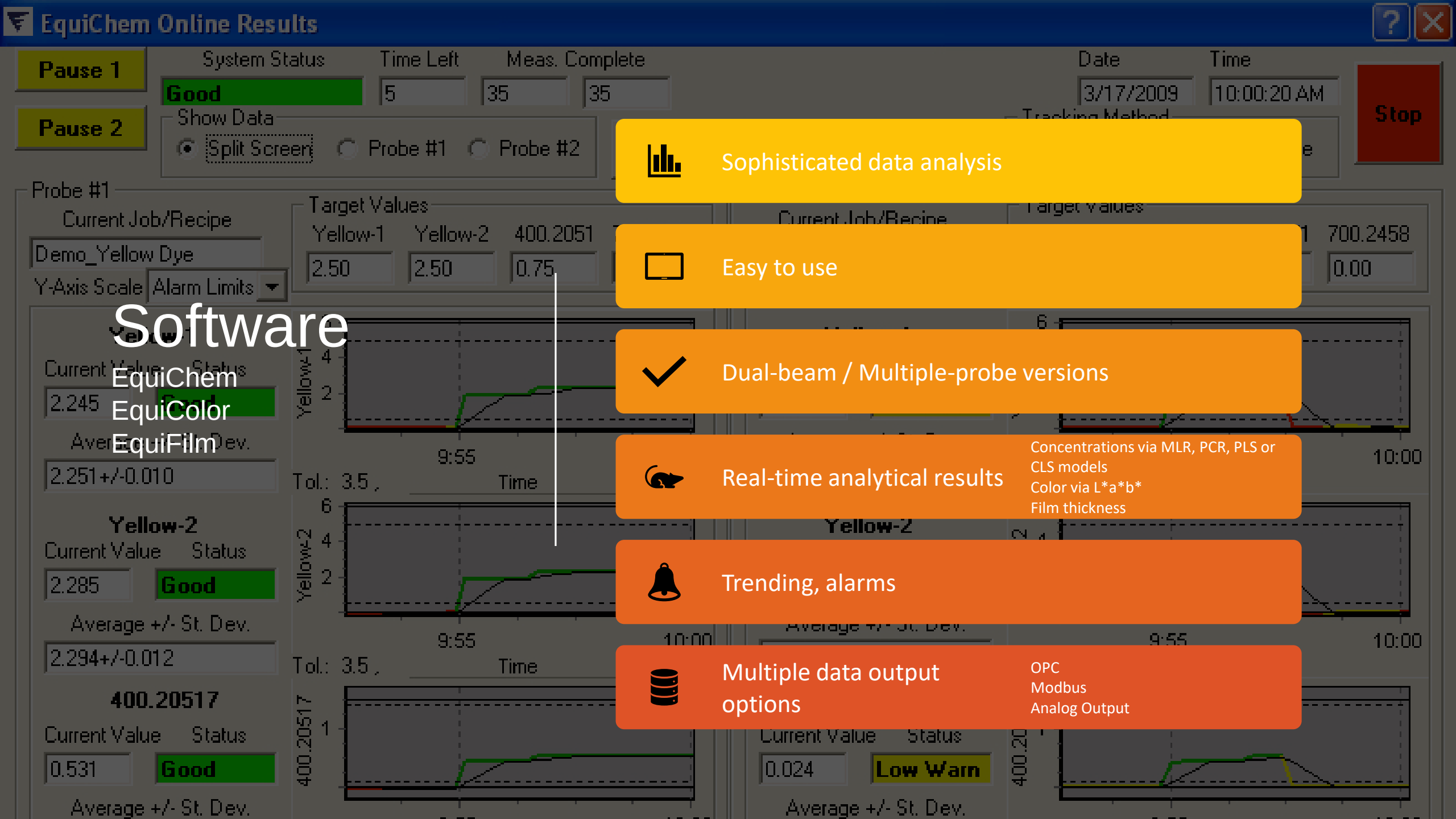
ALL PROBES – TECHNICAL SPECIFICATIONS

Probe	Type	Optical Path Length (mm)	Diameter (in)	Temp. Range (°C)	Pressure (psi)	Seals	Body
Reflection Polymer Melt Probe	Reflection	0 (Contact)	0.5	10 – 500	5000	Metal to Sapphire	SS, Hastelloy
Transmission Polymer Melt Probe	Transmission	5 – 12, Custom	0.5	10 – 500	5000	Metal to Sapphire	SS, Hastelloy
Retro-Reflection Probe	Transmission	2, 5, 10, 20, 50	0.5	0 – 260	3000	Kalrez	SS, PEEK, Ti
Transmission Cell	Transmission	1, 2, 10, 20, 50, 100, Custom	1.25	0 – 260	3000	Kalrez	SS
Micro-Path Transmission Cell	Transmission	.5 – 1	1.125	0 – 260	3000	Kalrez	SS
Attenuated Total (Internal) Reflection Probe	Transmission	1.5 microns	0.5	0 – 260	1200	Kalrez	SS, PEEK, Ti
Color Probe	Reflection	0 – 2 (sampling depth)	0.75	0 – 260	2000	Kalrez	SS, Ti
Large-Area Surface Probe	Reflection	20 (standoff distance)	N/A	0 – 50	15	N/A	
Transmission Lenses	Transmission	25 – 1000	N/A	0 – 50	15	N/A	
LASP/Integrating Sphere	Transmission	150 – 200 (standoff distance)	N/A	0 – 50	15	N/A	

