PeCOD® COD Monitoring

| FAST, SAFE & GREEN Results |

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PeCOD® COD Analyzer

- A patented technology that measures Chemical Oxygen Demand (COD) in real time by oxidizing organic matter, and measuring the extent of oxidation
- PeCOD® eliminates the use of **mercury and potassium dichromate**
- Safe for the environment and the analyst
- Results in less than 15 minutes
  - Final effluent in <7 minutes
- Accurate method with a detection limit of 0.7 mg/L, and upper range of 15,000 mg/L

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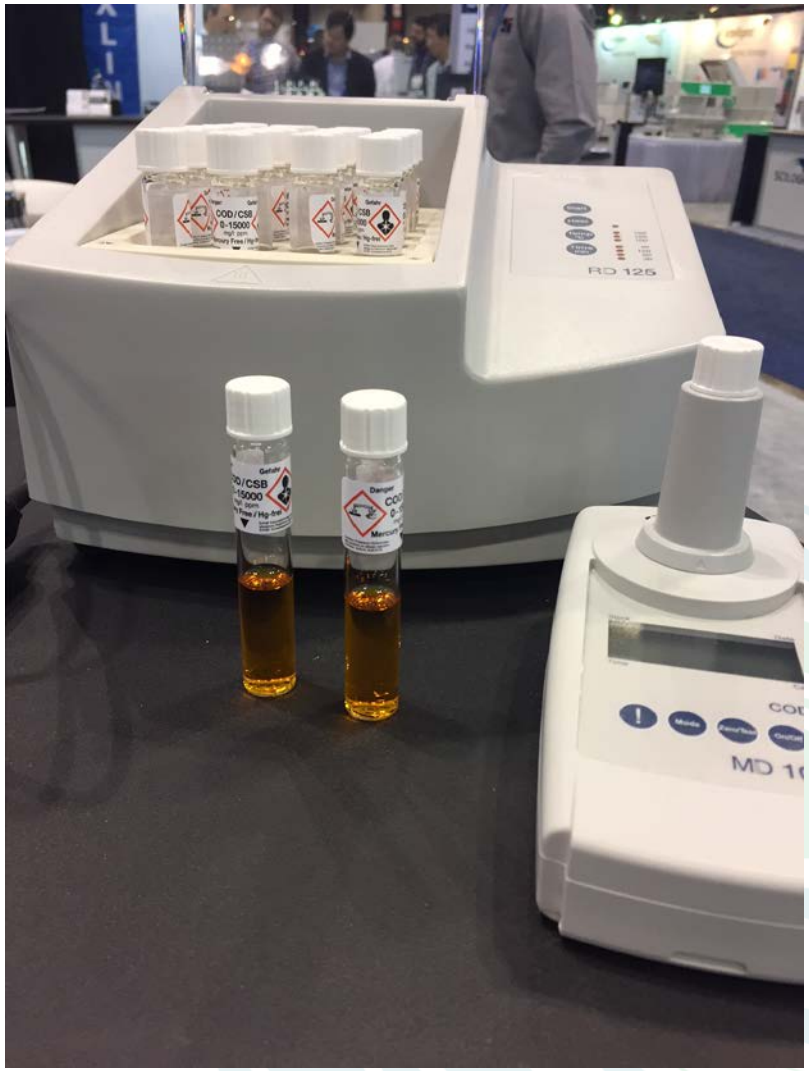
Chemical Oxygen Demand

- Chemical oxygen demand (COD) is the amount of oxygen required to fully oxidize organic matter
    - It is used as a measurement of the oxygen-depletion capacity of a sample contaminated with organic waste
- COD is a valuable measurement for the determination of water quality in natural waterways and waste streams



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Nanotechnology

- The core of the technology is the PeCOD® Analyzer sensor, which consists of a UV-activated nanoparticle TiO_2 (titanium dioxide) photocatalyst coupled to an external circuit.
- The powerful oxidizing potential of UV-illuminated TiO2 ensures that virtually all species will be fully oxidized giving a true measure of COD.

