APPLICATIONS OF FAST TRANSPORTABLE CHROMATOGRAPHY

Gulf Coast Conference

Prepared by: A. Coderre (Clearstone Engineering Ltd)

Introduction: Adam Coderre

- M.A.Sc., Mechanical Engineering
  - Specializing in emissions measurement
  - Thesis research in optical PM (soot) diagnostics
- Project Engineer with Clearstone
  - Emission inventories and environmental reporting
  - Field measurements and emission factor development

Introduction: Clearstone Engineering

- Canadian company specializing in energy, greenhouse gas and air pollution management at oil and gas facilities.
- Domestic focus on quantification methodology, data management systems and emission reporting
  - Calculate/report emissions for oil & gas companies,
  - Verify regulated facilities and reduction projects,
  - Support regulation development and refinement.
- International work in Mexico, Colombia, Ecuador, USA, Uzbekistan, Qatar, Russia, Ukraine and China:
  - Flare gas and methane emissions reduction,
  - Energy efficiency management,
  - Related auditing and capacity building.

Clearstone Clients

Testing & Measurement Equipment

- Target parameters:
  - Temperature, pressure, velocity or flow, and composition
- Key criteria:
  - Portable, safe, and practical to use
  - Accurate and repeatable
  - Data logging and trending capabilities
- Advanced techniques:
  - HC emission imaging IR cameras
  - Clamp-on flow meters (transit-time and Doppler systems)
  - Real-time trend analysis (short & medium term)
  - Micro-GCs:
    - Detailed gas analyses (C1 to C16, fixed gases; N2O coming soon)
    - Liquid analyses (C3 to C44)
    - Tracer tests (e.g. to determine flaring rates and efficiencies)

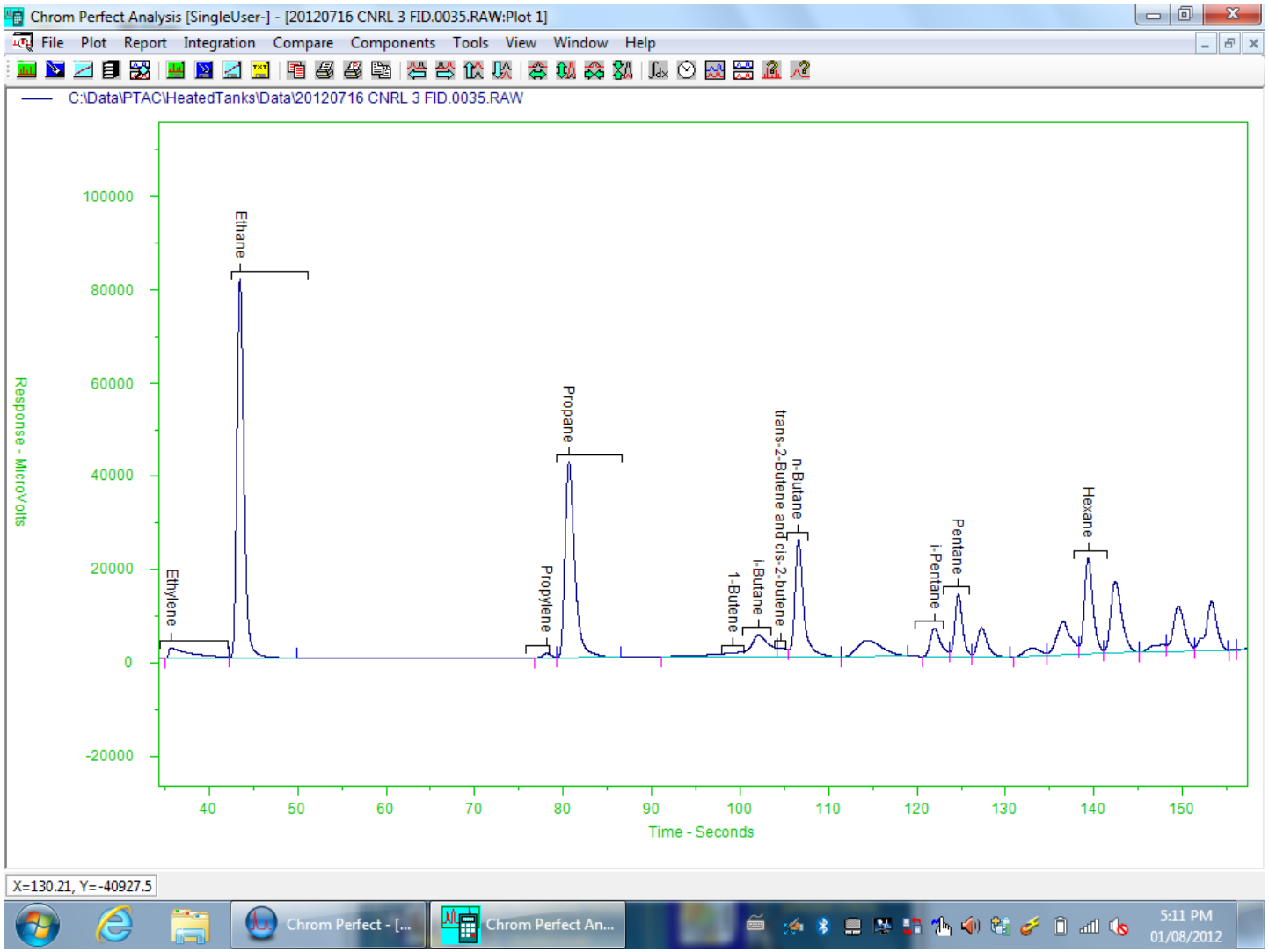
Gas and Liquid Analyses

- Normal practice: off-site lab or temporary setup of standard full-sized GCs:
  - Transport issues, instrument warm-up time, stability issues, potential sample degradation, slow analyses
- Use of custom micro-GCs:
  - Fast, light-weight, compact, modular, easy setup, stable operation, low power requirements
  - Direct process connection, eliminating potential sample degradation

