

UNIVERSITY OF FLORIDA

2014-09-08 Campaign Report

Stan Mayfield Biorefinery

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In this document the results of the 2014-09-08 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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Introduction

The Stan Mayfield Biorefinery, located in Perry, Florida, is a facility managed by the University of Florida that was built with state funds. The main purpose of the facility is to work out the main issues that arise from the scale-up of a lignocellulosic ethanol process that was developed at the University of Florida. It is our goal to attract private investment by demonstrating the feasibility of this technology. We have now completed the start-up and commissioning of the main process, with the distillation unit being the only equipment that has not been fully commissioned. In this report, we will give a summary of the results from the latest campaign, as well as future plans for the next runs.

During the previous campaign, we were successful in operating the liquefaction process continuously for ~31 h in order to perform for the first time an ~8000 gal fermentation in Fermentor C. In addition, the enzyme concentration during liquefaction was reduced to 10% of the biomass dry weight and the pump-feed-outlet for liquefaction was changed from the bottom drain to the side of the tank to prevent rocks from damaging the peristaltic pump.

For this campaign, the main objective was to complete an 8,000 gallon fermentation of sugarcane bagasse slurry using 15% solids liquefaction slurry. Also, the enzyme cocktail used for this campaign was changed to the latest commercial version from Novozymes® (NS22146). The conditions used for pretreatment were maintained the same as the previous campaign; 150 psi (185 °C or 365 °F), 7.5 min retention time, and 0.8% (of the dry weight of biomass) acid concentration. However, the screw press was operated at 5 RPM and no hydrolysate was squeezed throughout the campaign. The liquefaction temperature and pH were maintained at the optimum values for the commercial enzyme (pH = 5.0, T = 50 °C or 122 °F), and the concentration of enzyme was reduced from 10% of the dry weight during the previous campaign to 5%.

This campaign is a significant step forward, as we will be using a higher solids loading during liquefaction and fermentation, but reducing by 50% the enzyme requirement.

Results summary

Pretreatment

The pretreatment unit was continuously operated for 60 h using sugarcane bagasse (biomass batch number 10021). Five separate samples were obtained for analysis during operation. After 36 h there was a power outage and all systems had to be re-started. The pretreatment system was not operated for a longer time due to a small oil leak that was identified in the reversing screw conveyor, and an apparent clog starting to form in the bottom knife-gate-valve of the dump chamber. Contrary to the previous run, we did not squeeze hydrolysate from the pretreated biomass while feeding the liquefaction tank.

Conditions;

Temperature = 365 °F (185 °C)

Pressure = 150 psi

Retention time = 7.5 min

Biomass flow rate = 210 lb DW/h

Acid solution flow rate = 6.67 GPH

Acid solution concentration = 3% (w/w)

Final acid concentration (calculated) = 0.8%

Results;

Sugar/ Inhibitor	Hydrolysate Concentration			
	g/L		g/kg	
	Average	StDev	Average	StDev
Glucose	6.1	1.8	10.6	2.7
Xylose	45.5	6.9	80.1	12.5
Galactose	2.9	0.5	5.2	0.7
Arabinose	8.6	1.0	15.0	1.5
Total Sugars	63.1	9.1	110.9	14.7
HMF	0.7	0.1	1.2	0.2
Furfural	1.7	0.2	2.9	0.2
Acetate	7.5	1.5	13.3	3.0
Total Inhibitors	9.8	1.7	17.4	3.4

Liquefaction

Biomass was continuously fed into the liquefaction tank for a total of 53 h, with continuous operation into Fermentor C for ~45 h. Once the pretreatment unit was no longer operational, the liquefaction conditions were maintained for an additional 1.5 h while pumping the slurry into Fermentor C.

However, there were some issues with level control during the operation of the pH Adjustment Tank. The level of the pH Adjustment Tank became erratic after the probe was covered with biomass slurry. Therefore, the liquefaction tank level and the operation of the liquefaction pump were carried out manually for the duration of the run.

Eight separate samples were taken. The first one, when the liquefaction tank had reached the pre-determined level of 50% (t=0 h), and the rest every six hours after that. The retention time was 6 h and the enzyme used for digestion was Novozymes® NS22146 fed at a constant rate of 0.021 gpm for a 5% (v/w) enzyme loading. The enzyme flow rate was maintained using previously created calibration curves relating flow rate with pump speed. The reason for this was that the flowmeter in the enzyme lines can't read accurately at such low flow rates. Approximately 90 gal of 19% ammonium hydroxide were used to adjust pH in the liquefaction (pH = 5.0) and pH adjustment tanks (pH = 7.0) during the entire run.