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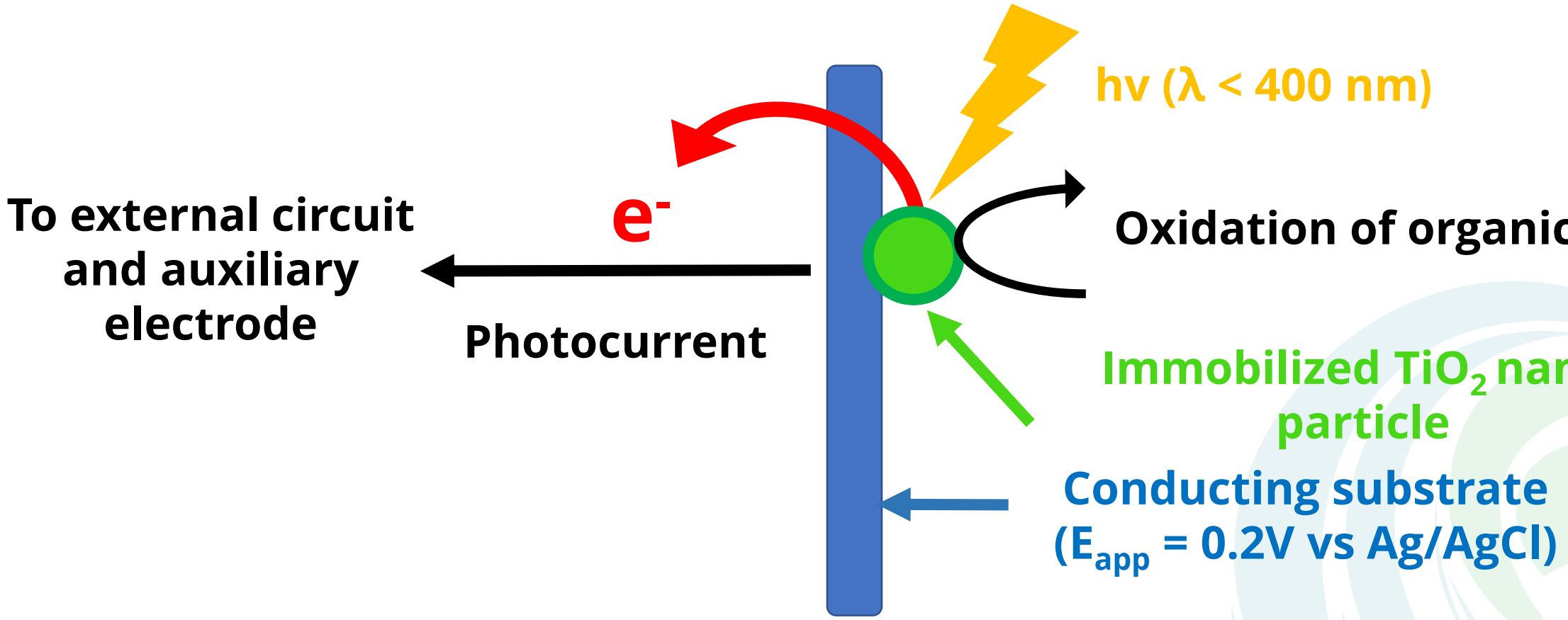
| PeCOD® | A Nanotechnology Based Approach