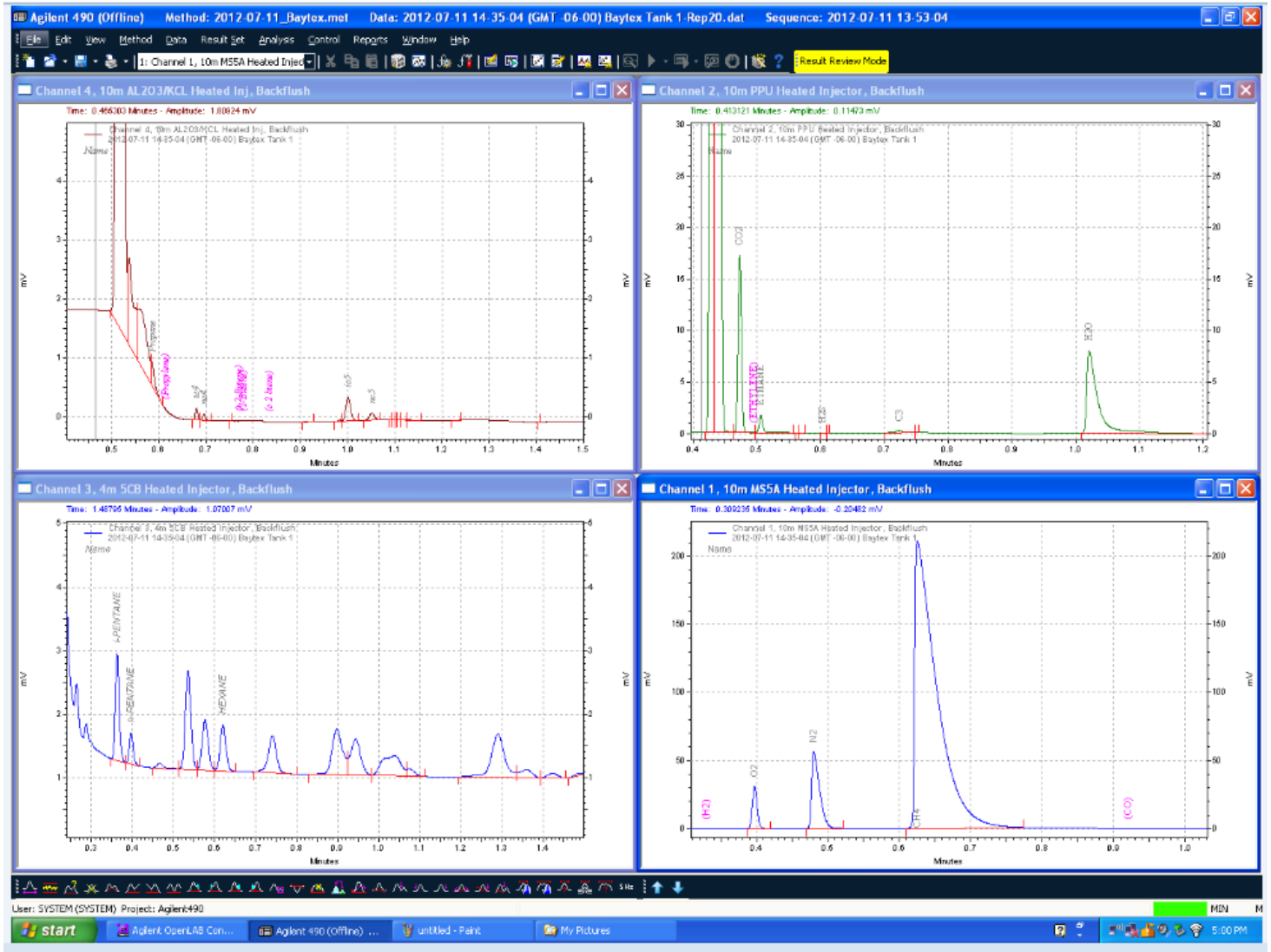
Clearstone Gas & Liquid GCs

- Agilent 490
  - Four channels with TCDs
  - Isothermal column modules
  - Easy set-up with field case (batteries, carrier gas cylinders)
- Calidus CS
  - Parallel FID and TCD
  - Column-switching mechanism expands low-end resolution
  - Temperature ramping capability
- Calidus 101-HT
  - Single-channel FID
  - Liquid analysis (boiling point profile) up to C44