Liquefaction Data Sheet												
Date and time created		9/12/2014 9:29										
Enzyme Flow Rate (FIC-8304-03)		0.021 gal/min										
Biomass Flow Rate		210 lb DW/h										
UV Water Flow Rate		1.61 gal/min										
UV Water Temperature		80 °F										
Liquefaction Target Temperature		122 °F										
Liquefaction Target pH and Level		pH = 5.0; level = 50%										
Liquefaction Target % Dry Weight		15.0%										
COMMENTS:												
Sample #	Date	Time	Lab pH	Temp (°F)	Tank Level	% DW (moisture balance)			% DW (oven)			Average DW
						1	2	3	1	2	3	
1	9/10/2014	10:00 PM	5.00	121.9	49.6%	14.46%	14.87%	14.66%	14.00%	14.15%	14.43%	
2	9/11/2014	4:00 AM	5.04	121.8	50.2%	14.19%	14.66%	15.02%			14.62%	
3	9/11/2014	10:00 AM	5.02	121.7	49.8%	15.42%	14.69%	14.66%	15.00%	15.00%	14.95%	
4	9/11/2014	4:00 PM	5.01	121.9	50.0%	16.18%	14.06%	15.16%	15.59%	15.61%	15.32%	
5	9/11/2014	10:00 PM	5.06	122.1	52.0%	14.97%	14.82%	15.03%	15.26%	15.21%	15.06%	
6	9/12/2014	4:00 AM	5.1	121.8	49.2%	15.01%	13.90%	14.36%			14.42%	
7	9/12/2014	10:00 AM	5.04	121.8	51.5%	13.76%	13.65%	12.82%	14.02%	14.04%	13.66%	
8	9/12/2014	4:00 PM	5.01	121.7	49.7%	13.71%	13.76%	14.27%	14.25%	14.30%	14.06%	

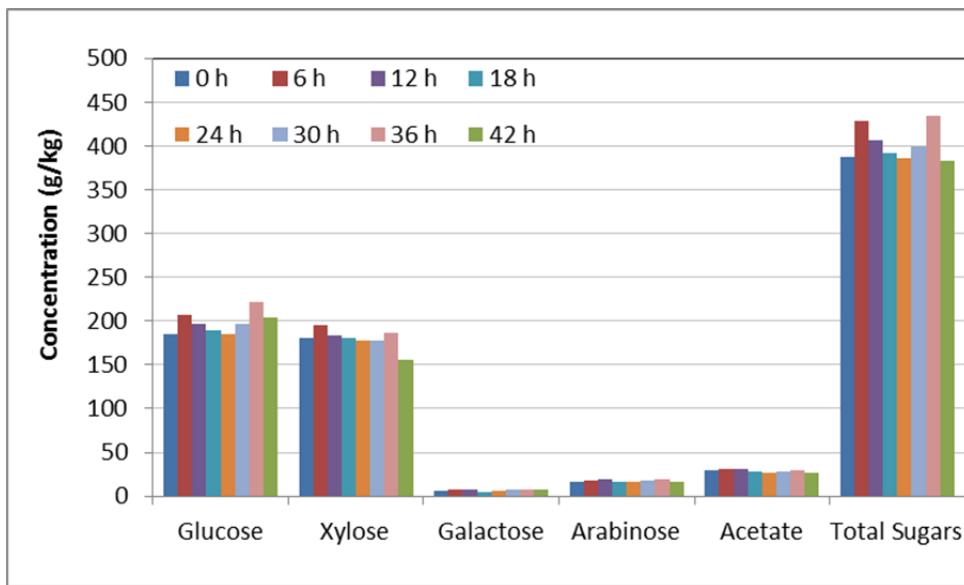


Figure 1. Sugar concentration in liquefaction tank with an enzyme loading of 5% and a retention time of 6 h. The first sample was taken after target level of 50% was reached.