Roughly 2 times the oxidizing power vs. dichromate

- i.e. Benzene, 1.8 by COD_{Cr} and 2.6 by peCOD

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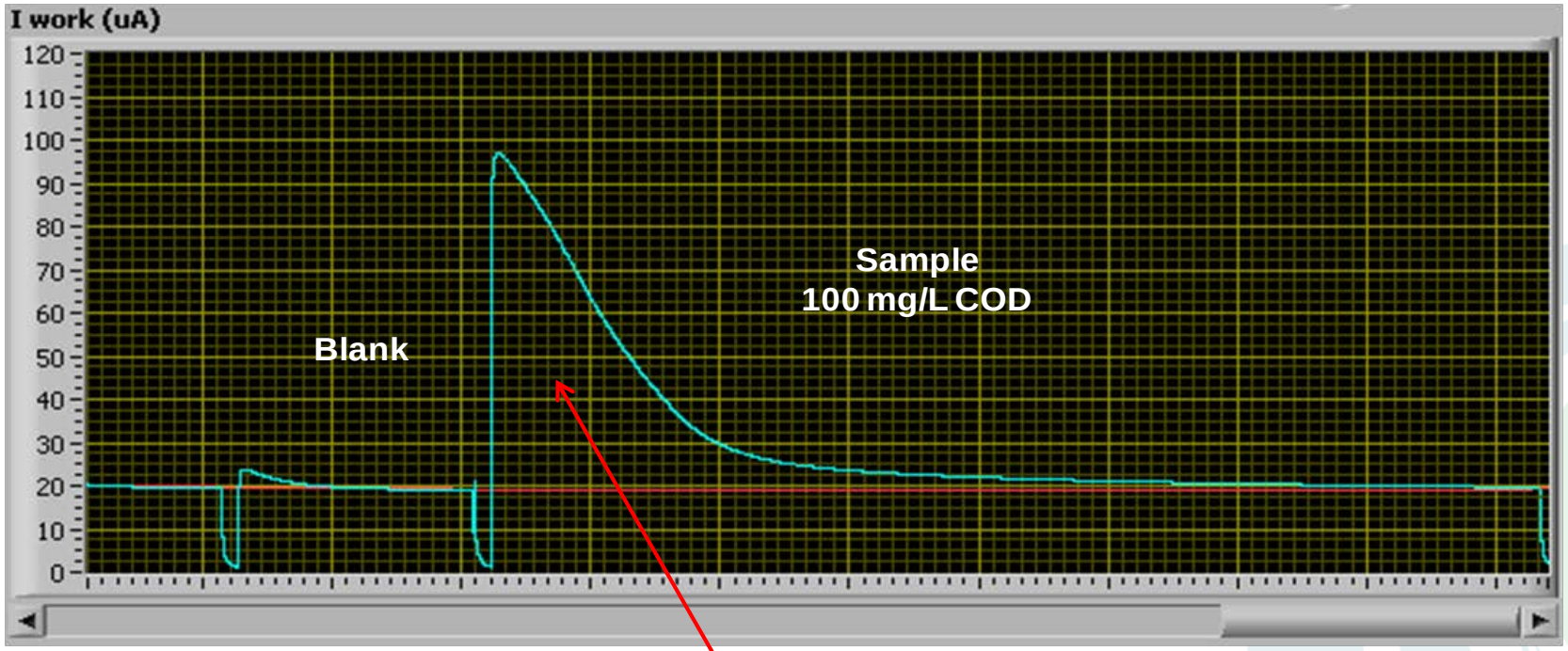
Electrons to COD



Time 4 min

Area under curve = Q_{net}

COD = $k \cdot (Q_{net} - Q_{blank})$

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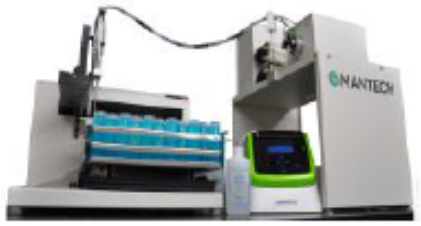
PeCOD® Analyzer System Configurations

Description	Benchtop L100	Automated L100	Online L100	Online P100
				
Area for Installation	Minimal bench space	Minimal bench space	Can be installed on a table, rolling cart or in a cabinet	Mounted on wall/stand or mounted to ground with feet

Pulp & Paper Installations To Date

- Multiple Benchtop PeCOD's in a single mill for Rapid Simultaneous Testing of multiple sampling points
  - Laboratory and Directly in the Treatment Plant
- PeCOD with Autosampler for laboratory supporting multiple mills
- Online is not yet available for Pulp & Paper due to sample filtering and biological growth before the analyzer