	OPTICS CHOICES			Fiber Type			
Probe	**UV Fused Silica**	**NIR Fused Silica**	**Sapphire**	**UV Silica Core/ Silica Clad**	**NIR Silica Core/ Silica Clad**	**Fiber* Length Standard (m)**	**Extension Tube Length (in)**
Reflection Polymer Melt Probe			Yes	Standard	Optional	5	N/A
Transmission Polymer Melt Probe			Yes	Standard	Optional	5	N/A
Retro-Reflection Probe	Yes	Yes	Yes	Yes	Yes	3	4, Custom
Transmission Cell	Yes	Yes	Yes	Yes	Yes	3	2
Micro-Path Transmission Cell	Yes	Yes	Yes	Yes	Yes	1	N/A
Attenuated Total (Internal) Reflection Probe	Yes	Cubic Zirconia	Yes	Standard	Optional	3	4, Custom
Color Probe			Yes	Standard	Optional	5	8
Large-Area Surface Probe	Yes			Standard	Optional	3	N/A
Transmission Lenses	Yes	Yes		Yes	Yes	3	N/A
LASP/Integrating Sphere	Yes			Standard	Optional	3	N/A

PVC-coated steel monocoil; PTFE sleeve optional


EquiChem Online Results
Pause 1
Pause 2
System Status
Good
Time Left
5
Meas. Complete
35
35
Date
3/17/2009
Time
10:00:20 AM
Stop
Show Data
Split Screen
Probe #1
Probe #2
Probe #1
Current Job/Recipe
Demo_Yellow Dye
Y-Axis Scale
Alarm Limits
Target Values
Yellow-1
Yellow-2
400.2051
2.50
2.50
0.75
700.2458
0.00
Current Value
Status
2.245
Average +/- St. Dev.
2.251+/-0.010
Yellow-2
Current Value
Status
2.285
Good
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2.294+/-0.012
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Good
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Tol.: 3.5
Time
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Current Value
Status
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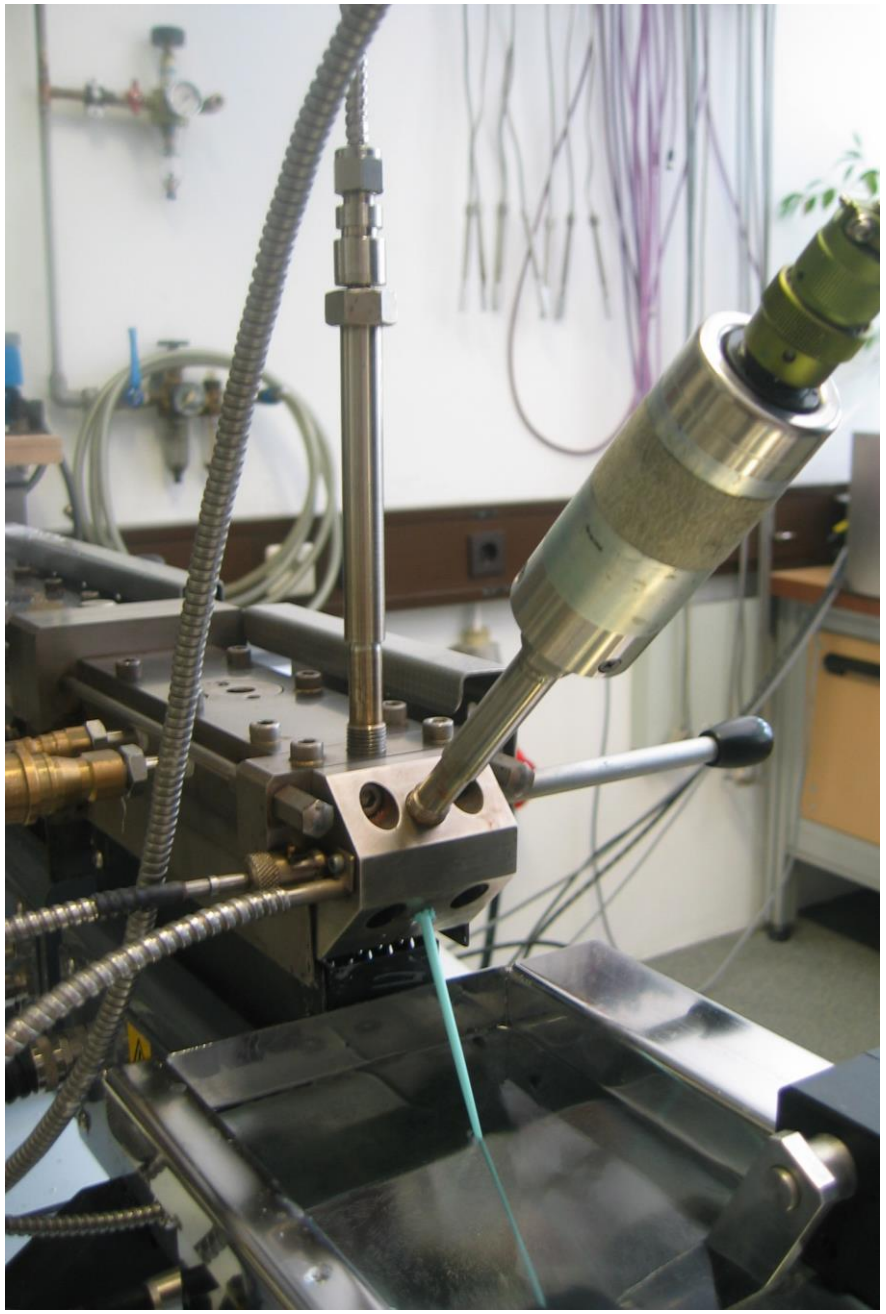
Low Warn
Average +/- St. Dev.
Software
EquiChem
EquiColor
EquiFilm
Sophisticated data analysis
Easy to use
Dual-beam / Multiple-probe versions
Real-time analytical results
Concentrations via MLR, PCR, PLS or CLS models
Color via L*a*b*
Film thickness
Trending, alarms
Multiple data output options
OPC
Modbus
Analog Output

