

UNIVERSITY OF FLORIDA

2014-07-07 Campaign Report

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7/21/2014

In this document the results of the 2014-07-07 campaign are presented. Sugarcane bagasse was pretreated with dilute phosphoric acid and steam explosion, after which an enzymatic liquefaction completed the solubilization of the biomass. The biomass slurry was continuously transferred to the fermentor, where it was inoculated using the ethanologenic strain SL100 that had been propagated using previously squeezed hydrolysate.

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Results summary

Pretreatment

Pretreatment unit was continuously operated for 32 h using sugarcane bagasse (biomass batch number 10019). Two separate samples were obtained for analysis during operation.

Conditions;

Temperature = 365 °F (185 °C)

Pressure = 150 psi

Retention time = 7.5 min

Biomass flow rate = 216 lb DW/h

Acid solution flow rate = 6.67 GPH

Acid solution concentration = 3% (w/w)

Final acid concentration (calculated) = 0.78%

Results;

Sugar/ Inhibitor	Hydrolysate Concentration			
	g/L		g/kg	
	Average	StDev	Average	StDev
Glucose	4.9	0.7	9.6	1.4
Xylose	34.9	2.4	67.6	4.7
Galactose	2.7	0.3	5.3	0.5
Arabinose	7.6	1.1	14.8	2.1
Total Sugars	50.2	4.5	97.3	8.7
HMF	0.6	0.1	1.2	0.1
Furfural	1.3	0.0	2.5	0.1
Acetate	5.7	0.5	11.0	1.0
Total Inhibitors	7.6	0.6	14.8	1.2

Liquefaction

Biomass was continuously fed into the liquefaction tank for a total of 17.5 h, with continuous operation into Fermentor C for ~10 h. Once the pretreatment unit was no longer operational, the liquefaction conditions were maintained for an additional 5 h while pumping the slurry into Fermentor C through the pH Adjustment Tank. Three separate samples were taken. The first one, when the liquefaction tank had reached the pre-determined level of 76.4% (t=0 h), the second six hours later (t=6 h), and the third 12 h later as the slurry was being transferred into Fermentor C (t=12 h). The enzyme loading used was 15% (v/w) of the dry weight of the biomass. The retention time was 7 h to allow for the level to be high enough to cover both liquefaction impellers and avoid the problems with the level sensor that arise from the splashing of the slurry. Approximately 40 gal and 30 gal of 19% ammonium hydroxide were used to adjust pH in the liquefaction tank and pH adjustment tank respectively.

Liquefaction Data Sheet												
Date and time created		7/10/2014 13:00										
Enzyme Flow Rate (FIC-8304-03)		0.065 gal/min										
Biomass Flow Rate		216 lb DW/h										
UV Water Flow Rate		2.5 gal/min										
UV Water Temperature		80 °F										
Liquefaction Target Temperature		122 °F										
Liquefaction Target pH and Level		pH = 5.0; level = 76.4%										
Liquefaction Target % Dry Weight		11.5%										
COMMENTS:												
Sample #	Date	Time	Lab pH	Temp (°F)	Tank Level	% DW (moisture balance)			% DW (oven)			Average DW
1	7/10/2014	1:00 PM	5.1	121.8	76.20%	11.35%	11.78%	11.89%	11.85%	11.64%	11.67%	
2	7/10/2014	7:00 PM	5.1	121.9	77.58%	9.86%	11.51%	10.89%	11.85%	11.64%	11.15%	
3	7/11/2014	1:00 AM	5.3	122	53.30%	11.64%	12.06%	11.74%	12.40%	11.03%	11.77%	

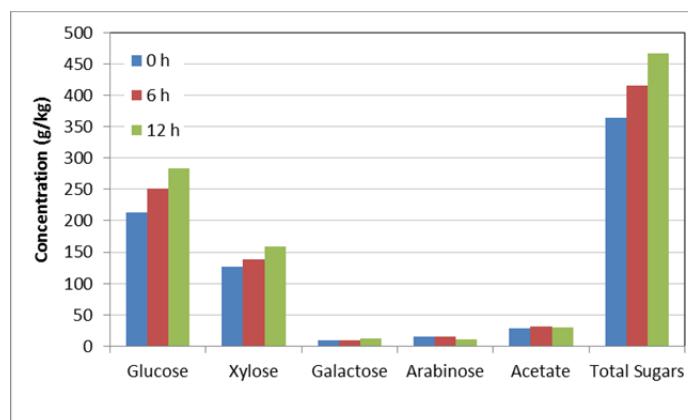


Figure 1. Sugar concentration in liquefaction tank with an enzyme loading of 15% and a retention time of 7 h. The first sample was taken after target level was reached.

Seed Propagation

Propagation was carried out using hydrolysate squeezed the week before from pretreated (185°C , 7.5 min, 0.89% acid) sugarcane bagasse (biomass batch number 10018). The hydrolysate was stored in a 300 gal tote and pumped directly into each propagator using the C5 pump and lines. The final concentration of hydrolysate in Propagator 2B and Propagator 3B was 30%. The hydrolysate was conditioned the day before by adjusting the pH to 9.0 after diluting with UV water. Approximately 6 gal and 25 gal of 19% ammonium hydroxide were used to increase the pH to 9.0 for Propagator 2B and 3B respectively. The nutrients were added just before the scheduled inoculation (sodium metabisulfite, final concentration of 1.5 mM; magnesium sulfate, final concentration of 1.5 mM; and trace metals, final concentration 1X), and 5 g/L glucose was added to each propagator prior to inoculation. The pre-seed flask was grown in 2 L flasks (1 L broth volume; total volume of 4.5 L) using 30% hydrolysate from steam-gun-pretreated sugarcane bagasse (190°C , 0.5% acid soak, 5 min) and 1.0 mM sodium metabisulfite. The pre-seed flasks were incubated at 37°C and 200 RPM for 24 h. The ethanol concentration in the pre-seed flasks was 1.09 g/L just before inoculation of Propagator 2B (total volume of 2B was 42 gal). Propagator 2B was set at 98.6°F for 27 h prior to transfer for inoculation of Propagator 3B. The 27 h inoculation was the result of small problems we had adding the nutrients for Propagator 3B, which resulted in the delayed inoculation. The ethanol concentration in Propagator 2B was 3.8 g/L just before inoculation of Propagator 3B (total volume of 3B was 420 gal). Propagator 3B was set at 98.6°F for 24 h prior to transfer for inoculation of Fermentor C. The ethanol concentration in Propagator 3B was 6.1 g/L right before inoculation of Fermentor C.

Conditions;

Pre-seed flask – 4.5 L of 30% steam-gun hydrolysate (190°C , 0.5% acid soak, 5 min prepared 4/12/2014)

Propagator 2B – 42 gal total volume, 30% Hz, 2.8% inoculum, 5 g/L glucose added

Propagator 3B – 420 gal total volume, 30% Hz, 10% inoculum, 5 g/L glucose added

Results;

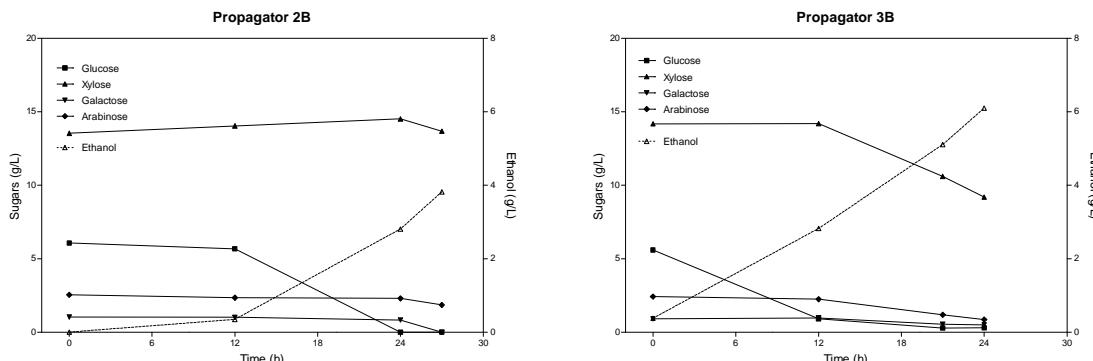


Figure 2. Sugars and ethanol concentration for the seed train. The final concentration of hydrolysate used was 30% with an additional 5 g/L glucose added.

Fermentation

To start the fermentation, ~1100 gal of slurry were pumped to the bottom of Fermentor C, after which the entire contents of Prop 3B were used as inoculum. The slurry continued to be pumped in for an additional 10 h with ~488 gal slurry left in the liquefaction tank. The contents of the liquefaction could not be completely emptied due to damage in the peristaltic pump rollers caused by small rocks that were transferred in with the biomass, causing the tubing inserts of the pump to rupture. The fermentation was completed in 36 h with a max ethanol titer of 26.1 g/L. The decrease in ethanol at the 48 h mark may have been the result of evaporation caused by the constant air flowing through the spargers. Cell counts were as high as 2.5×10^9 at the 36 h mark. Once the fermentation was completed (after 48 h), the temperature was adjusted to 140 °F (60 °C) and samples were taken to measure inactivation of the cells. After just 1 hour, there was a 6-log drop in CFU/mL (from 2×10^9 to 2×10^3) and after 3 h, the cell count was 2.2×10^2 .

