Electron Machine Corporation

Applying Refractometers to the on-line Measurement of Green Liquor Density

Western Canada BLRBAC
Spring 2014

C.A. Vossberg

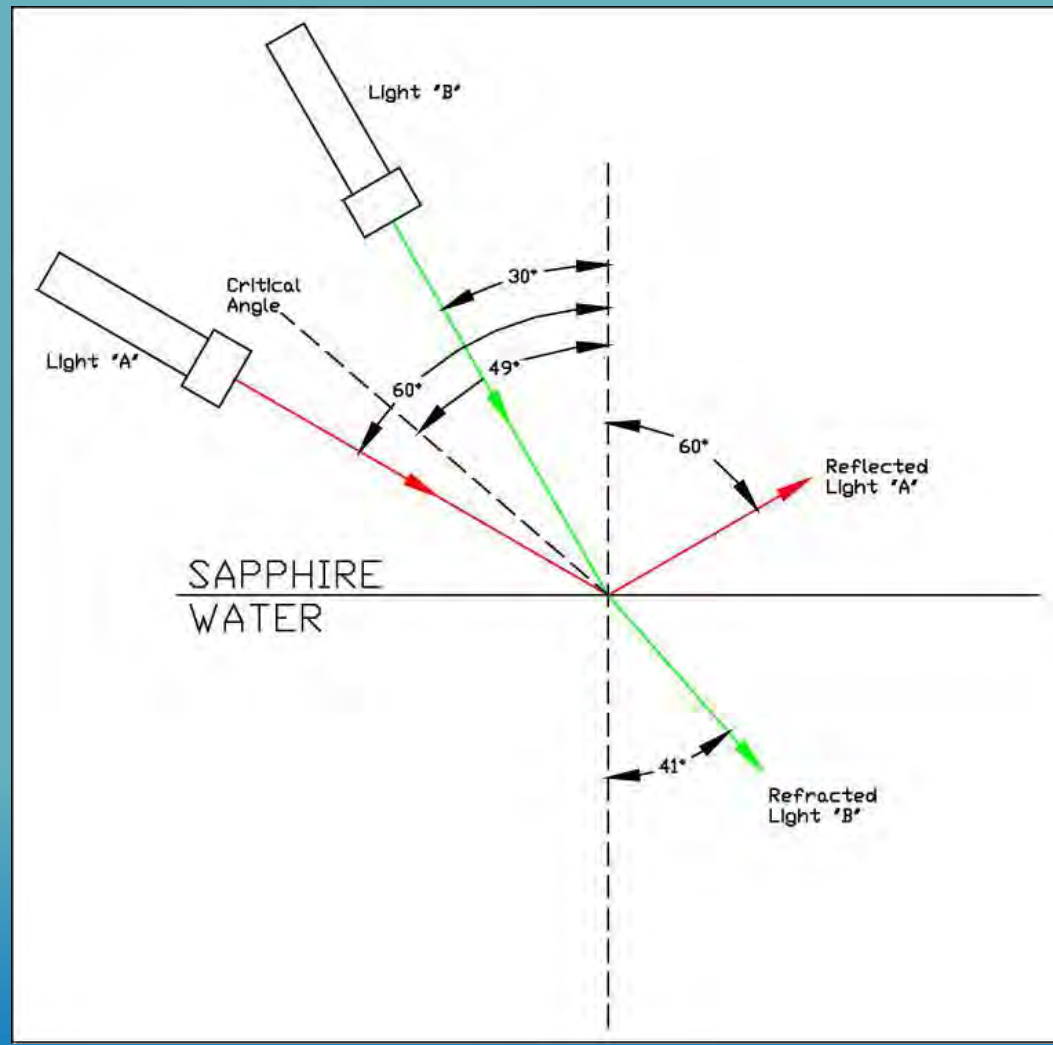
Agenda:

- Background information
- Refractometer basic principles
- Key issues facing green liquor refractometer measurement
- Experimental installation review

Green Liquor Refractometers:

- On-line measurement of green liquor density or (TTA) at two stages in the process:
  - Outlet of Dissolving Tank (focus of presentation)
  - After Clarifier
- Allows real-time control of the green liquor dilution to meet the target TTA
- Benefits:
  - Indication (and prevention) of excessive green liquor density and impending crystallization
  - Improved white liquor quality
  - Consistent black liquor solids
  - Maintain a desired process solution
    - Accurate Process Control
    - Economical Operation
    - Decreased Offline Testing