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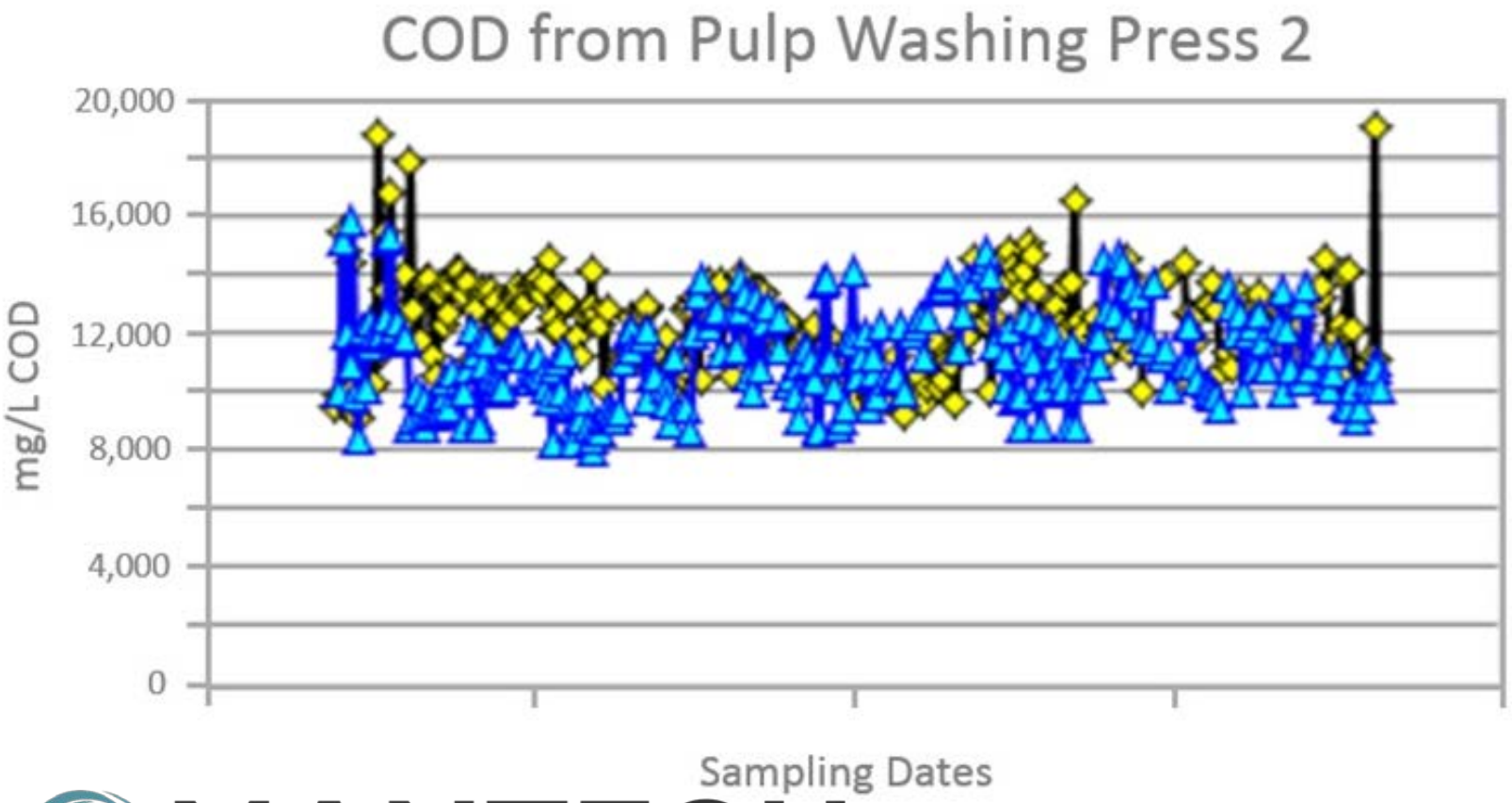
ARAUCO
Growing the Future

PeCOD generated US$10,000/day in savings!



National award for improving Sustainability Health & Safety, and Profit.

They now have 5 PeCOD units in 2 mills.
Engineers can ALWAYS have a result within 15 min, sampling from any point.