Conditions;

Total volume ≈ 3720 gal (≈3300 gal slurry at 11.8% DW, ≈420 gal inoculum)

Inoculum = 11.3%

Duration = 48 h

Solids loading = 10.5%

Results;

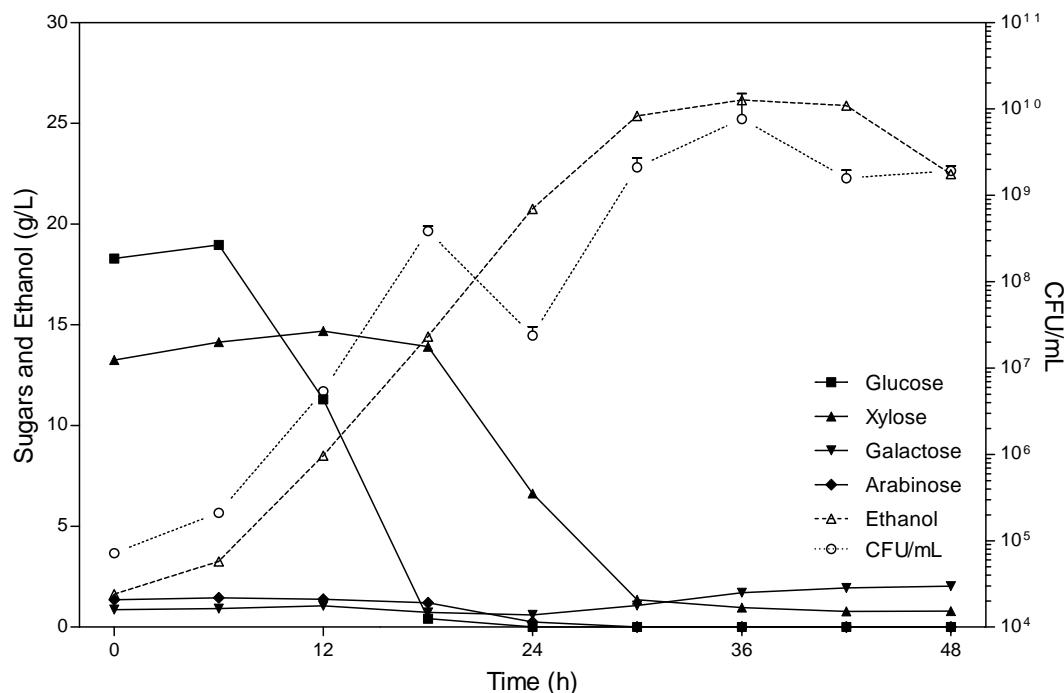


Figure 3. Sugars, ethanol, and CFU concentration during fermentation. The first sample was taken right after inoculation.

Biomass Mass Balance

Pretreated biomass goes into liquefaction for ~17.5 h; biomass flow rate = 216 lb DW/h; total biomass through liquefaction = 3780 lb DW.

Liquefaction DW = 11.8%; fermentation total volume = 3720 gal; inoculum size = 420 gal. Dry weight of the fermentation (if it was operated in batch) = $\frac{11.8\% * (3720 \text{ gal} - 420 \text{ gal})}{3720 \text{ gal}} = 10.5\%$ dry weight.

$3720 \text{ gal} * 8.34 \frac{\text{lb}}{\text{gal}} * 10.5\% = 3260 \text{ lb DW}$ added to the fermentation. However, liquefaction was not completely emptied; ~488 gal were not transferred to the fermentor. $488 \text{ gal} * 8.34 \frac{\text{lb}}{\text{gal}} * 11.8\% = 480 \text{ lb DW}$.

From the calculation based on the pretreatment flow rate, the amount of biomass liquefied was **3780 lb DW**. From the liquefaction dry weights and fermentation and liquefaction levels we calculated $3260 + 480 = \mathbf{3740 \text{ lb DW}}$.

Appendix

Process trends

Pretreatment

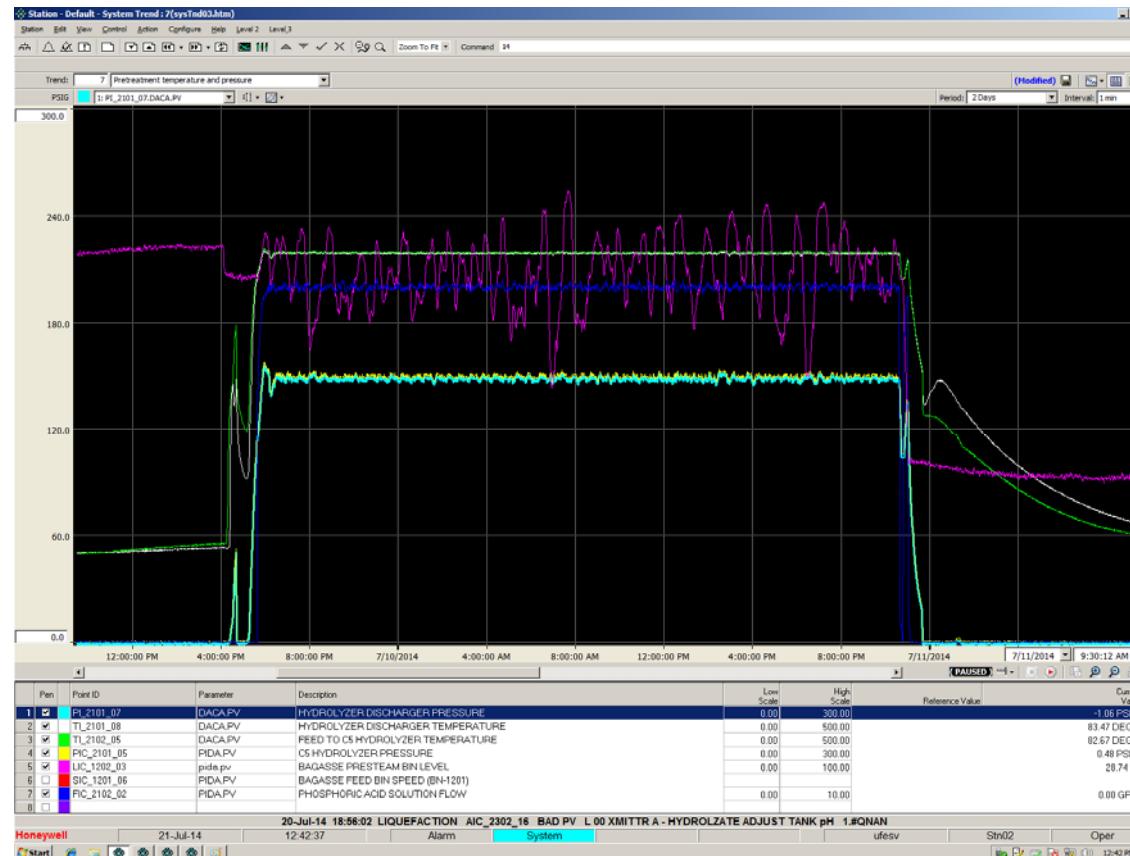


Figure 4. Temperature, pressure, pre-steam bin level, and phosphoric acid flow rate during pretreatment. Set points were; pressure, 150 PSI; retention time, 7.5 min; acid flow rate, 6.67 GPH; biomass flow rate, 100% (216 lb DW/h).