Sample Chromatogram: CS FID ROI



Sample Chromatogram: 490 ROIs

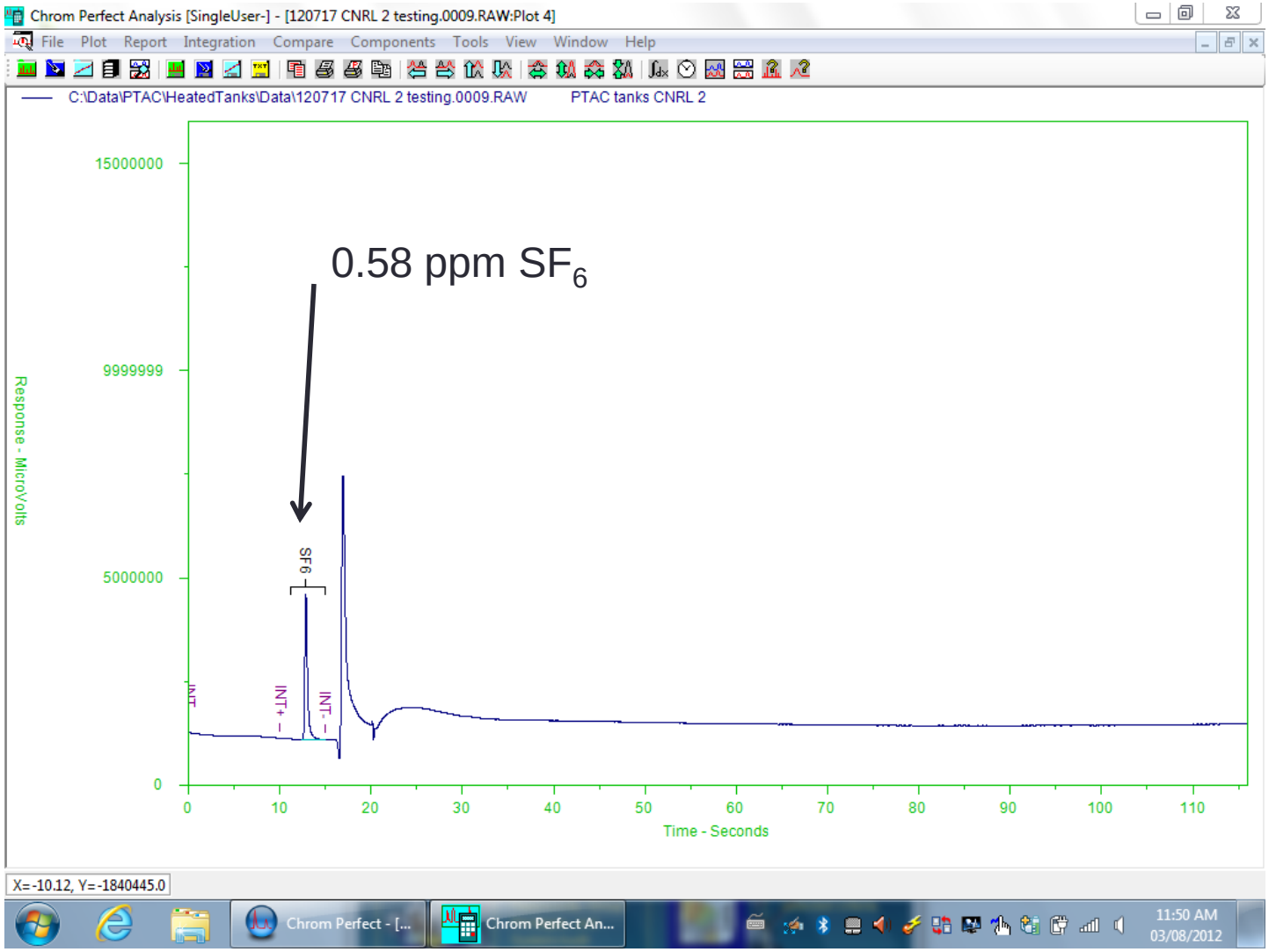


Tracer Testing

- Tracer compound (SF_6) introduced, measured downstream
- Flow rate by concentration
  - E.g. 1 lpm SF_6 released, measured 1 ppm = 10^6 lpm total
- Dispersion data by concentration ratio
  - Known ratio of SF_6 to target compound at release point
  - Trace SF_6 measured downstream, scaled to find target concentration

- Custom Calidus GC from Falcon Analytical
  - DBD/DID detector
  - Can measure low ppb levels of SF_6
  - Testing feasibility of also measuring N_2O