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Joint Finland and Canada Project

CORECOD
Novel Concepts for Recalcitrant COD Reduction

Supporting Sustainability

PeCOD chosen as the COD testing solution, since rapid test results with true COD method (not surrogate) was critical

NOT Selected by CORECOD Project:

- CODcr

- TOC

- UV254

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Poster at NWBC, Stockholm, 2017

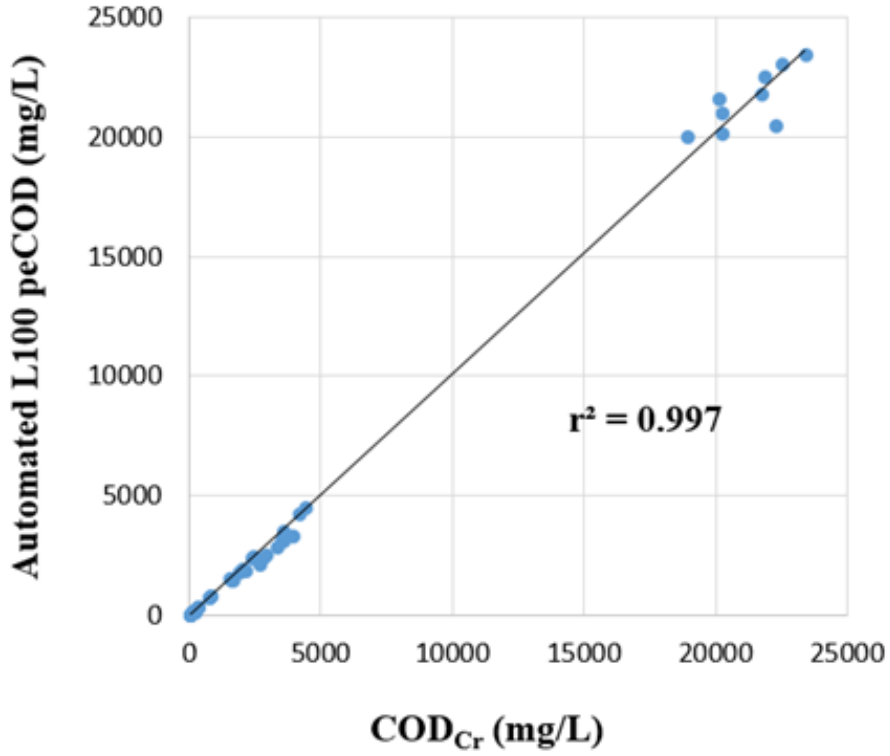
Improved Wastewater Treatment & Mill Performance with new COD monitoring Technology

Robert Menegotto[1], Stephanie Horner[1], Pauliina Tukianien[2], Antti Grönroos[2], Marjatta Piironen[3], Sakari Halttunen[3], Iiris Joensuu[3], Serge Genest[4], Brian O'Connor[4]

[1]MANTECH, Canada, [2]VTT, Finland, [3]Kemira, Finland, [4]FPInnovations, Canada

Abstract

- The objective of this transnational project is to determine novel concepts for the reduction of recalcitrant chemical oxygen demand (COD) in water intensive industries, with a focus on the pulp and paper industry. A new COD method, photoelectroChemical Oxygen Demand (peCOD), is being utilized to help evaluate the COD reduction of the new water treatment technologies and methods at various stages of the pulp and paper wastewater treatment process. A comparison of COD results using peCOD and dichromate COD (COD_{Cr}) method were conducted for many different effluents from kraft and mechanical pulp mills. Studies were completed in multiple laboratories with several different peCOD configurations. The peCOD method demonstrated a strong correlation to COD_{Cr} method for all effluent sample types and indicated excellent reproducibility for comparative results.