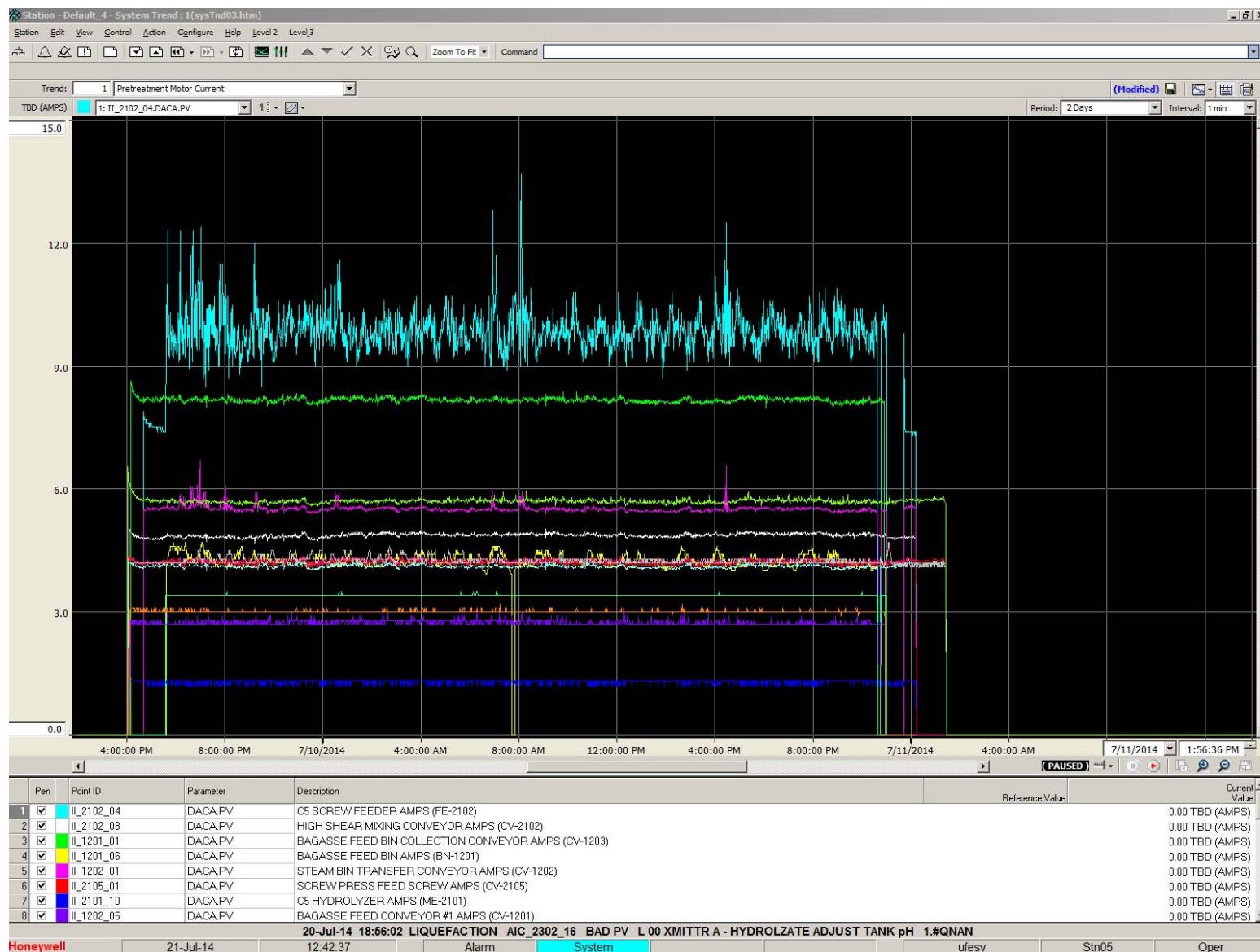


Figure 5. Current load for all biomass handling and pretreatment motors. The clear blue trend with a lot of variability represents the load of the plug-screw feeder.

Liquefaction and pH Adjustment

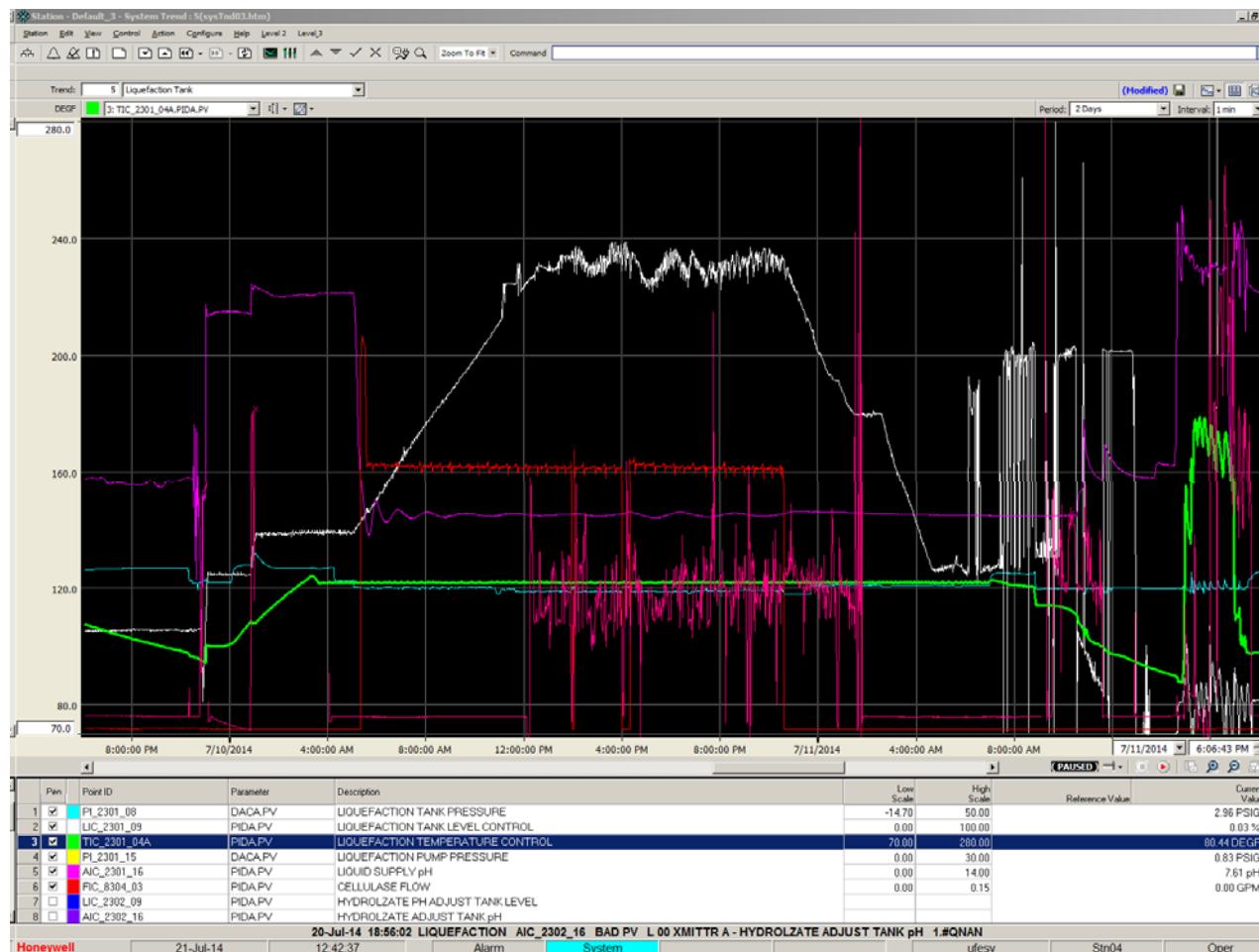


Figure 6. Liquefaction trend. An initial amount of water was added to the tank to ensure that the pH probe and the bottom impeller were covered before adding any biomass. This can be observed with the white (level) and purple (pH) trends. As soon as biomass was fed into the liquefaction tank, the pH dropped and the level started to increase in a more gradual way. After the desired level was reached, the slurry was pumped into the pH Adjustment Tank, as can be observed by the magenta trend, which indicated the pressure in the slurry line right after the liquefaction pump. After the big spike in pressure in the slurry line (magenta), the slurry line was clogged and we proceeded to pump the slurry using a hose to connect the liquefaction pump with the top of the pH Adjustment Tank.