Measurement Principle



R.I. (sapphire) = 1.760

R.I. (water 20°C) = 1.33335

If the angle of Light 'B' = 30°, then

$(1.760)\ \sin 30 = (1.33335)\ \sin \theta_r$

$$\sin \theta_r = \frac{(1.760)\ \sin 30^\circ}{1.33335} = 0.6600$$

$$\theta_r = \sin^{-1}(0.6600) = 41.30^\circ$$

Critical Angle is when $\theta_r = 90^\circ$

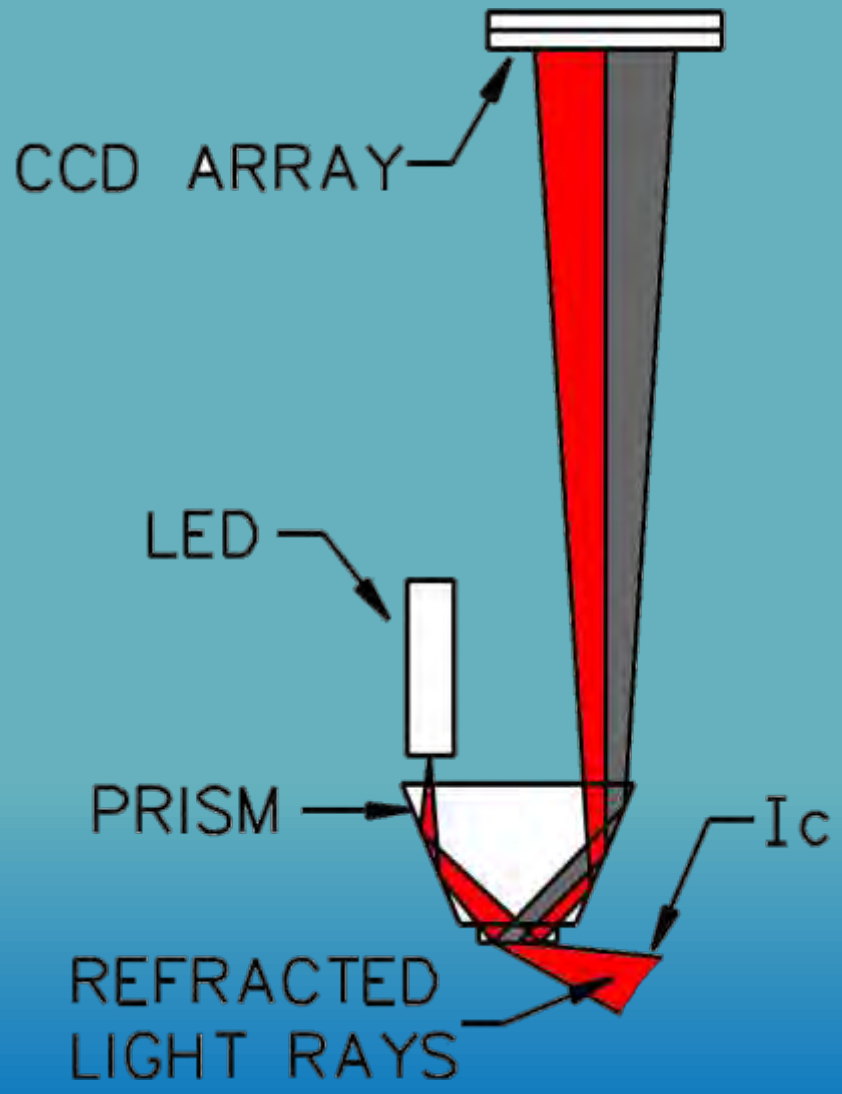
$(1.760)\ \sin \theta_i = (1.33335)\ \sin 90^\circ$