EquiChem Online Results

Applications

- Chemical Concentration
- Color Measurement
- Turbidity & Haze
- Film Thickness



Plastics Industry
Color Measurement

In a Laboratory Extruder

Plastics Industry Color Measurement

In a Production Extruder

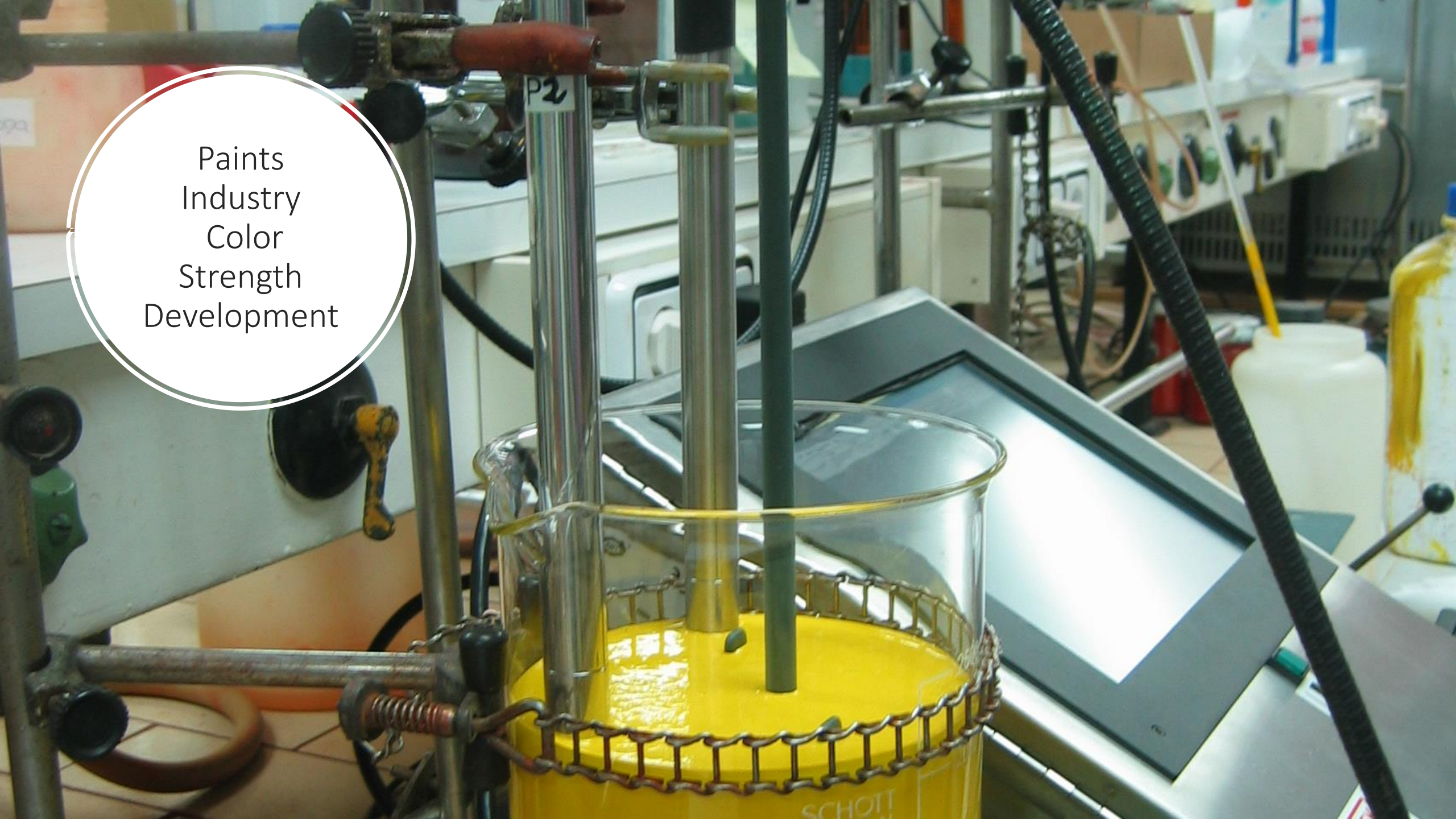
Plastics
Industry
In-line Color
Measurement