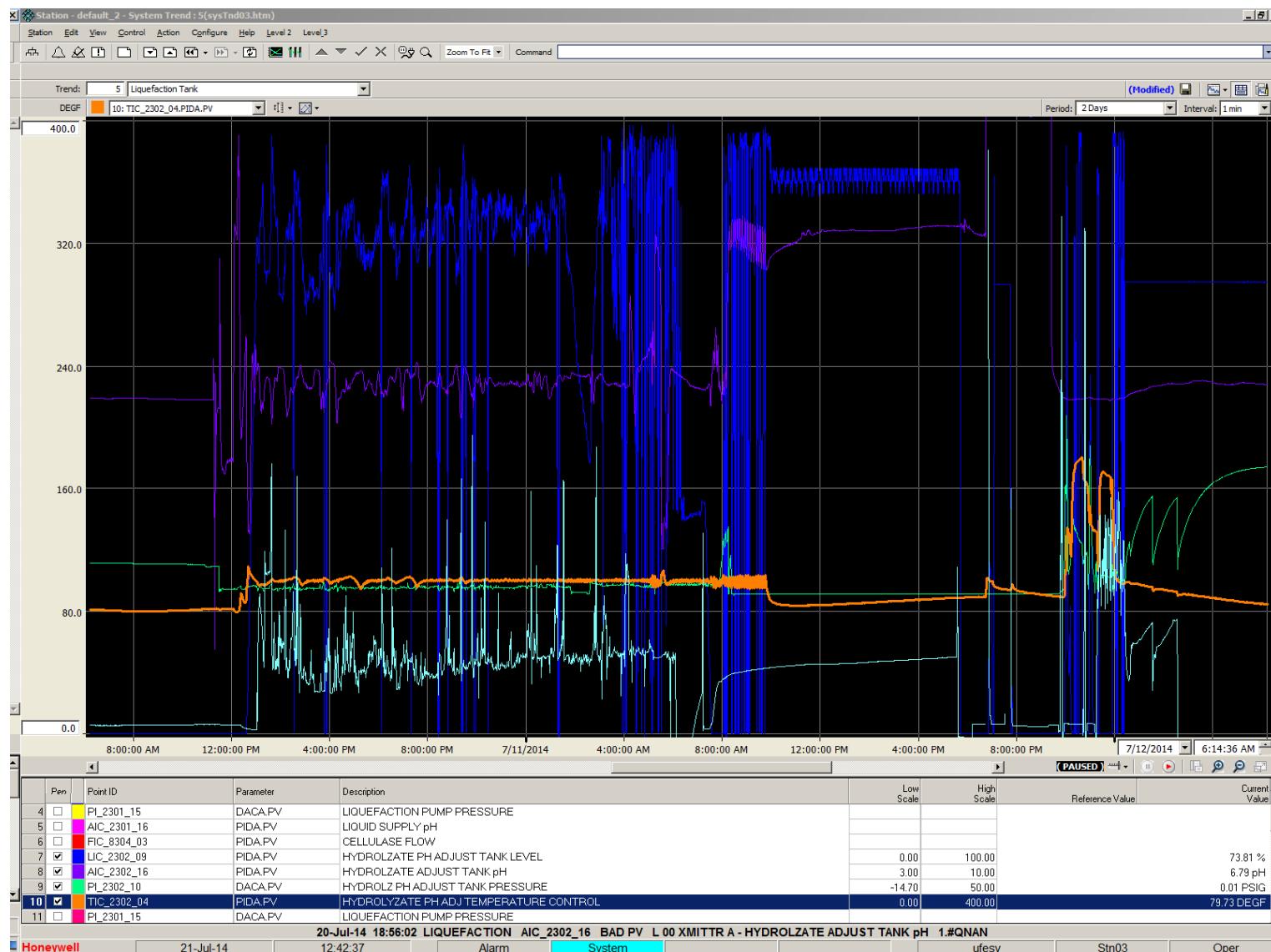


Figure 7. pH Adjustment Tank trend. The level trend (blue) has many spiked due to errors in the level reading when the tank was too full (>85% level). This problem was ongoing due to the difficulty in maintaining a constant level in the pH adjustment tank resulting from problems with the peristaltic pumps (liquefaction and pH adjustment pumps).

Propagation

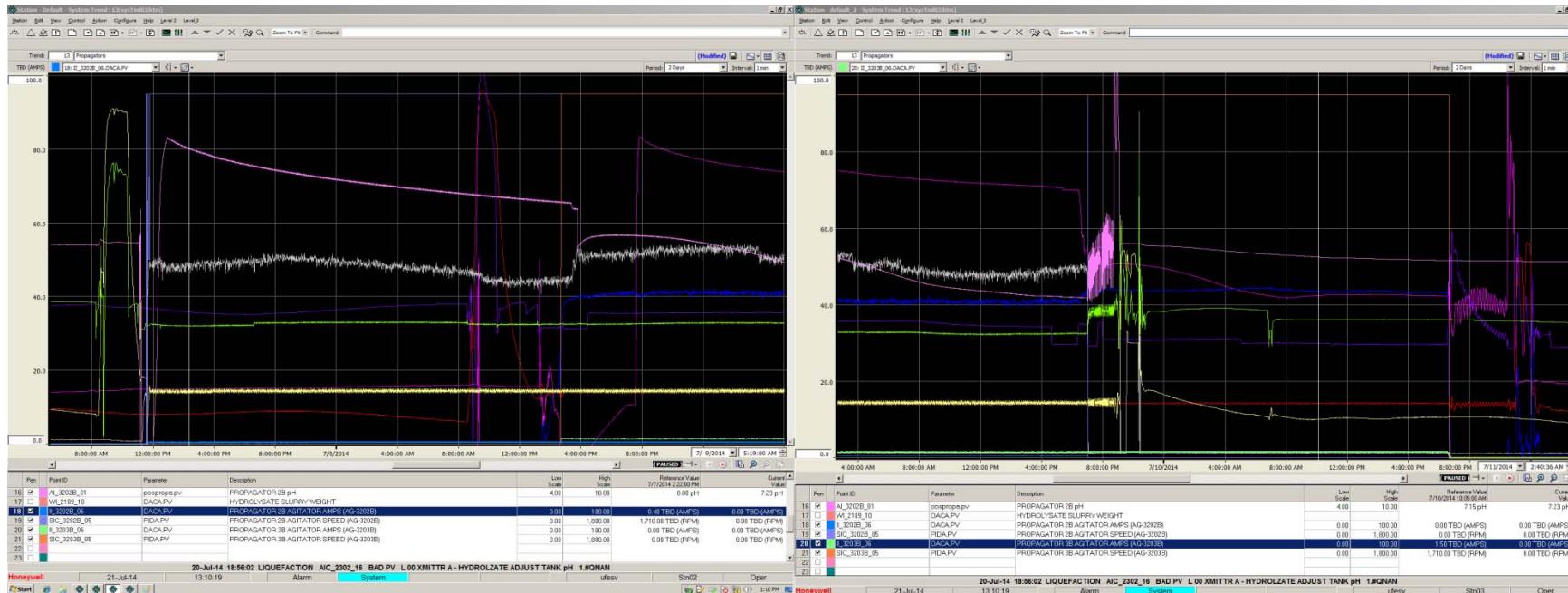


Figure 8. Trend for propagators 2B and 3B. After sterilizing each propagator, the hydrolysate and water were added and the pH was adjusted to 9.0. The diluted hydrolysate was incubated overnight at 98.6 °F. Propagator 2B was inoculated with 4.5 L of media grown in the lab through a side port in the propagator itself. Propagator 3B was inoculated by discharging the entire contents of Propagator 2B. After 24 h of growth, Propagator 3B was used to inoculate Fermentor C. When each tank was drained, a clean-in-place (CIP) procedure was carried out.

Fermentation

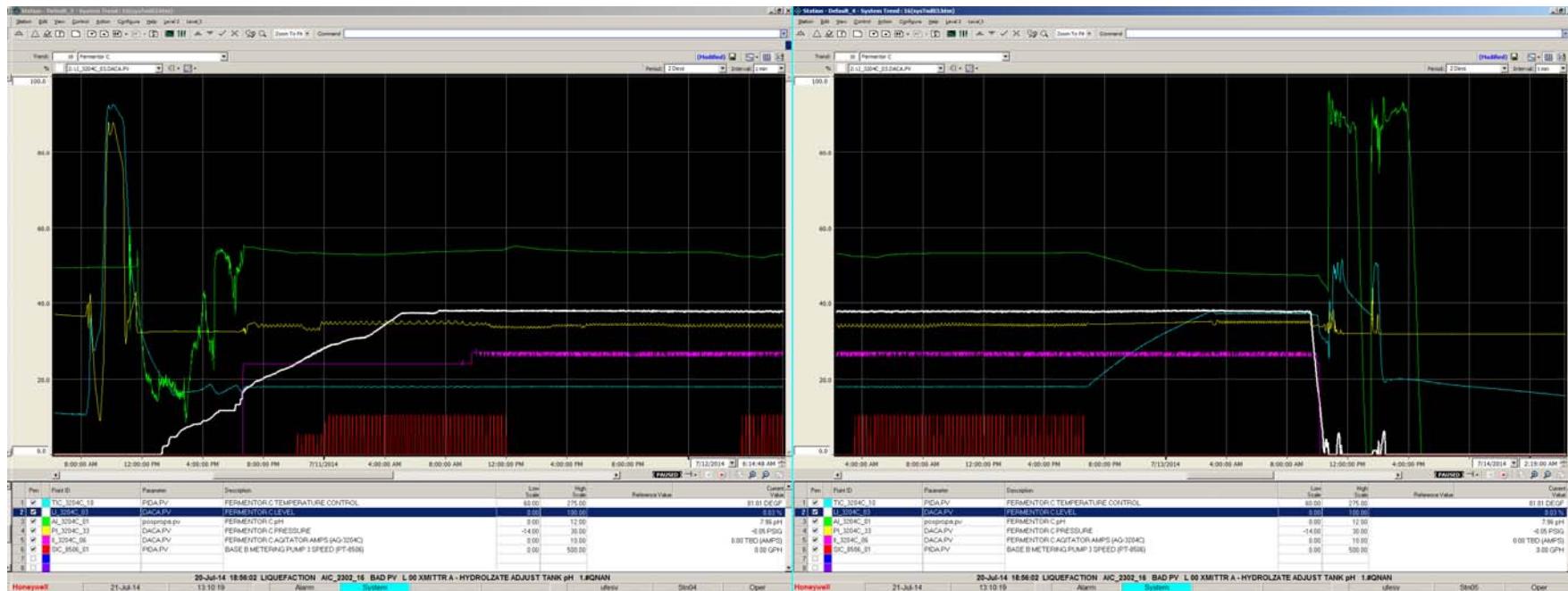


Figure 9. Fermentor C trend. After autoclaving, slurry from the liquefaction tank was added through the pH adjustment tank. After ~6 h of adding slurry to the fermentor, the entire contents of Propagator 3B were added to the Fermentor C as inoculum. This step is marked by the change in the pH trend to a smooth line (once the fermentation slurry covered the probe during inoculation). As can be observed, the level (white) continued to increase as more slurry was added to the tank. The temperature (light blue) was maintained through the fermentation (48 h), and then it was increased to 140 °F for validation of the heat kill. After the slurry was transferred to the beer well, a clean-in-place (CIP) procedure was carried out.