$$\sin \theta_i = \frac{(1.33335)\ \sin 90^\circ}{1.760} = 0.7576$$

$$\theta_i = \sin^{-1}(0.7576) = 49.25^\circ$$

http://interactagram.com/physics/optics/refraction/

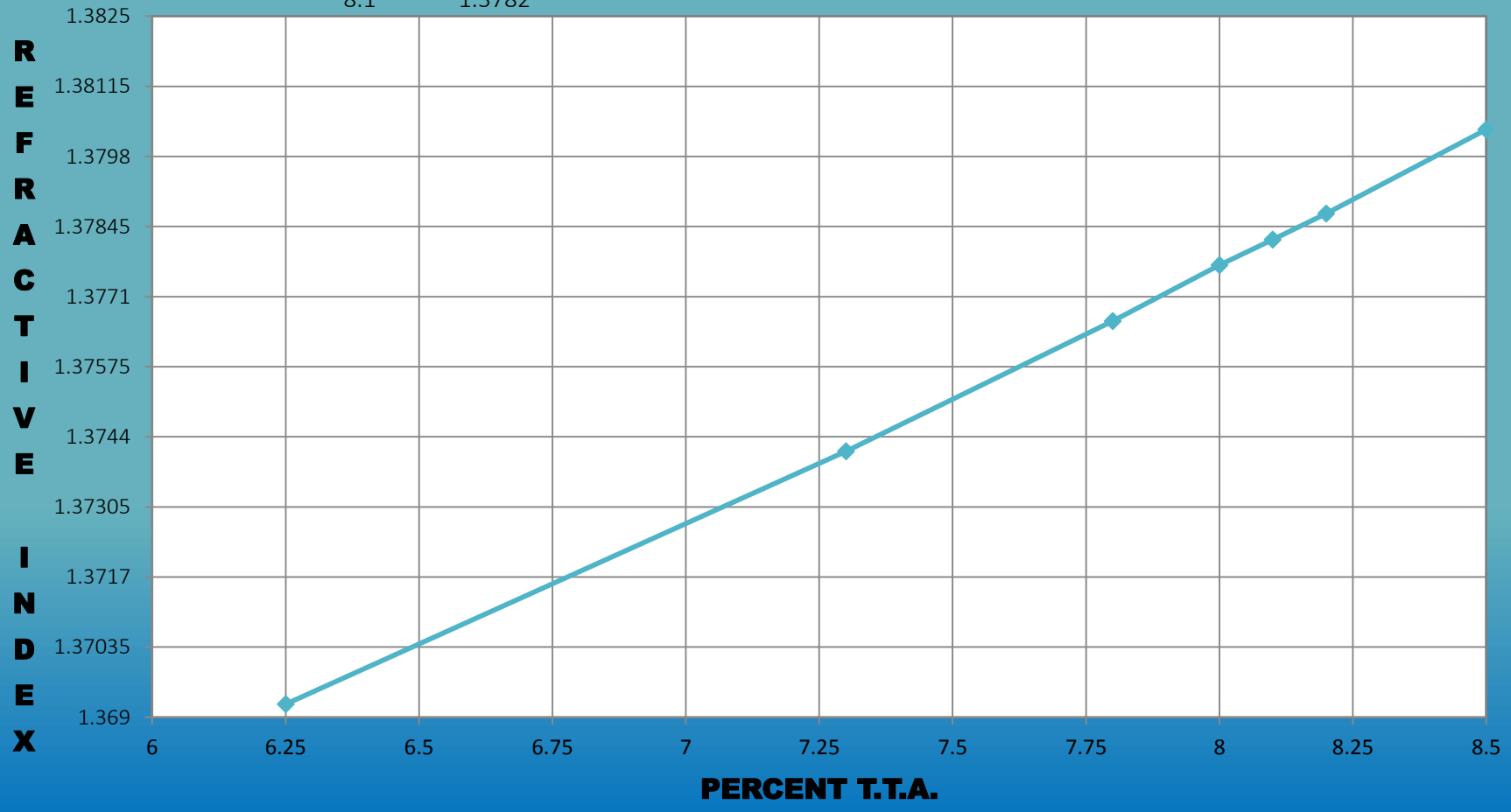
Measurement Principle



Measurement Principle

GREEN LIQUOR T.T.A.

Electron Machine	X	Y	X	Y	X	Y	X	Y	X	Y
Date: 10/20/2000	6.25	1.3692	8.2	1.3787						
Test: G.L. TTA	7.3	1.3741	8.5	1.3803						
Chem:	7.8	1.3766								
Instr: ABBE	8	1.3777								
	8.1	1.3782								



Key Issue facing Refractometer Green Liquor Measurement:

- Optical coating
- Duration of on-line measurement before optical coating occurs
- Maintenance of cleaning method
- Thermal changes

Optical Coating:

An optical coating problem associated with green liquor has been an on-going problem resulting in the adaptation of several different cleaning methods:

- Steam
  - Inadequate scale removal (may accelerate scaling)
  - Thermal shock
  - Relatively low pressure over process
- Mechanical removal
  - Adequate scale removal
  - Frequent service intervals
- Chemical removal
  - Adequate scale removal
  - Frequent service intervals
- High-pressure mill water
  - Adequate scale removal
  - Poor water quality
  - Thermal change
  - Frequent maintenance intervals