Reflection Polymer Melt Probe
In Position – Close Up

Residence Time

- An in-line UV-Vis spectrophotometer can be used to gain insights into the effects of process variables on residence time distribution
  - Effects of feed rate and screw speed
  - Effect of screw design
  - Contributions of individual elements
- A basic theoretical estimate of the residence time agreed with experimental data

Paints Industry – Color Strength Development Test



Paints
Industry
Color
Strength
Development

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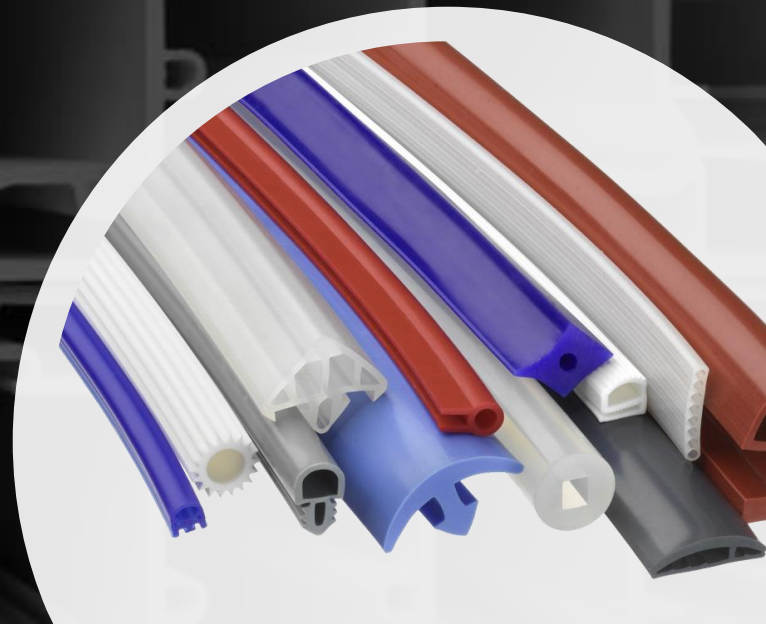
Paint Industry Color Strength Measurement

In Production

Off-Spec Material Production

Loss Calculation

- Opportunity Cost
- Energy Waste
- Material Waste
- Operating Losses
- Downtime & Process Restoration Losses
- Shipping, Packaging & Interest Losses
- Potential Legal Claims
- Machine Wear & Tear



Off-Spec
Material
PLASTIC SHEET

Off-Spec Material MASTERBATCH

- Wasted Material, Energy, and Time during Color Changes

Plastics Extrusion Cost Example (24x7x365)

- Extrusion Production
  - 150,000 lbs. / week
- Material Consumption
  - $200,000 / week
- Raw Material Losses
  - $3,000 / week
- Estimated Annual Production Loss
  - 172.5 hours
- Estimated Total Annual Losses
  - $190,000

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Equispec + Probe System Cost	Payback (Months)
$40,000	2.6
$50,000	3.2
$60,000	3.9
$70,000	4.5

Benefits of Equitech's Technology

- IMPROVED UNDERSTANDING OF THE PROCESS
- TIGHTER PRODUCT QUALITY CONTROL
- INCREASE OF CAPACITY THROUGH EFFICIENCY IMPROVEMENT
- DIAGNOSIS OF MANUFACTURING PROBLEMS
- ENABLE CLOSED LOOP CONTROL

Thank you for your attention!

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