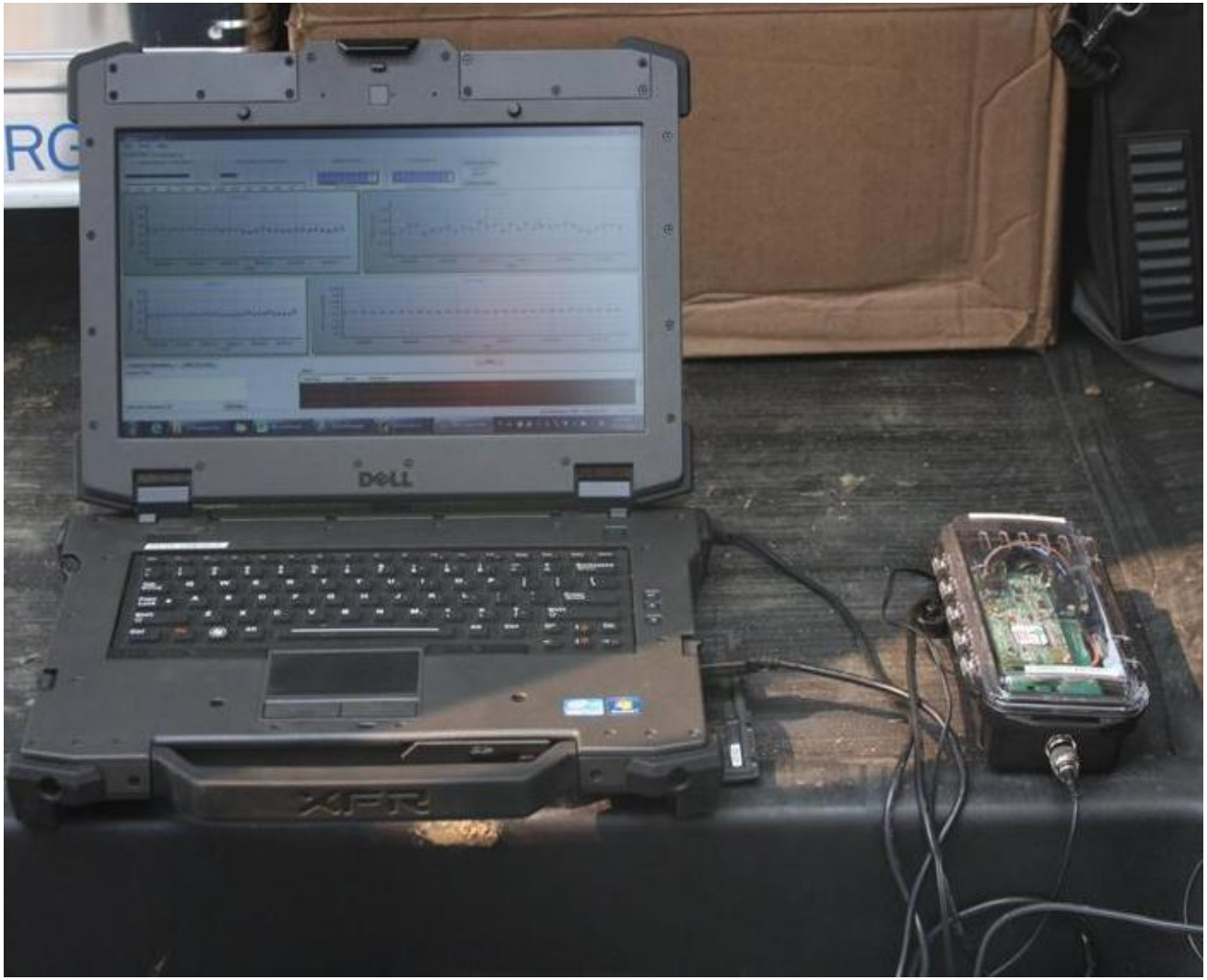
Sample Gas Chromatogram



Integrated Data Collection

- Onsite real-time data logging and trend analysis:
  - Normal practice:
    - Manual data logging, office-based graphing and analysis.
    - Un-synchronized or sequential monitoring of multiple parameters.
  - Custom wireless DAQ & transmission solution:
    - Key features: compact, battery-powered units with intelligent cabling; quick set-up, designed for use in hazardous locations.
    - Benefits: fast deployment, high-speed multi-parameter sampling, auto-synchronization (date and time stamping), sampling radius of up to 3 km, real-time data logging and trend analysis of multiple parameters, applicability in congested process areas through the use of repeaters.
- Most measurement equipment adapted accordingly