Clean-In-Place (CIP)

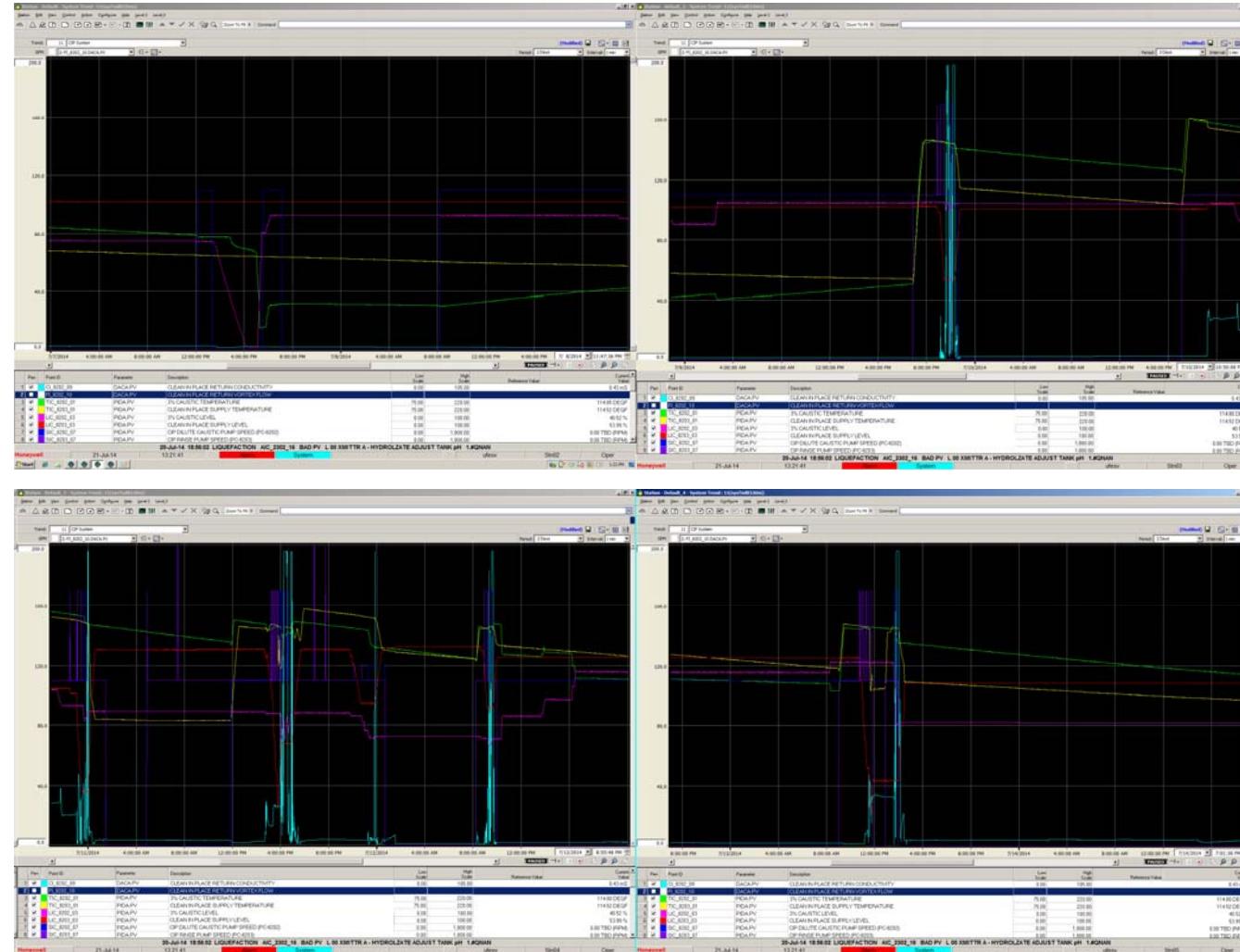


Figure 10. Clean-In-Place system trend. Initially, the caustic tank was emptied (purple line is level in caustic tank) and refilled with a fresh caustic solution. Once the set temperature (green and yellow trends) was reached in the rinse and caustic tanks, the CIP cycle was started. The conductivity trend (light blue) starts to spike during the caustic clean-up of the tank.

Scrubbers

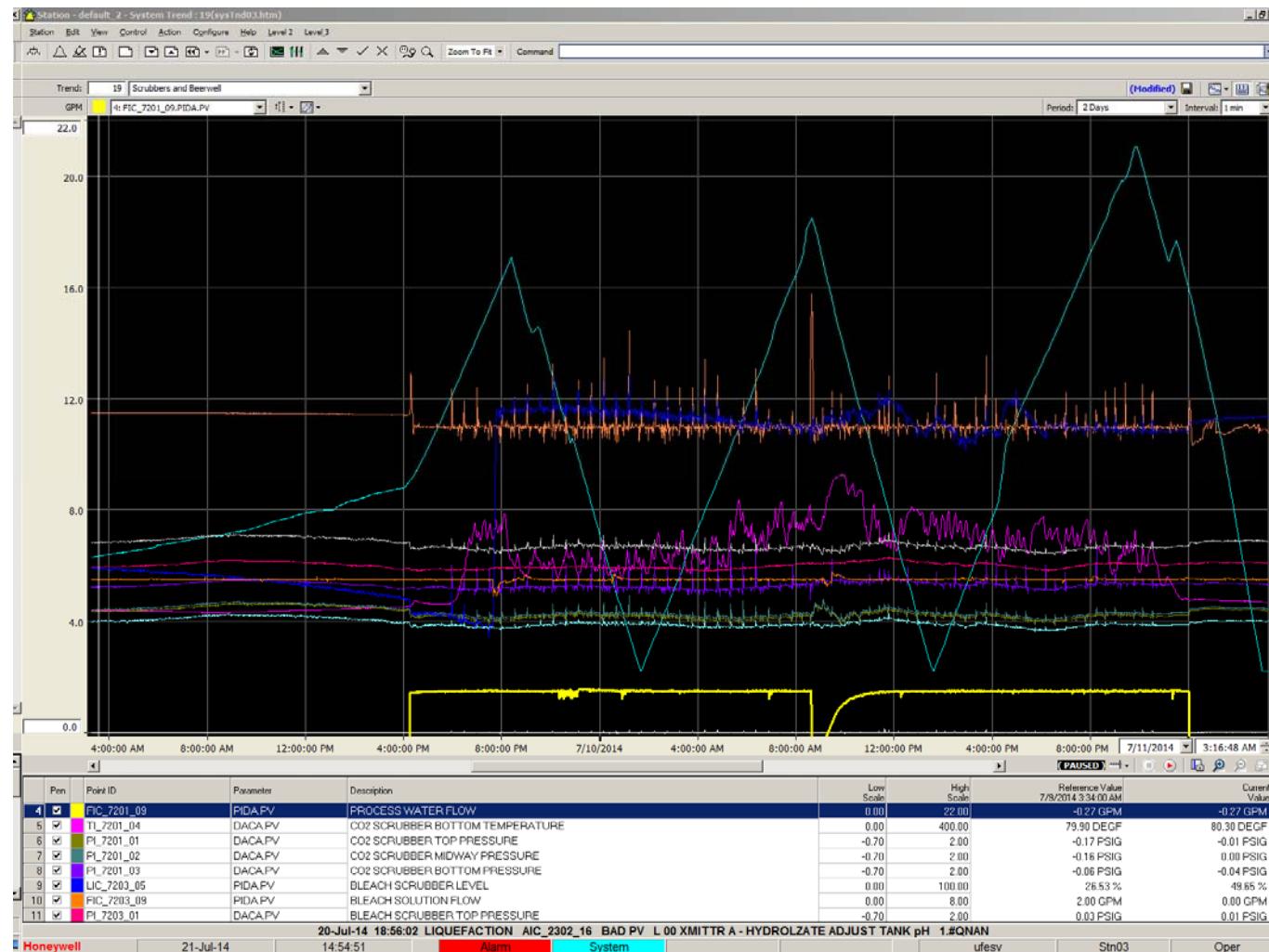


Figure 11. Trends for the scrubber system. Once pretreatment was started, the CO₂ Scrubber was started as well (the bleach scrubber had already been operational due to propagation taking place). The spikes observed in some of the trends are caused by the steam released from the pretreatment every time the dump chamber releases the biomass into the flash tank. The yellow line is the flow of process water into the CO₂ scrubber and the light blue line going up and down across the screen is the wastewater level. As soon as the wastewater level is above 80% it is pumped out to Georgia Pacific into their wastewater ponds.