Seed Propagation

For the initial pre-seed flask the hydrolysate used was squeezed beforehand from pretreated (185 °C, 7.5 min, 0.79% acid) sugarcane bagasse (biomass batch number 10019), and the same was true for the propagation steps that followed, with the hydrolysate obtained from biomass batch number 10021. The hydrolysate was stored in the C5 Tank and pumped directly into each propagator using the C5 pump and lines. The final concentration of hydrolysate in the pre-seed flask and Propagator 2B was 30%. For Propagator 3B, the amount of hydrolysate added was very small. When adding hydrolysate to the propagator, the level of Propagator 3B was used as reference to determine the amount of hydrolysate added. However, there was an error in the level reading, possibly due to foaming in the tank. This resulted in a false increase in the level of the tank and the final hydrolysate concentration was ~10%. The hydrolysate was conditioned the day before by adjusting the pH to 8.0 after diluting with UV water. 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 prior to inoculation for propagator 2B. Air was sparged through the fermentation broth at 0.01 vvm (0.05 ft³/min and 0.5 ft³/min for Propagator 2B and propagator 3B respectively). The pre-seed flask was grown in 2 L flasks containing 1 L broth volume (total volume of 7.6 L). The pre-seed flasks were incubated at 37 °C and 200 RPM for 24 h. The ethanol concentration in the pre-seed flasks was 1.79 g/L just before inoculation of Propagator 2B (total volume of 2B was ~40 gal). Propagator 2B was set at 98.6 °F for 24 h prior to transfer for inoculation of Propagator 3B. Propagator 2B had an ethanol concentration of 5.3 g/L and a cell count of 1.24×10^8 CFU/mL after 12 h of growth. Propagator 3B was set at 98.6 °F for 20 h prior to transfer for inoculation of Fermentor C. The inoculation time was shortened when we realized the error in the amount of hydrolysate added (resulting in low concentrations of sugars present). The low concentration of

hydrolysate resulted in a low ethanol number after 20 h of incubation. The ethanol concentration in Propagator 3B was 1.85 g/L and the cell count was 1.7×10^7 CFU/mL right before inoculation of Fermentor C.

Conditions;

Pre-seed flask – 7.6 L of 30% hydrolysate

Propagator 2B – 40 gal total volume, 30% Hz, 5% inoculum, 5 g/L glucose added, 0.01 vvm

Propagator 3B – 320 gal total volume, ~10% Hz, 12% inoculum, 0.01 vvm

Results;

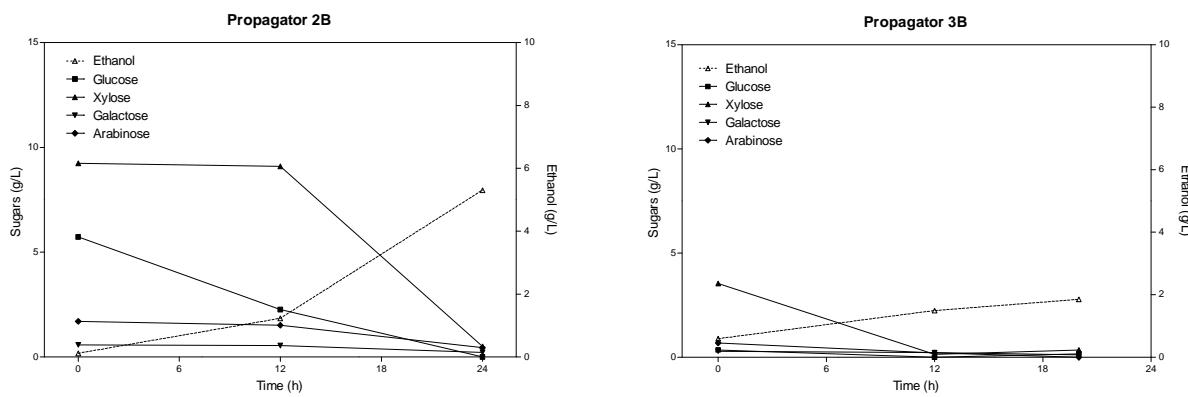


Figure 2. Sugars and ethanol concentration for the seed train. The ethanol and sugar numbers for propagator 3B were lower than expected due to an error when adding the hydrolysate.