Real-Time Trend Analysis



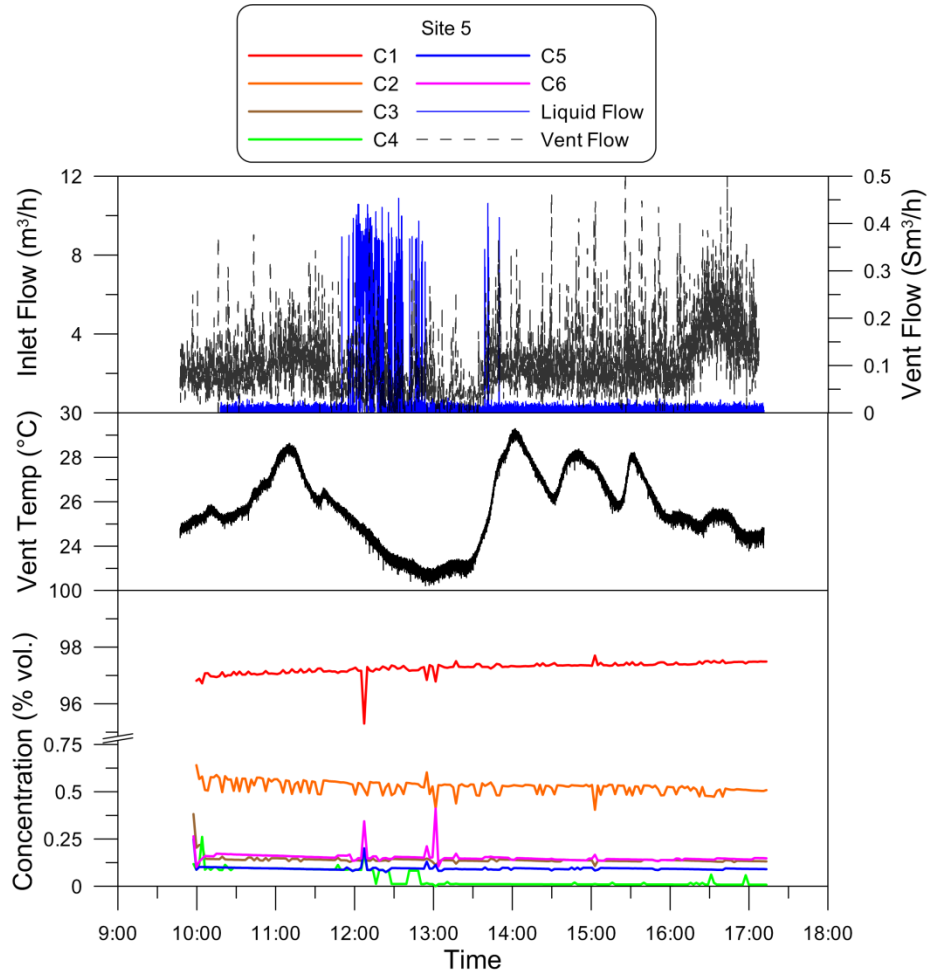
Application: Heated Heavy Oil Tanks

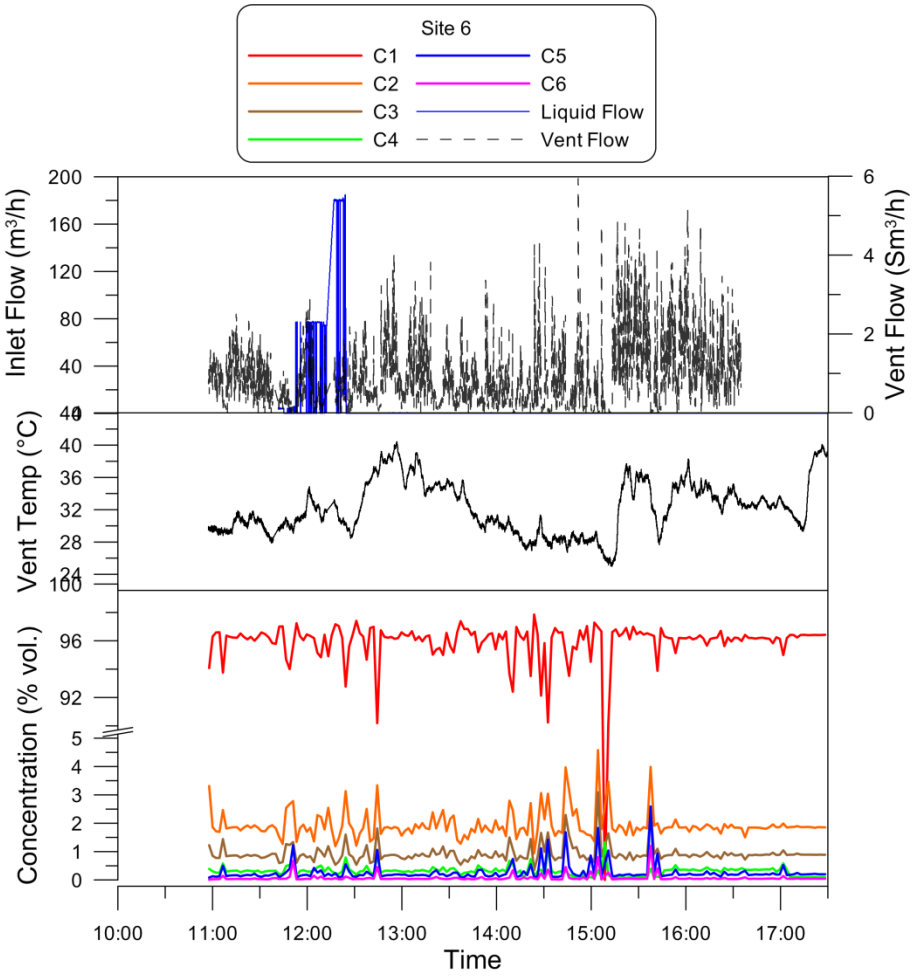
- Objectives of the study:
  - Evaluate magnitude and composition of vapour losses
  - Determine variability in emission rate and composition
  - Evaluate the impact of tank operating temperature on emissions
  - Determine the fate and composition of any aerosol emissions
- Work completed:
  - Emissions tests performed on 6 tanks at 6 heavy oil batteries
  - Detailed laboratory analyses of tank vapours, casing gas, and PM conducted for each site
  - Trending of temp, flow, and composition data
- Work remaining:
  - Tracer tests
  - Tank temperature variations

Micro Gas Chromatographs & Sampling System

Micro Gas Chromatographs

Sample Measurement Results Expressed on an Air-free Basis





Application: Convective Losses

- Quantifying thermal convective losses from storage tanks
  - Fixed-roof, free-venting tanks
  - Hydrocarbon liquids, gasoline
- Vent Emission Monitoring Systems (VEMS)
  - Self-powered, standalone, state-of-the-art SCADA system
  - Cellular and satellite communication with Clearstone servers
  - On-site radio and wired connections to laptop
  - Control-room style control and trend analysis
  - Data collection and trending over substantial time periods
- Vapour analysis and monitoring a key element

VEMS Installation

- Continuous measurements:
  - Ultrasonic flow meter
  - Oxygen sensor
  - Hydrocarbon sensor
  - Vent gas temperature
- Current: underground gasoline storage tank
- Several more systems for other applications in development

Application: NAMA Development

- Nationally Appropriate Mitigation Actions
  - Fundamental for market-based post-2012 climate regime
  - Measurable, quantifiable reductions in GHG emissions
  - Access to funding for mitigation action
- Canada working with Mexico and Columbia to develop highly-credible NAMAs for Oil and Gas production:
  - Baseline activity determination
  - Quantification of mitigation/reduction opportunities
  - Economic evaluation, business case development
  - Performance improvements: measurable, monitorable, sustained
- Clearstone to begin measurement work in November
  - Measurement studies at representative facilties
  - Gas/liquid analyses and tracer tests are key components

Future Development

- Integration of GCs into central data collection system
- Development of standalone field cases for custom GCs
- Improved method development for various applications
- Adaptation of DID system to measure other compounds