Agitation

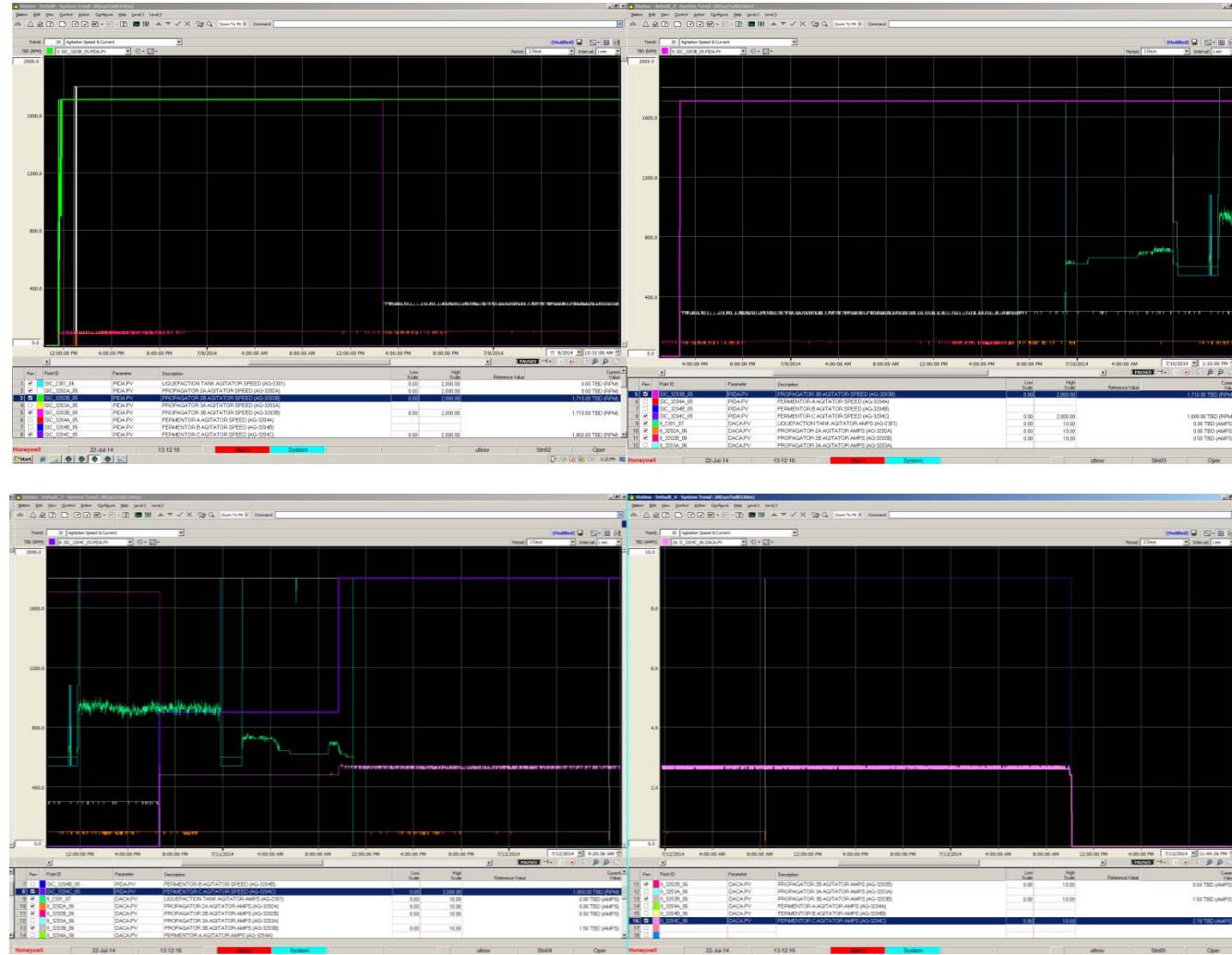
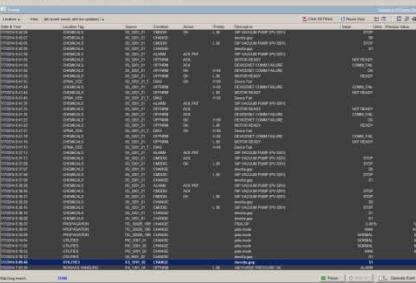
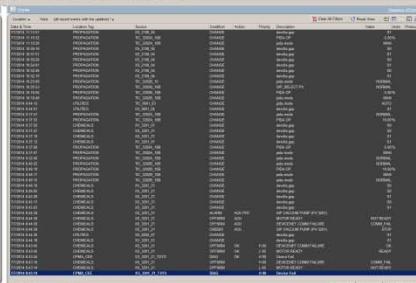
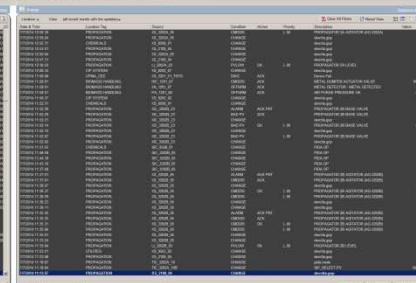
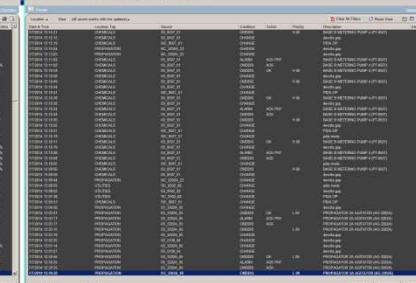
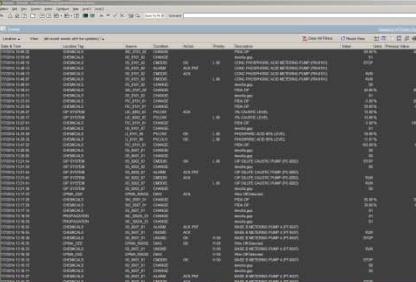
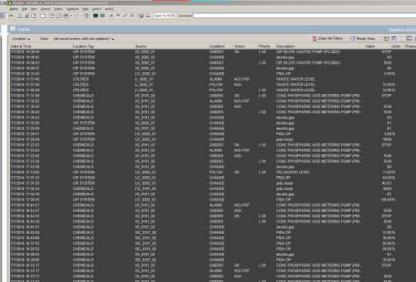
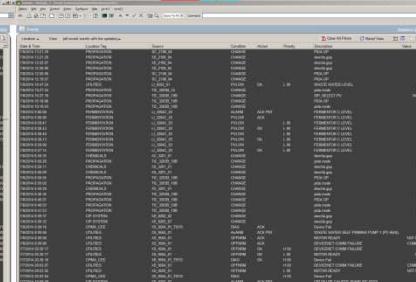
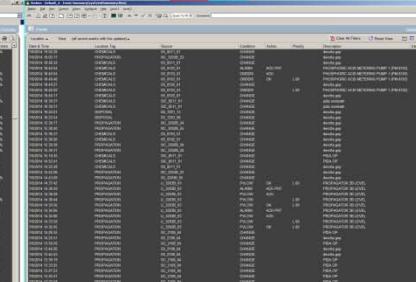
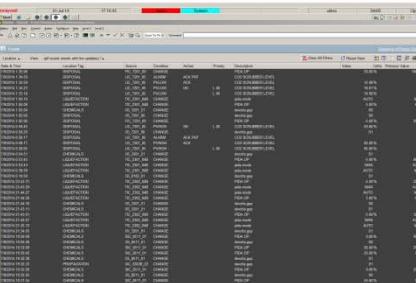
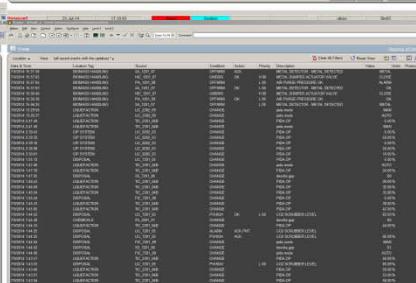
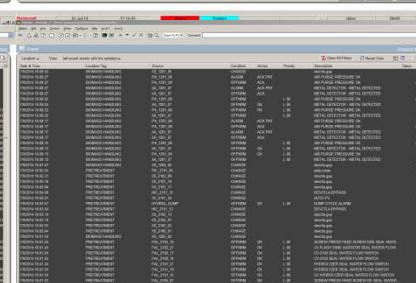
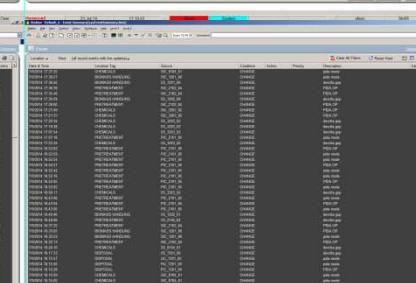
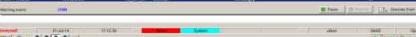
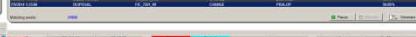
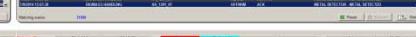
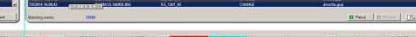
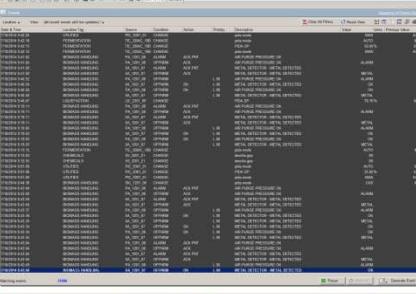
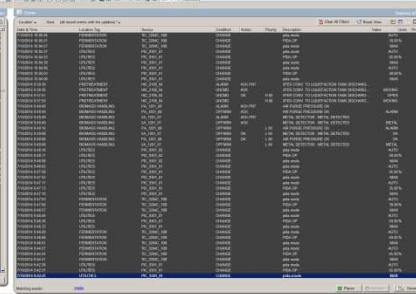
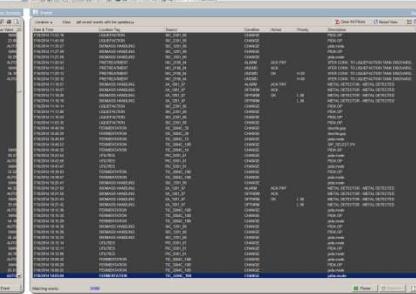
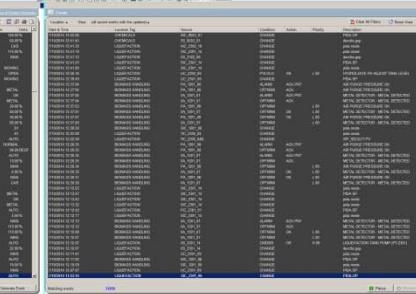
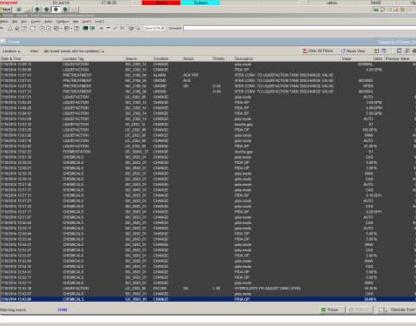
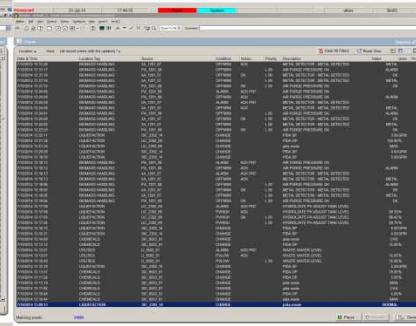
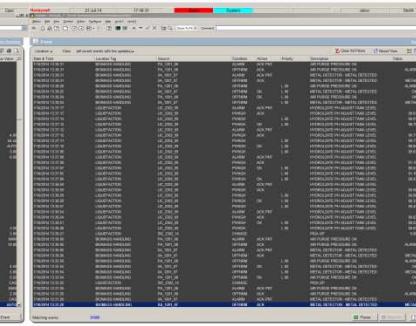
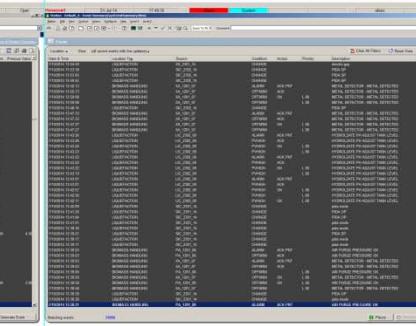
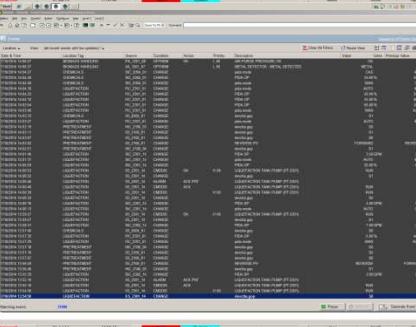
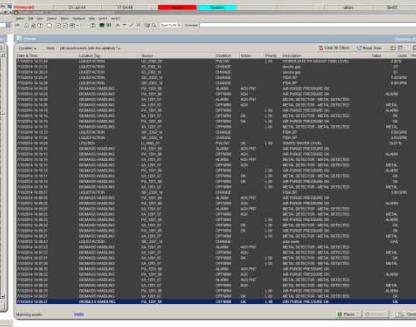
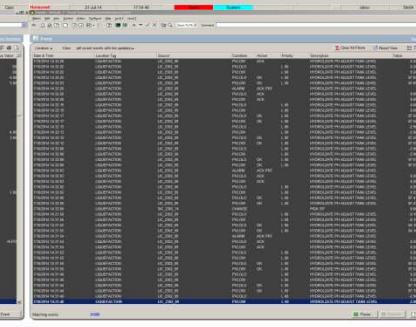
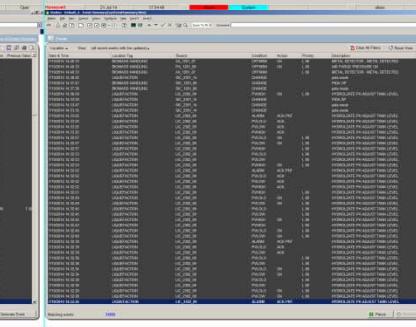