Fermentation

To start the fermentation, ~1880 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 36 h with ~680 gal slurry left in the liquefaction tank. The contents of the liquefaction could not be completely emptied because, starting the previous campaign, the slurry from the liquefaction tank is transferred from the side of the tank, instead of the bottom. The fermentation was completed in 48 h with a max ethanol titer of 20.9 g/L. Cell counts were as high as 7.5×10^8 CFU/mL at the 48 h mark. Once the fermentation was completed, the temperature was adjusted to 140 °F (60 °C) and held for 3 h before transferring the contents to the Beer Well. Approximately 110 gal of 19% aqueous ammonia were used for pH control for fermentation and propagation. The slow start of the fermentation was due to the low sugar content present during the secondary propagation (Propagator 3B). The sugars were all used and the cells were starving when the fermentation was inoculated. Even though the solids content during liquefaction was increased to ~15%, the ethanol titer for the fermentation did not increase when compared to the previous campaign (20.9 g/L in both cases). This can be explained in part by the increase in lactic acid. After 24 h, the lactic acid started to increase through the end of fermentation,

reaching a level of 10.1 g/L of lactic acid and pointing to contamination with lactic-acid-producing bacteria that seemed to gain ground in the latter stages of the fermentation.

Conditions;

Total volume \approx 8000 gal (\approx 7680 gal slurry at 14.6% DW, \approx 320 gal inoculum)

Inoculum = 4%

Duration = 54 h

Solids loading = 14%

Results;

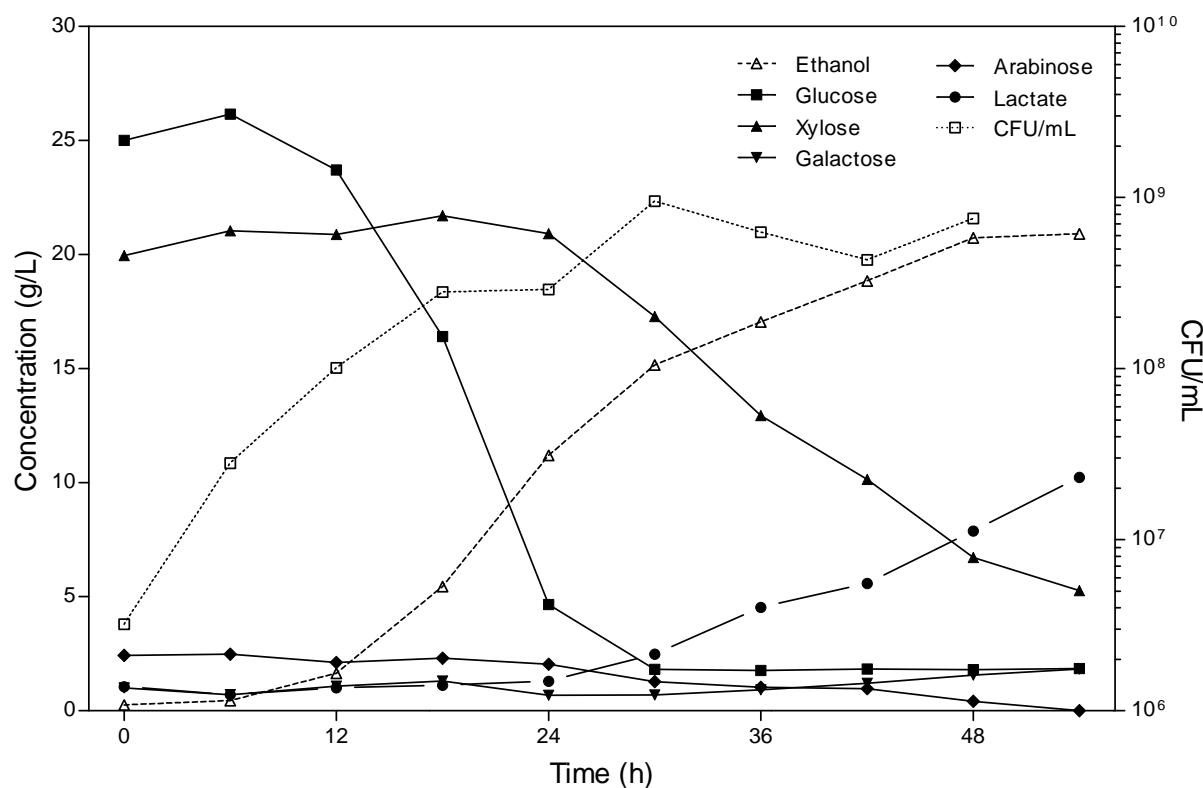


Figure 3. Sugars, ethanol, lactic acid, and CFU concentrations during fermentation. The first sample was taken right after inoculation.