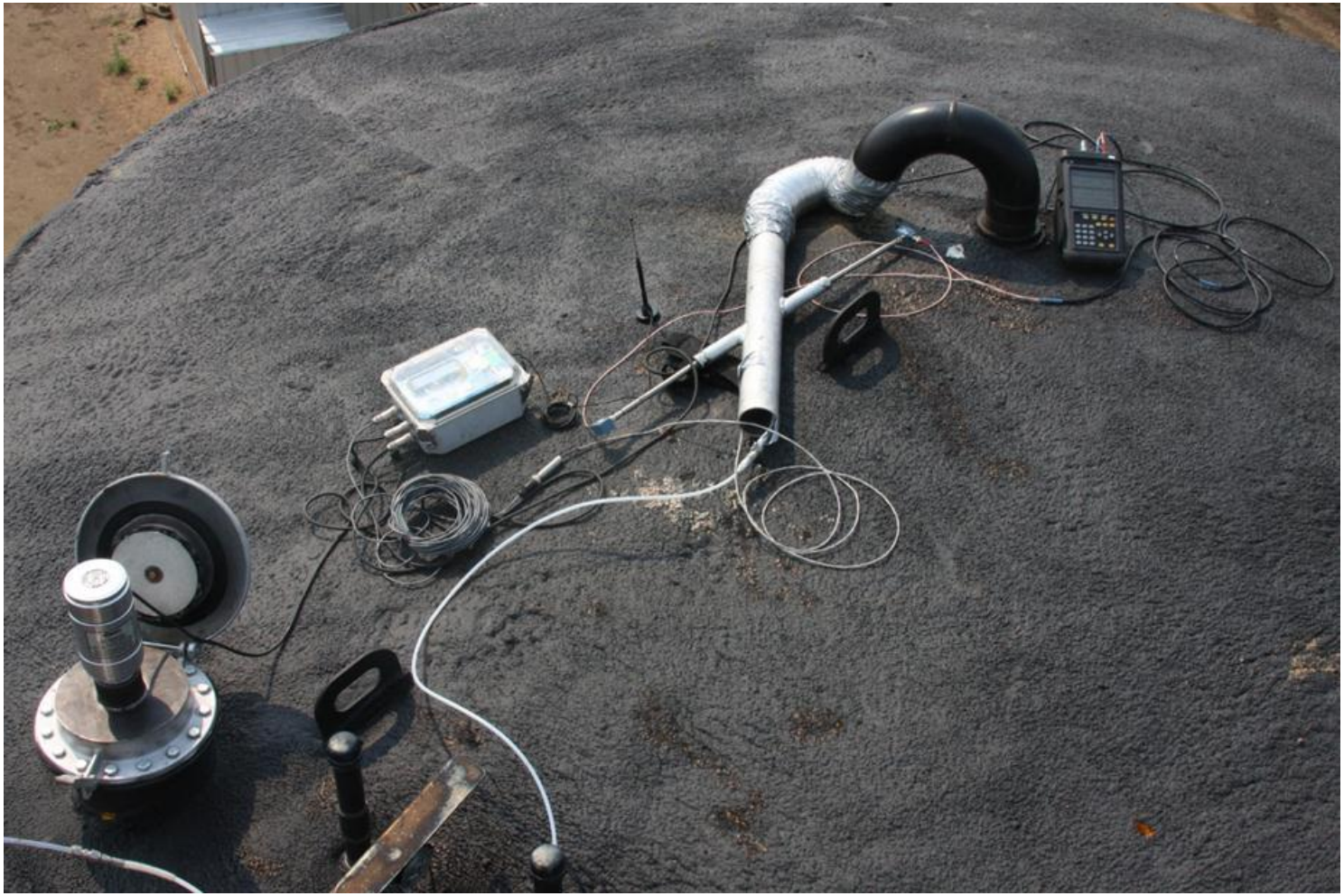
Thank you!

Questions or comments?