Key Experimental Findings of Joint Canada-Finland Project to Reduce Hard COD from Pulp and Paper Mills

- peCOD COD method is applicable to the Pulp & Paper wastewater matrix
- peCOD is the first method in 60 years to be an alternate, true oxidation method for COD
- H2O2 is a positive interference for the CODCr method increasing results
- H2O2 is not an interference for the peCOD method
  - Critical finding for bleaching and advanced oxidation processes in general
  - Can be used to optimize bleaching process and provides correct, trusted results in the influent

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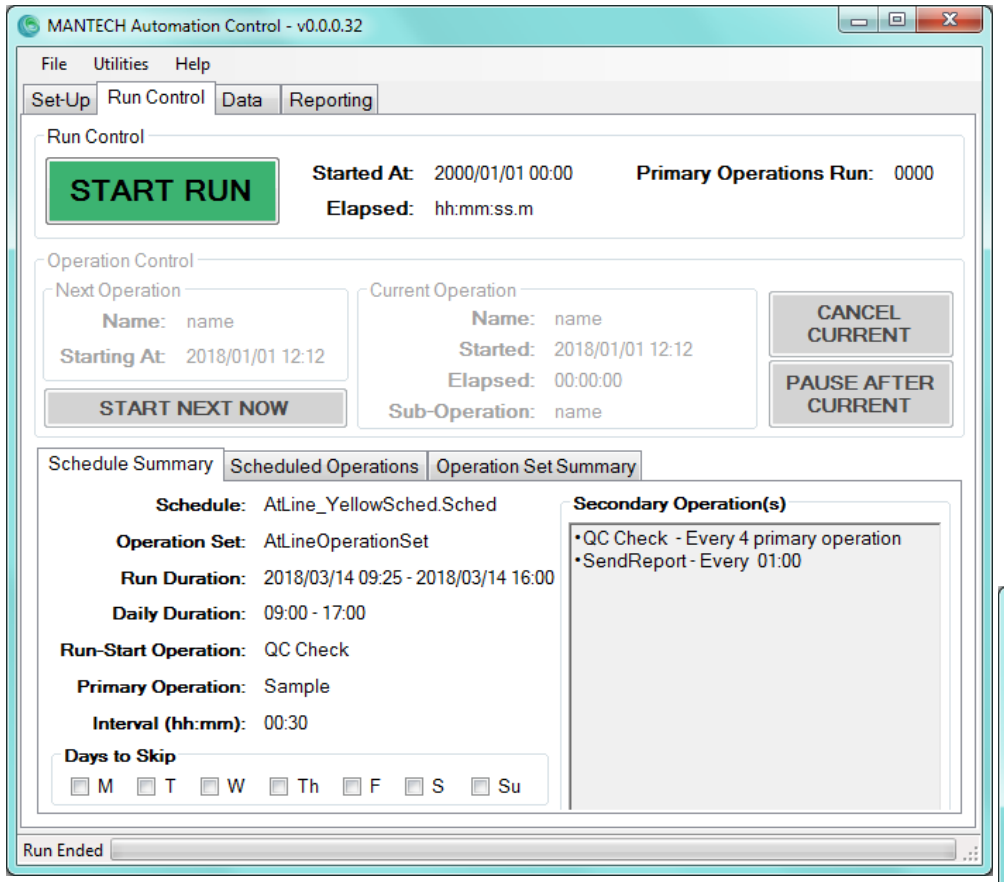
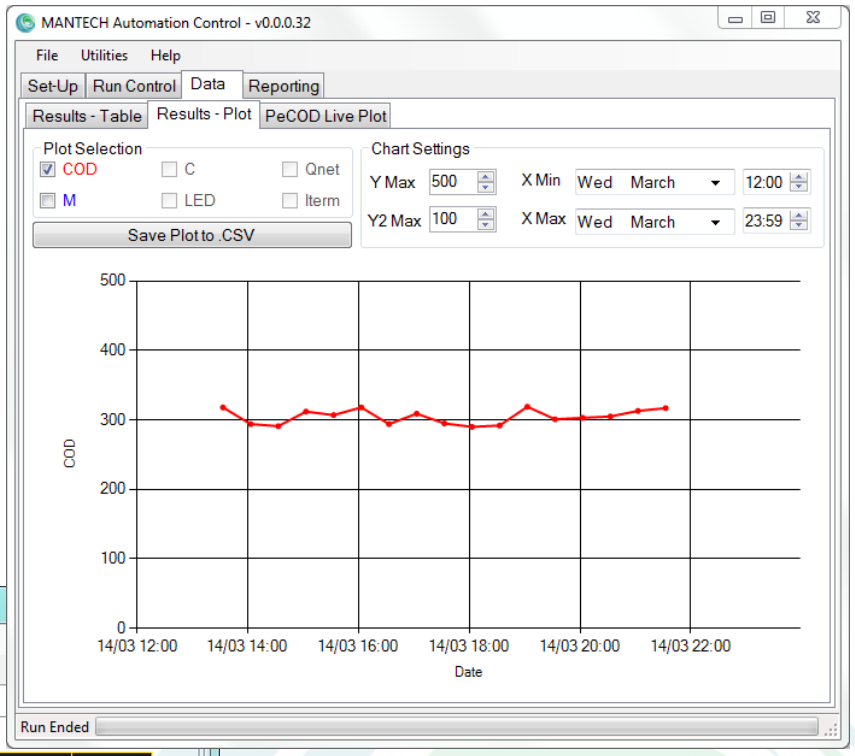
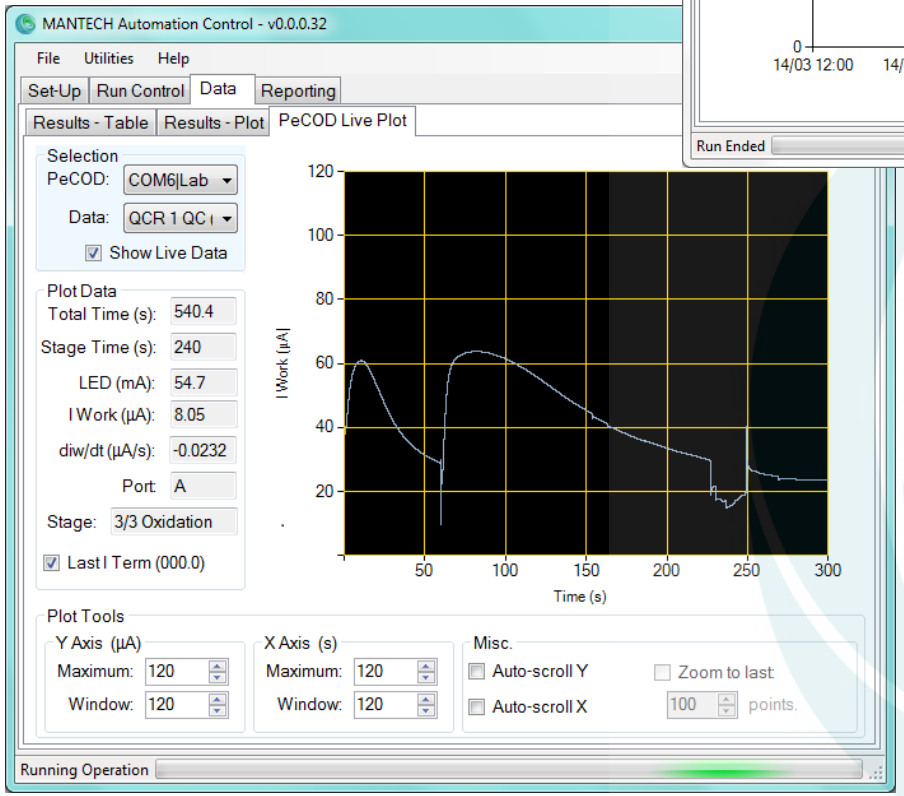
PeCOD® Pro