Biomass Mass Balance

Pretreated biomass goes into liquefaction for ~52 h; biomass flow rate = 210 lb DW/h; total biomass through liquefaction = 10920 lb DW.

Liquefaction DW = 14.6%; fermentation total volume = 8000 gal; inoculum size = 320 gal. Dry weight of the fermentation (if it was operated in batch) = $\frac{14.6\% \times (8000 \text{ gal} - 320 \text{ gal})}{8000 \text{ gal}} = 14\% \text{ dry weight}$. $8000 \text{ gal} * 8.34 \frac{\text{lb}}{\text{gal}} * 14\% = 9341 \text{ lb DW}$ added to the fermentation. However, liquefaction was not completely emptied; ~824 gal were not transferred to the fermentor (680 gal in liquefaction + 144 gal left in pH adjustment tank). $824 \text{ gal} * 8.34 \frac{\text{lb}}{\text{gal}} * 14.6\% = 1003 \text{ lb DW}$.

From the calculation based on the pretreatment flow rate, the amount of biomass liquefied was **10920 lb DW**. From the liquefaction dry weights and fermentation and liquefaction levels we calculated $9341 + 1003 = \mathbf{10344 \text{ lb DW}}$.

Conclusion

During this campaign we have been successful in the pretreatment and fermentation of more than 4.5 tons of sugarcane bagasse. The major milestones completed were; 1) increasing the solids loading during liquefaction to 14.6%, 2) reducing the enzyme levels during liquefaction from 10% to 5%, 3) continuous operation of the pretreatment unit for ~60 h, 4) continuous operation of liquefaction for ~45 h, and 5) the second 8,000 gal fermentation. The fermentation was completed in 48 h, reaching an ethanol titer as high as ~21 g/L, leaving us considerably short of the goal of 40 g/L. Contamination with lactic acid bacteria was observed during the last 24 h of fermentation, contributing to the lower-than-expected ethanol levels. In addition, the ethanologenic strain was starved during the secondary propagation, contributing to slow start at the beginning of the fermentation and possibly contributing to the contamination observed in the second half of the fermentation.

The main goal for our upcoming campaign will be to increase the ethanol titer for the fermentation and significantly reduce the contamination observed in the previous campaign. Therefore, during the next campaign, the liquefaction retention time will be increased to 12 h. We hope that this will allow more time for the enzymatic hydrolysis to take place in order to increase the available sugars for fermentation, which in turn, should help us reach our goal of 40 g/L of ethanol. Also, additional steps will be added to try to minimize the risk of contamination during fermentation. First, CIP connections will be added to the nutrient lines for secondary propagation and fermentation tanks so that they can be cleaned prior to inoculation. Second, steam lines will be added to the same nutrient lines in order to sterilize them. Third, all lines involved with the transfer of slurry or broth from the propagation and liquefaction stages to the fermentation, will be sterilized together with their respective tanks.