Measurement Duration:

Aggressive scaling can immediately begin occurring after an optical cleaning without time for an accurate measurement:

- Declining industry wide
- Greater attention to green liquor control
  - Reduce variation of TTA
    - You help us we help you
  - Adequate dissolving tank mixing
  - Anti-scaling additives
  - Reducing thermal changes

Maintenance of Cleaning Method:

High maintenance equipment leads to an unsuccessful installation:

- Expensive
- Labor intensive
- Unreliable
- Leads to operator distrust
- Difficult for real-time control

Thermal Changes:

Thermal changes have been observed to aggravate the scaling and coating issues associated with green liquor resulting in increased refractometer maintenance:

- Prism shock
  - Steam purge can increase coating
  - Prism cracking
    - Hotter than process
    - Colder than process
- Cleaning nozzle fouling
  - Temperature change may contribute to scaling
    - Complete nozzle blockage
    - Water stream deflection

Green Liquor Experimental Installations:

- Green Liquor Dissolving Tank:
  - Four different installations
    - Custom install locations tailored to individual mill requirements
    - Removable high pressure cleaner adapter
    - Heated water purge system
    - One experimental cleaning nozzle flushing system
  - Cleaning methods
    - High pressure cleaner supplied with heated de-mineralized water
      - Approximately 1500psi
      - Water temperature 160F
    - Boiler Feed Water
      - Approximately 800psi
      - Water temperature 160-200F
  - Significant incremental improvements

Installation 1

Three different dissolving tanks.

- Components:
  - (3) MPR E-Scan with High Pressure Cleaning Systems
  - Installed in dissolving tank green liquor recirculation 2” line
  - All units use smelt spout cooling water @ ~160F with drain solenoid to ensure hot water supply
  - Removable high pressure nozzles
  - 9 months ago changed from normal mill water to heated water
- Results with heated water:
  - Before: monthly service interval of sensing head due to cracking prisms and nozzle fouling
  - Now:
    - Using instrument for automated control
    - Sensing head service interval greatly enhanced
    - Nozzle service has been extended marginally
- Pro/Con with install:
  - Ease of isolation for sensor maintenance
  - Operations must insure clean recirculation line
  - Improper cleaning of recirculation line can result in damage to sensing head

Installation 2

Two different dissolving tanks, one boiler.

- Components:
  - (2) MPR E-Scan with High Pressure Cleaning Systems
  - Installed in dissolving tank green liquor recirculation 2” line
    - One tank in service at a time
    - Second tank in weak wash clean
  - Removable high pressure nozzles
- Pro/Con with install:
  - Ease of isolation for sensor maintenance
  - Must have two dissolving tanks
  - Operations must insure clean recirculation line

Installation 3

Three dissolving tanks with two discharge lines and dedicated weak wash supply

- Components:
  - (6) MPR E-Scan
  - Installed in dissolving tank green liquor 6” discharge lines
  - All units use high pressure boiler feed water with drain solenoid to ensure hot water supply
  - Removable high pressure nozzles
- Results:
  - Using instrument for automated control
  - Systems in operation for 6 months with no major issues or servicing
- Pros/Cons with install:
  - Simple system
  - Direct product sampling
  - Low maintenance
  - Availability of high-pressure boiler feed water and associated piping
  - Low risk of green liquor intrusion into boiler feed water