Simple Click and Go Software







Sample analysis is easy!

- **Mix salt with sample in tube**
- **Gently shake and put intake sample tube into sample**
- **Click “Start Run”**

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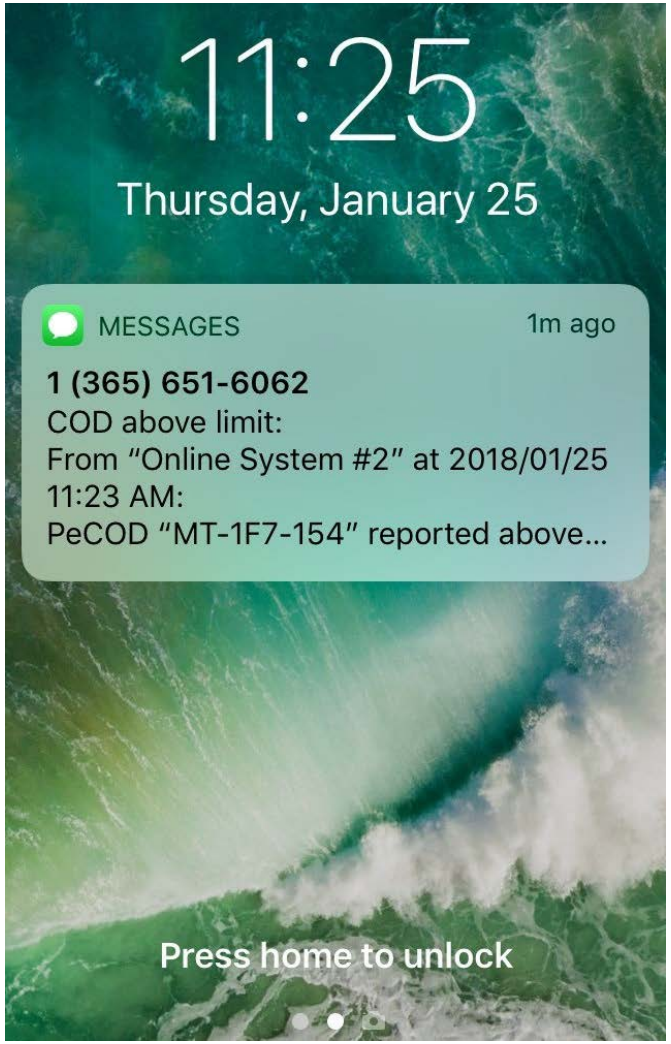
Alerts – Benchtop and Online



R

Tue 06/03/2018 4:26 PM

remotedata@mantech-inc.com

MANTECH Automated Alert

To remotedata@mantech-inc.com

EmailTranslator V1.1

From "Online System #5" at 2018/03/06 3:30 PM:
>PeCOD "MT-1A5-135" last completed calibration: PASS
>(2018/03/06 15:24, M=0.0323, C=118.4, Iterm=18.43)
>Turbidity “MT-1K7-213” last completed calibration: PASS
>(2018/03/02 11:41, 0.02=0.0243, 0.5=0.5102, 1.0=0.9946, 10.0=10.1034)
>pH “4469-2” last completed calibration: PASS
>(2018/03/03 21:50, 4.0=179.43, 7.0=1.85, 10.0=-182.11)

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CORECOD Project Outcome Utilization 1

Hard COD Reduction by AOP – 300ppm to 50ppm

UV254

Influent

1ry & 2ry Treatment

3ry AOP Treatment

peCOD applicable to all grab sample points of interest and checks UV254 (since it is a surrogate)

CORECOD Project Outcome Utilization 2

CODCr

- Laboratory, PPE, 8hrs/day, 5 days/week
- Operators operating “blind” at other times

The future is now

PeCOD® Analyzer

- In plant, 24/7
- Operators do the analysis and get COD when they want and need it
- From paper machines, bleaching control, wastewater treatment optimization, nutrient control and effluent compliance
- Used in both laboratory and plant environments

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OPPORTUNITY from CORECOD Project

Matrix Specific Alternate COD Method Approval by PeCOD

Adoption in Multiple Countries Including Finland

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CORECOD PROJECT RESULT – Adding Endusers very quickly!

ARAUCO
Sembremos Futuro.

kemira
Where water meets chemistry™

PORT HAWKESBURY PAPER

CANFOR

WestRock

FPInnovations

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Opportunity for Pulp and Paper Mills

Begin with peCOD in Laboratory Operations

- **Improve Health and Safety for everyone**
- **Rapid COD results delivered to operational engineers**
- **Impactful decisions made from fast COD results increases profit**

Thank You!