Clamp-on Transit-time and Doppler Ultrasonic Liquid Flow Meters

Radar Liquid Level Monitoring System

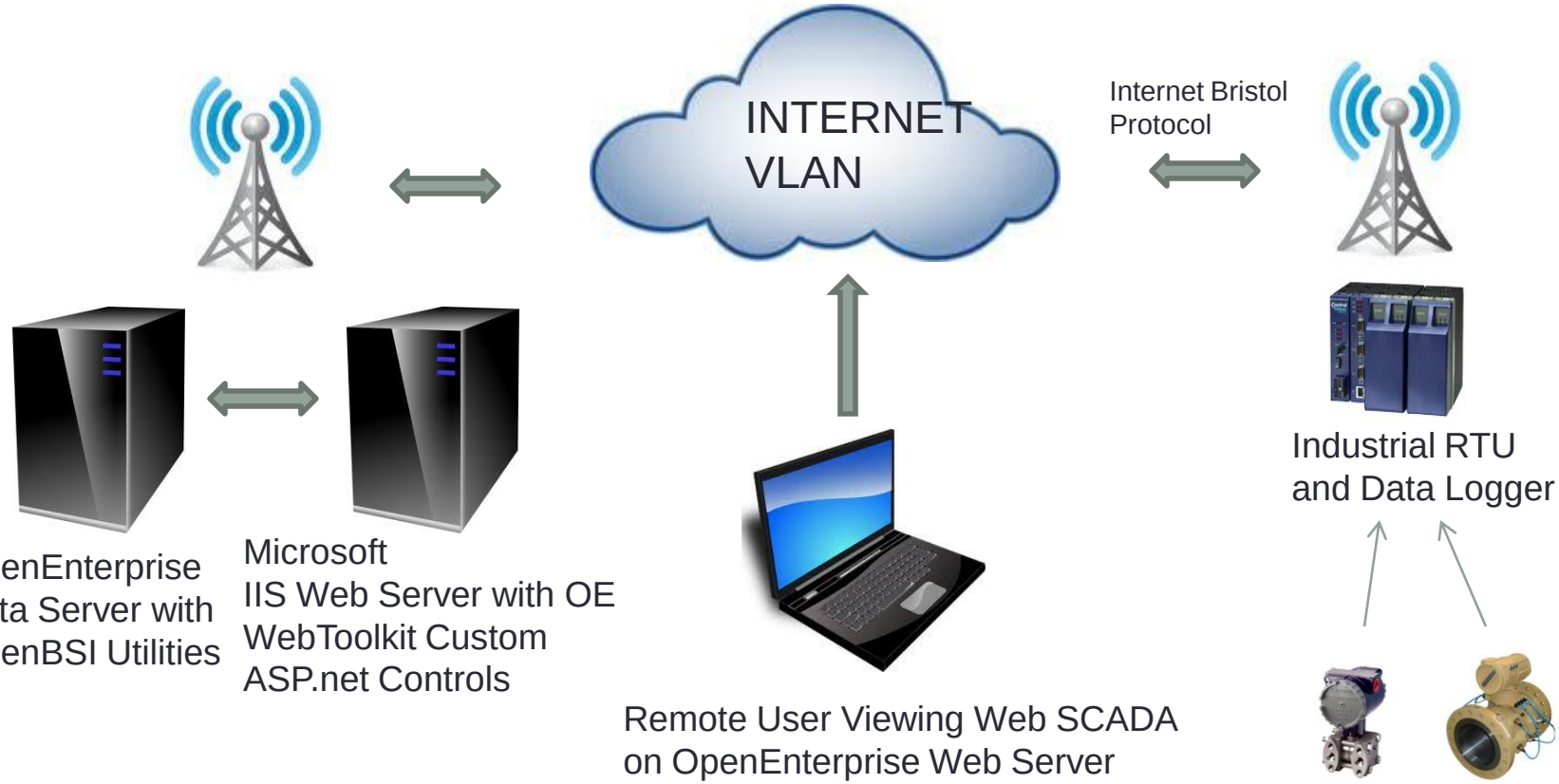
Vent Emission Monitoring System



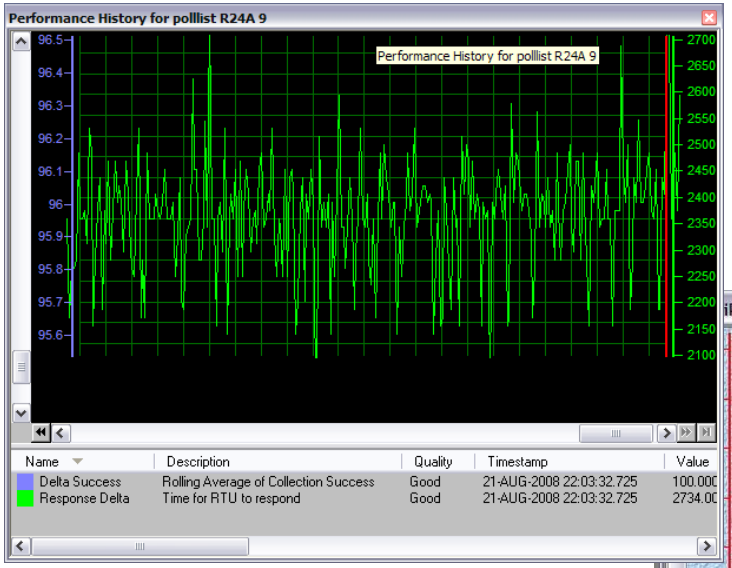
VEMS Cont'd

- Standalone SCADA system for refined system monitoring:
  - Normal practice:
    - Used by industry for coarse process monitoring (e.g., sampling intervals of 5 minutes or greater) of process parameters at remote facilities.
  - Key requirements:
    - Ability to perform rigorous energy & mass balances, and assess source variability over extended periods at sampling intervals as low as 16 ms.
  - Custom solution:
    - Key features: self-powered (solar/wind), compact, rugged design for extreme ambient conditions and hazardous locations, built-in RTU and data logger, cellular and satellite communications, on-site radio communications, 40 parameters with expandability, system health monitoring and state-of-the-art SCADA software.
    - Benefits: high-speed multi-parameter sampling, programmable panel, control-room style control and trend analysis, secure internet access, self diagnostics, auto-data retrieval and alarming, programmable sampling algorithms, etc.

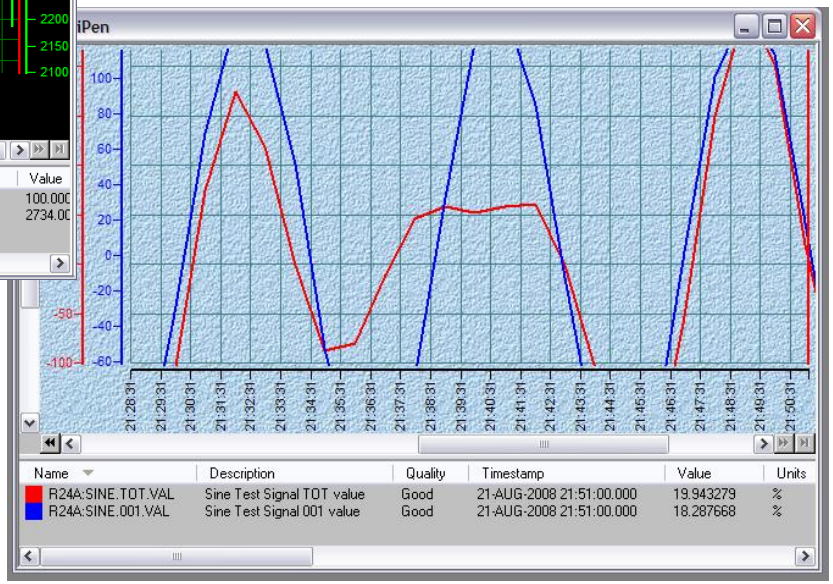
Clearstone Project Overview using Emerson OpenEnterprise and ControlWave RTU