Figure 12. Agitation speed and current load. The liquefaction load was the only one with considerable variation in the load probably due to the agitator configuration (only one with two-stage impellers) and the nature of the process.

Event Log

The image shows a 4x4 grid of 16 computer monitors arranged in four rows and four columns. Each monitor displays a detailed log or database table of industrial data. The tables include columns such as 'Timestamp', 'Location Tag', 'Series', 'Type', 'Value', and 'Priority'. The data is primarily composed of numerical values, with some descriptive text like 'METAL DETECTOR' and 'ALARM' interspersed. The interface includes various buttons and tabs at the top of each monitor's window, and a progress bar at the bottom of each screen.

The image consists of a 4x4 grid of 16 computer monitor screenshots. Each screenshot shows a table of data with the following columns:

- Date
- Time
- User
- Job event name with the updated by
- Details
- Status
- Notes
- Priority
- Progress

The data in the tables is nearly identical across all 16 screens. It includes entries such as:

- Job event names: ACK PNT, ACK HST, CHARGE, DISCHARGE, etc.
- Status: OK
- Priority: Normal
- Progress: 0.0%

The time column shows a progression from 10:14:00 to 21:24:14. The user column shows various users like 'SYSTEM', 'DANIEL', 'ALAN', etc. The notes column contains some descriptive text about the job events.

The image consists of a 3x4 grid of 12 screenshots of a software application. Each screenshot shows a table of log entries. The columns in the table include:

- Date
- Time
- User
- Job name
- Start
- End
- Duration
- Progress
- State
- Details
- Notes
- Errors

The logs contain numerous entries for tasks such as "get event metric with the generic" and "get event metric with the updated". The "Progress" column shows values like 0.00%, 0.01%, 0.02%, etc., up to 100.00%. The "State" column often shows "OK" or "IN PROGRESS". The "Errors" column is frequently empty or shows minor errors like "ORA-00001". The "Details" column contains detailed log messages.

This figure consists of a 3x4 grid of 12 screenshots, each showing a table of network log data. The columns in the table are: Date, Time, User, Job, Event, Details, and Duration. The data spans from June 20, 2014, to June 21, 2014. The logs include entries for ACK, PULL, PUSH, and FILE operations on various hosts (192.168.1.10, 192.168.1.11) and ports (22, 23, 25, 26, 27, 28). The interface features a toolbar at the top and a status bar at the bottom.

The image displays a 3x4 grid of 12 computer screens, each showing a log file from a different location and date. The logs are presented in a table format with columns for Date, Time, Location, File, Check, Description, Status, Report, Latitude, Longitude, and Accuracy.

Log File Headers:

- Location:** View all event records with the specified 'Location' filter.
- Date:** View all event records with the specified 'Date' filter.
- Time:** View all event records with the specified 'Time' filter.
- File:** View all event records with the specified 'File' filter.
- Check:** View all event records with the specified 'Check' filter.
- Description:** View all event records with the specified 'Description' filter.
- Status:** View all event records with the specified 'Status' filter.
- Report:** View all event records with the specified 'Report' filter.
- Latitude:** View all event records with the specified 'Latitude' filter.
- Longitude:** View all event records with the specified 'Longitude' filter.
- Accuracy:** View all event records with the specified 'Accuracy' filter.

Log File Columns:

- Date:** The date of the event.
- Time:** The time of the event.
- Location:** The location where the event occurred.
- File:** The file associated with the event.
- Check:** The check status of the event.
- Description:** A detailed description of the event.
- Status:** The current status of the event.
- Report:** The report number associated with the event.
- Latitude:** The latitude coordinate of the event.
- Longitude:** The longitude coordinate of the event.
- Accuracy:** The accuracy of the event's location.