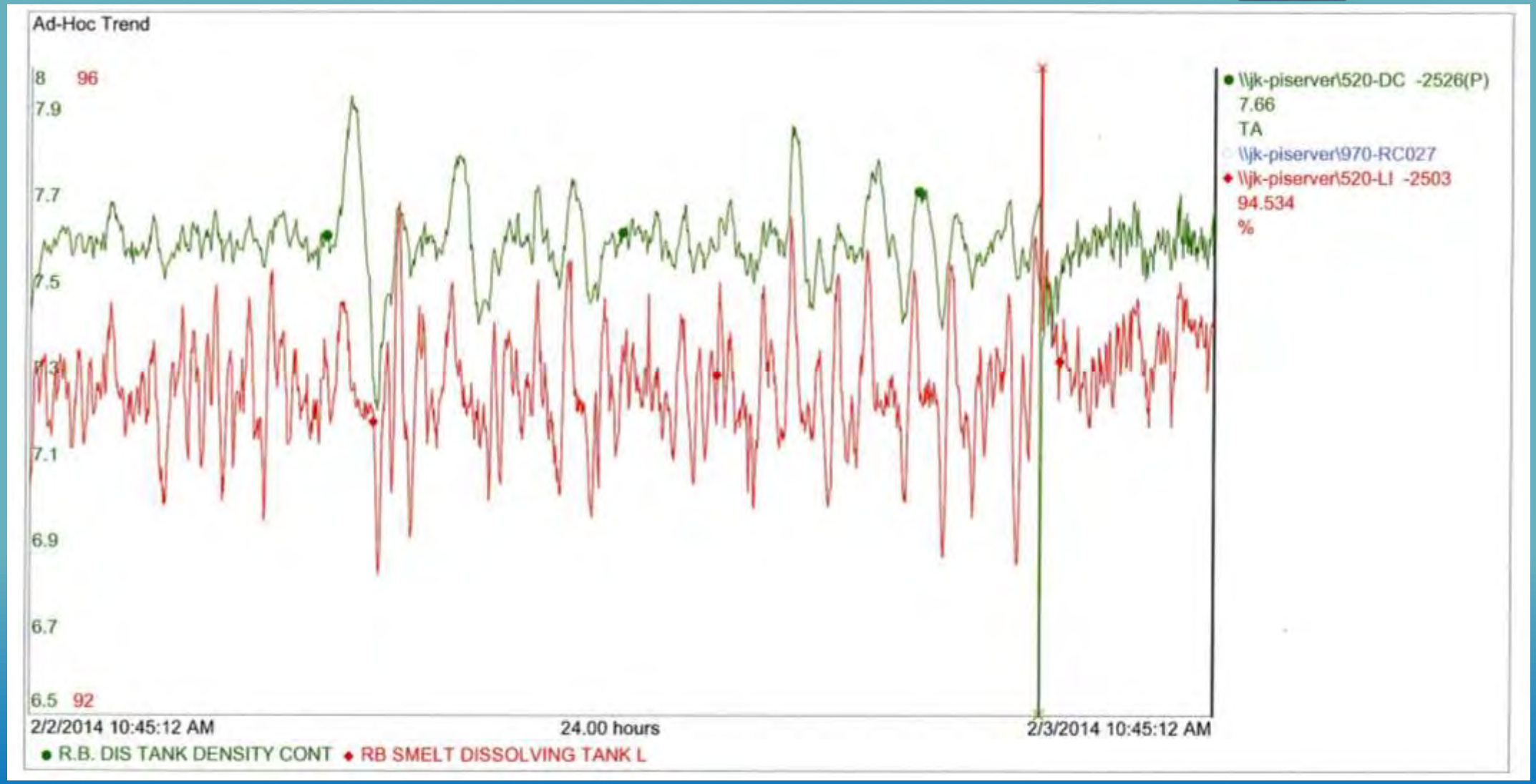
Installation 4

- One dissolving tank
- Components:
  - (2) MPR E-Scan with High Pressure Cleaning Systems
  - Both units use “de-min” water @ ~160F with drain solenoid to ensure hot water supply
  - Removable high pressure nozzles
  - Installed in 8” dissolving tank green liquor discharge / weak wash supply lines
  - One unit has automated vinegar nozzle flushing system