OpenEnterprise Data Trending Objects



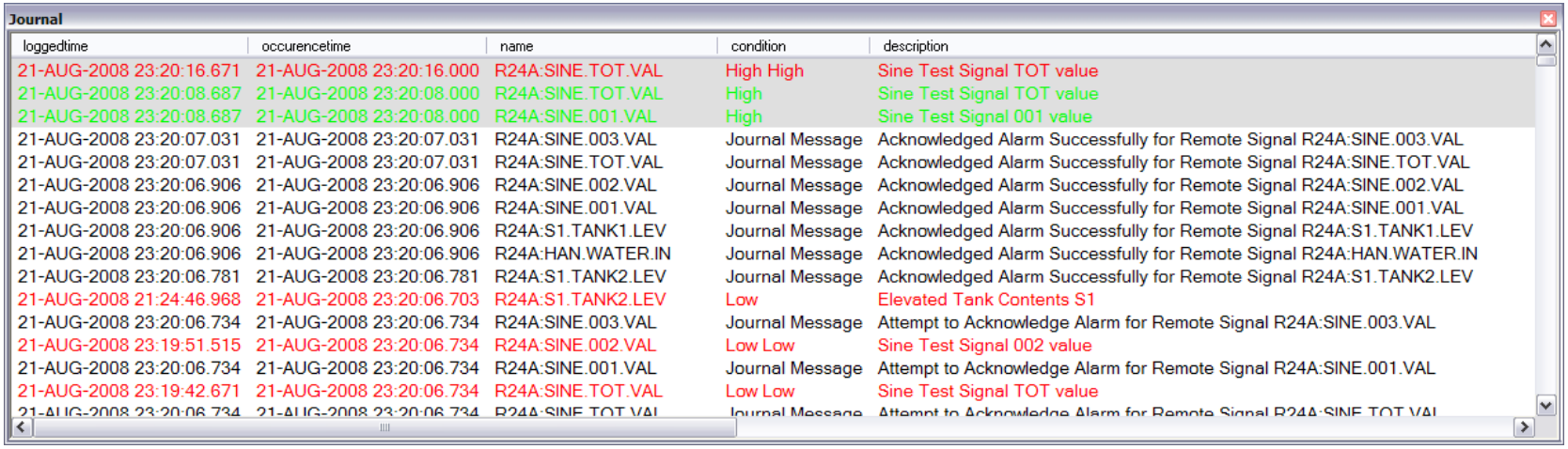
- Multi Pen (up to 12 on web control)
- Trend any analog data from real time or historical databases.
- Dynamic control of pen appearances



- Export to .csv, .jpg, and .bmp

OpenEnterprise Alarm Summary and Banner Objects

- Alarm Windows present a simple tabular view of the alarm system
- Alarm Windows can display either real-time (current) alarms, or an alarm history (including ‘events’)
- A single alarm window can include alarms/events from multiple servers concurrently and filtered by alarm attributes
- There are approx 70 different attributes per alarm.
- Color and appearance of the alarm can be controlled based on the alarm condition, priority and status (e.g. acknowledged, cleared etc)



Journal

loggedtime	occurencetime	name	condition	description
21-AUG-2008 23:20:16.671	21-AUG-2008 23:20:16.000	R24A:SINE.TOT.VAL	High High	Sine Test Signal TOT value
21-AUG-2008 23:20:08.687	21-AUG-2008 23:20:08.000	R24A:SINE.TOT.VAL	High	Sine Test Signal TOT value
21-AUG-2008 23:20:08.687	21-AUG-2008 23:20:08.000	R24A:SINE.001.VAL	High	Sine Test Signal 001 value
21-AUG-2008 23:20:07.031	21-AUG-2008 23:20:07.031	R24A:SINE.003.VAL	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:SINE.003.VAL
21-AUG-2008 23:20:07.031	21-AUG-2008 23:20:07.031	R24A:SINE.TOT.VAL	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:SINE.TOT.VAL
21-AUG-2008 23:20:06.906	21-AUG-2008 23:20:06.906	R24A:SINE.002.VAL	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:SINE.002.VAL
21-AUG-2008 23:20:06.906	21-AUG-2008 23:20:06.906	R24A:SINE.001.VAL	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:SINE.001.VAL
21-AUG-2008 23:20:06.906	21-AUG-2008 23:20:06.906	R24A:S1.TANK1.LEV	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:S1.TANK1.LEV
21-AUG-2008 23:20:06.906	21-AUG-2008 23:20:06.906	R24A:HAN.WATER.IN	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:HAN.WATER.IN
21-AUG-2008 23:20:06.781	21-AUG-2008 23:20:06.781	R24A:S1.TANK2.LEV	Journal Message	Acknowledged Alarm Successfully for Remote Signal R24A:S1.TANK2.LEV
21-AUG-2008 21:24:46.968	21-AUG-2008 23:20:06.703	R24A:S1.TANK2.LEV	Low	Elevated Tank Contents S1
21-AUG-2008 23:20:06.734	21-AUG-2008 23:20:06.734	R24A:SINE.003.VAL	Journal Message	Attempt to Acknowledge Alarm for Remote Signal R24A:SINE.003.VAL
21-AUG-2008 23:19:51.515	21-AUG-2008 23:20:06.734	R24A:SINE.002.VAL	Low Low	Sine Test Signal 002 value
21-AUG-2008 23:20:06.734	21-AUG-2008 23:20:06.734	R24A:SINE.001.VAL	Journal Message	Attempt to Acknowledge Alarm for Remote Signal R24A:SINE.001.VAL
21-AUG-2008 23:19:42.671	21-AUG-2008 23:20:06.734	R24A:SINE.TOT.VAL	Low Low	Sine Test Signal TOT value
21-AUG-2008 23:20:06.734	21-AUG-2008 23:20:06.734	R24A:SINE.TOT.VAL	Journal Message	Attempt to Acknowledge Alarm for Remote Signal R24A:SINE.TOT.VAL