Appendix

Process trends

Pretreatment

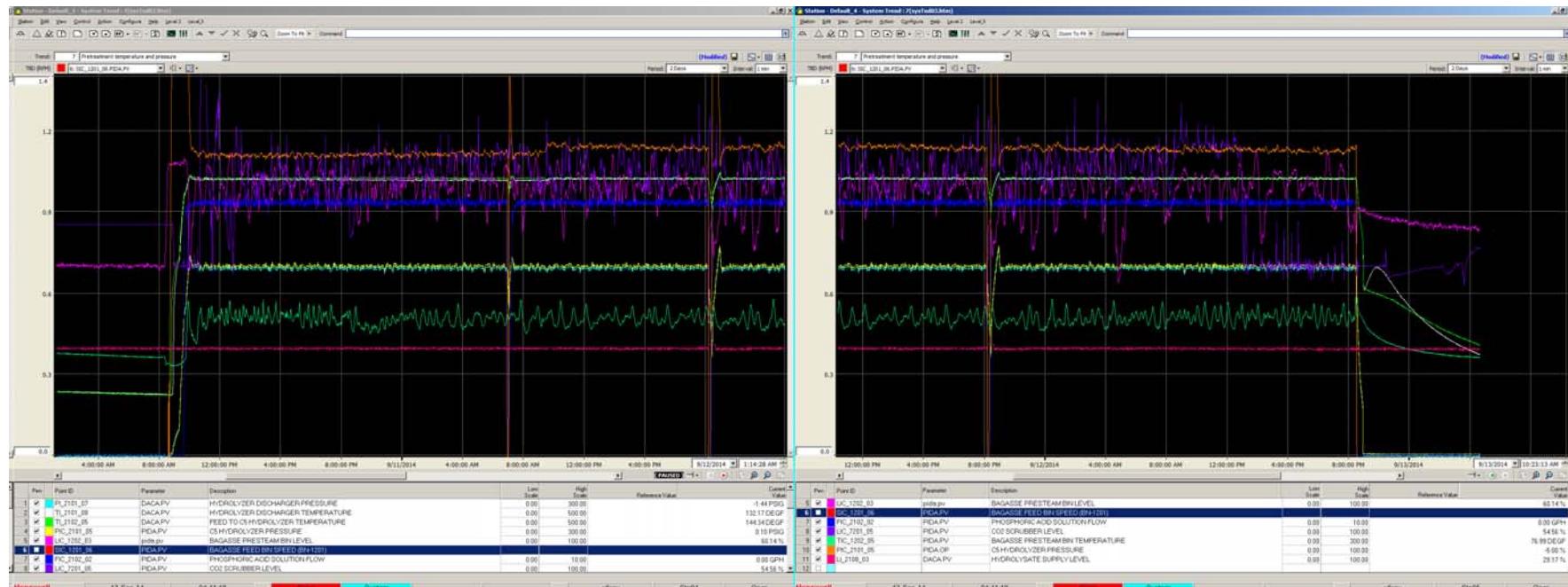


Figure 4. Temperature, pressure, pre-steam bin level, and phosphoric acid flow rate during pretreatment. Set points were; pressure, 150 PSI; retention time, 7.5 min; acid solution flow rate, 6.67 GPH; biomass flow rate, 100% (210 lb DW/h).