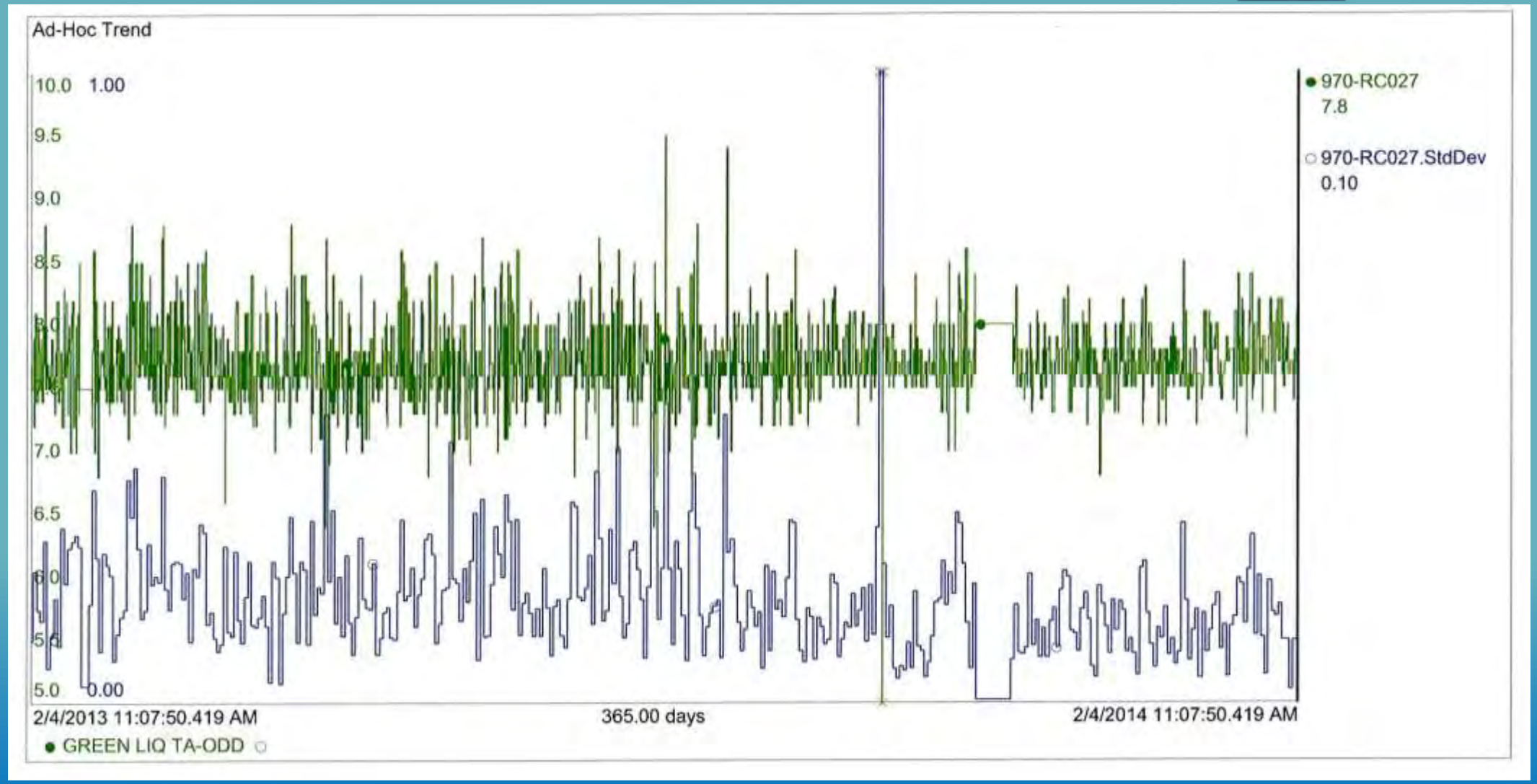
Installation 4

- Results:
  - Before: (1) year sensing head service interval w/purge every 7 minutes for 10 seconds
    - Using normal mill water
    - Replacing nozzles monthly
  - Now:
    - Using instrument for automated control
    - Both purge systems on the heated water
    - Possibly (2+) year sensing head service interval w/purge every 12 minutes for 5 seconds
    - Over 6 months on same nozzle
  - Automated vinegar nozzle flushing
    - 6 month run time
    - Improvements still to be determined
    - May increase service interval of nozzle
    - Enough to justify added maintenance and complexity of system?

Installation 4



Installation 4



Experimental Installations

Conclusion

- Optical coating
  - Adequately removed with heated high pressure water
- Duration of on-line measurement before scaling occurs
  - Increased with less green liquor TTA variation
- Maintenance
  - Heated water
    - Reduction in scaling aggravation
    - Reduced prism shock
    - Reduced issues with cleaning nozzle fouling
  - Refractometer sensing heads installed on green liquor discharge / weak wash supply
    - Feasible when sensing head and cleaning nozzle maintenance is prolonged
    - Alleviates need for separate cleaning of recirculation line
  - Vinegar flush may not be beneficial enough to justify added maintenance
- Thermal changes
  - High pressure water nearly same temperature as green liquor
  - Drain solenoid valve

Green Liquor Refractometer

Summary

- Incremental improvements to refractometer cleaning system
  - Realistic option for on-line green liquor measurement if pipeline scaling allows
  - Accurate process control
  - Low installation cost
  - Reduced maintenance requirements
- Increased green liquor control
  - Safer recovery boiler operation
  - Overall improvement to Kraft process
  - Reduced standard deviation of green liquor variability
  - Better consistency leads to less coating and scaling

Electron Machine Corporation

C.A. Vossberg (President)
Cell (352)-406-1352
ca@electronmachine.com

Brad Osborne (Sales/Marketing Manager)
Cell (352)-267-0118
brad@electronmachine.com