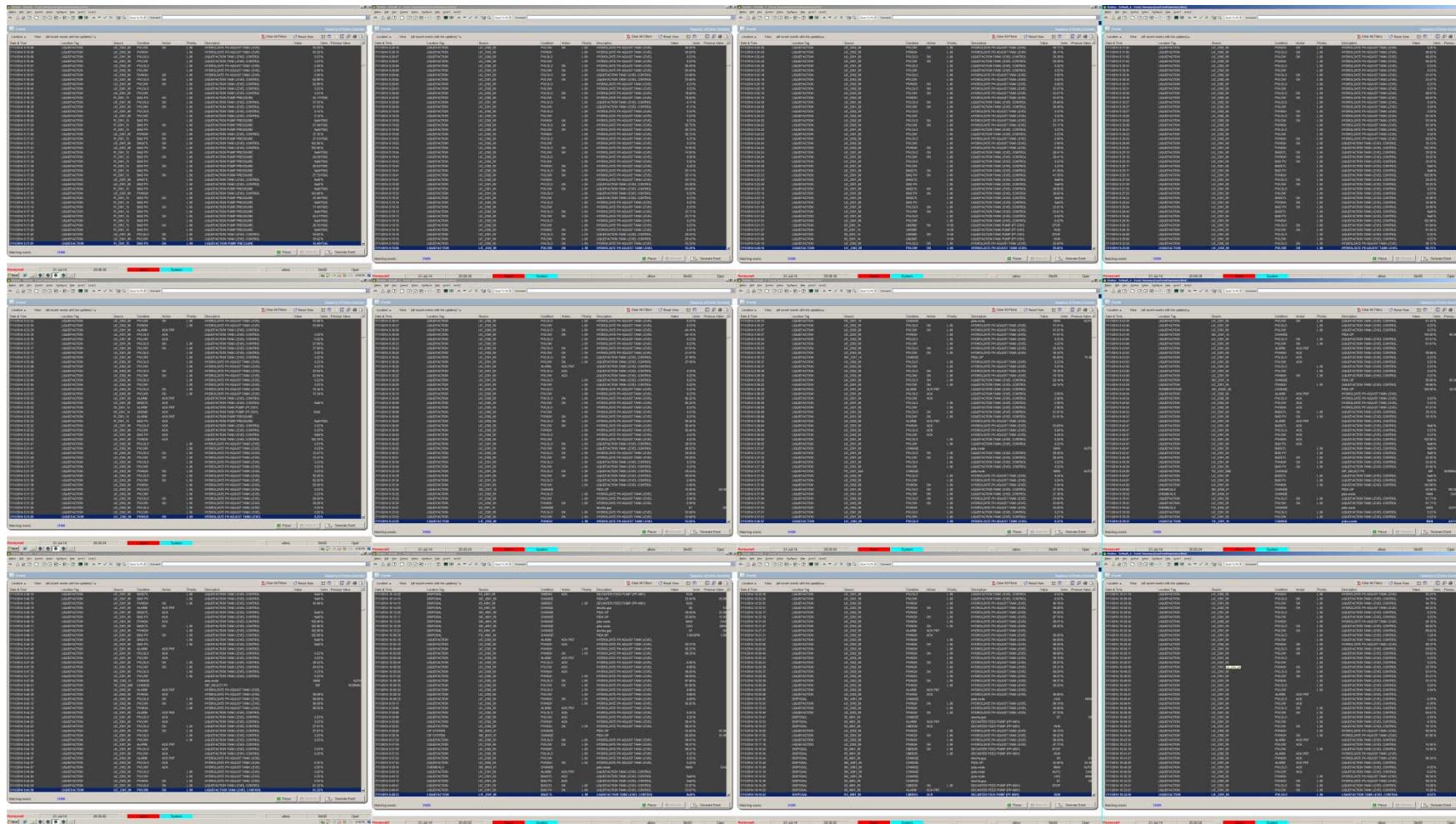
The image displays a 3x4 grid of 12 computer screens, each showing a log file from a network monitoring tool. The logs are presented in a table format with the following columns:

- Date
- Time
- User
- Job ID
- Event Type
- Description
- Status
- Duration

The logs show a variety of system events, primarily involving file transfers and processing tasks. Some examples of event descriptions include:

- File transfer initiated from user A to user B.
- File transfer completed successfully.
- File transfer failed due to permission issues.
- File processing started for job ID 12345.
- File processing completed for job ID 12345.
- File processing failed for job ID 12345.

The status column indicates the current state of each event, such as "IN PROGRESS" or "COMPLETED". The duration column shows the time taken for each task to complete.



The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with multiple log entries. The logs are organized into tables with columns for Date, Time, User, File Path, and Description. The content of the logs is repetitive, showing various system events and file operations. The screens are arranged in three rows and four columns, with each screen showing a different time range or specific log entries.

The image consists of a 3x4 grid of 12 screenshots, each showing a table of log entries. The columns in the table are:

- Date
- Time
- User
- Job
- Event ID
- Subsystem
- Module
- Function
- Description

The logs contain numerous entries, primarily showing database operations such as SELECT, OPEN, and CLOSE. Other entries include system-related tasks like INITIALIZATION and TERMINATION. The logs are timestamped from approximately 20:00:00 to 21:30:00.

The image consists of a 3x4 grid of 12 computer monitor screenshots. Each screenshot shows a table with the following columns:

- Date
- Time
- User
- Job
- Event
- Location
- File
- Phase
- Description
- Start
- End
- Duration
- Progress

The data in the tables is nearly identical across all 12 screens. Key entries include:

- Events: ACK PRC, CALIBRATION, PHASE 1, PHASE 2, PHASE 3, PHASE 4, PHASE 5, PHASE 6, PHASE 7, PHASE 8, PHASE 9, PHASE 10, PHASE 11, PHASE 12, PHASE 13, PHASE 14, PHASE 15, PHASE 16, PHASE 17, PHASE 18, PHASE 19, PHASE 20, PHASE 21, PHASE 22, PHASE 23, PHASE 24, PHASE 25, PHASE 26, PHASE 27, PHASE 28, PHASE 29, PHASE 30, PHASE 31, PHASE 32, PHASE 33, PHASE 34, PHASE 35, PHASE 36, PHASE 37, PHASE 38, PHASE 39, PHASE 40, PHASE 41, PHASE 42, PHASE 43, PHASE 44, PHASE 45, PHASE 46, PHASE 47, PHASE 48, PHASE 49, PHASE 50, PHASE 51, PHASE 52, PHASE 53, PHASE 54, PHASE 55, PHASE 56, PHASE 57, PHASE 58, PHASE 59, PHASE 60, PHASE 61, PHASE 62, PHASE 63, PHASE 64, PHASE 65, PHASE 66, PHASE 67, PHASE 68, PHASE 69, PHASE 70, PHASE 71, PHASE 72, PHASE 73, PHASE 74, PHASE 75, PHASE 76, PHASE 77, PHASE 78, PHASE 79, PHASE 80, PHASE 81, PHASE 82, PHASE 83, PHASE 84, PHASE 85, PHASE 86, PHASE 87, PHASE 88, PHASE 89, PHASE 90, PHASE 91, PHASE 92, PHASE 93, PHASE 94, PHASE 95, PHASE 96, PHASE 97, PHASE 98, PHASE 99, PHASE 100.
- Locations: L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, L16, L17, L18, L19, L20, L21, L22, L23, L24, L25, L26, L27, L28, L29, L30, L31, L32, L33, L34, L35, L36, L37, L38, L39, L40, L41, L42, L43, L44, L45, L46, L47, L48, L49, L50, L51, L52, L53, L54, L55, L56, L57, L58, L59, L60, L61, L62, L63, L64, L65, L66, L67, L68, L69, L70, L71, L72, L73, L74, L75, L76, L77, L78, L79, L80, L81, L82, L83, L84, L85, L86, L87, L88, L89, L90, L91, L92, L93, L94, L95, L96, L97, L98, L99, L100.
- Phases: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.
- Progress: 0.00%, 0.01%, 0.02%, 0.03%, 0.04%, 0.05%, 0.06%, 0.07%, 0.08%, 0.09%, 0.10%, 0.11%, 0.12%, 0.13%, 0.14%, 0.15%, 0.16%, 0.17%, 0.18%, 0.19%, 0.20%, 0.21%, 0.22%, 0.23%, 0.24%, 0.25%, 0.26%, 0.27%, 0.28%, 0.29%, 0.30%, 0.31%, 0.32%, 0.33%, 0.34%, 0.35%, 0.36%, 0.37%, 0.38%, 0.39%, 0.40%, 0.41%, 0.42%, 0.43%, 0.44%, 0.45%, 0.46%, 0.47%, 0.48%, 0.49%, 0.50%, 0.51%, 0.52%, 0.53%, 0.54%, 0.55%, 0.56%, 0.57%, 0.58%, 0.59%, 0.60%, 0.61%, 0.62%, 0.63%, 0.64%, 0.65%, 0.66%, 0.67%, 0.68%, 0.69%, 0.70%, 0.71%, 0.72%, 0.73%, 0.74%, 0.75%, 0.76%, 0.77%, 0.78%, 0.79%, 0.80%, 0.81%, 0.82%, 0.83%, 0.84%, 0.85%, 0.86%, 0.87%, 0.88%, 0.89%, 0.90%, 0.91%, 0.92%, 0.93%, 0.94%, 0.95%, 0.96%, 0.97%, 0.98%, 0.99%, 100.00%.

The image displays a 2x4 grid of computer monitors, each showing a terminal window with a large amount of text. The text appears to be log files or command-line output, likely from a network monitoring or system administration tool. The windows have a dark background with white text. The top row contains four monitors, and the bottom row contains four monitors. Each monitor has a title bar at the top with the text "File Edit View Insert Cell Window Help". The bottom of each monitor shows a toolbar with icons for file operations like Open, Save, Print, and Exit.

Location: /var/log/kern.log (last 1000 lines)	Location: /var/log/secure (last 1000 lines)	Location: /var/log/auth.log (last 1000 lines)	Location: /var/log/cron (last 1000 lines)
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Location: /var/log/kern.log (last 1000 lines)	Location: /var/log/secure (last 1000 lines)	Location: /var/log/auth.log (last 1000 lines)	Location: /var/log/cron (last 1000 lines)

The image consists of a 2x6 grid of screenshots from a log monitoring application. Each screenshot shows a table of log entries with the following columns:

- Date
- Time
- User
- Job name
- Status
- Queue
- Node
- Priority
- Description
- Duration

The logs capture various system activities, including periodic tasks and charging processes, across different nodes and queues over a period of about a week.