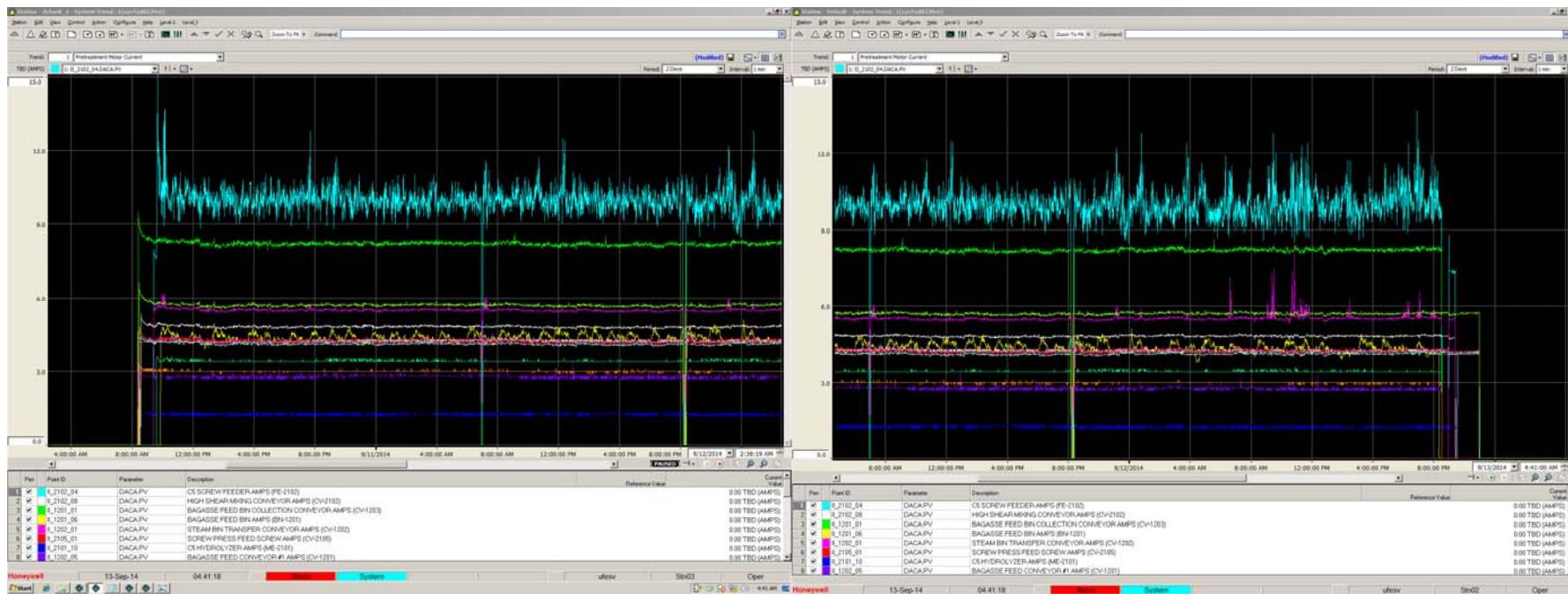


Figure 5. Current load for all biomass handling and pretreatment motors. The clear blue trend with a lot of variability represents the load of the plug-screw feeder. The green line represents the load of the feed bin collection conveyor.

Liquefaction and pH Adjustment

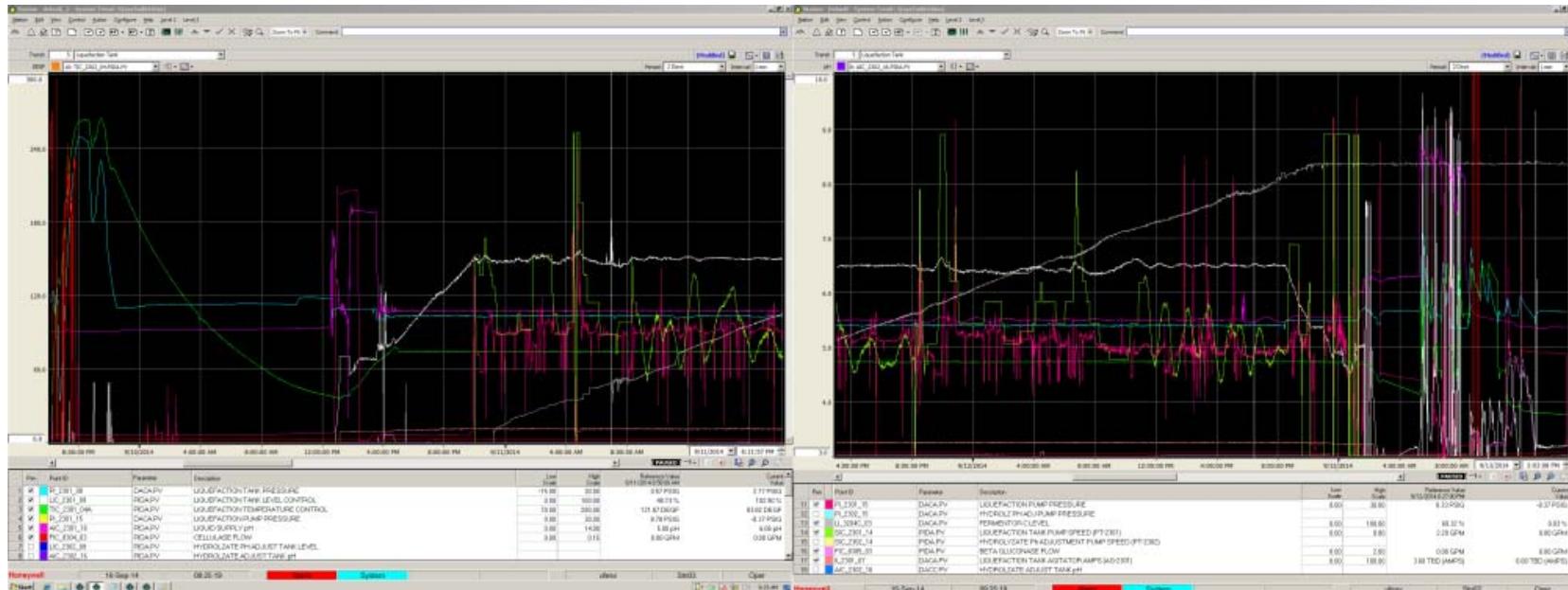


Figure 6. Liquefaction trend. An initial amount of water was added to the tank to ensure that the pH probe and the bottom impeller were covered before adding any biomass. This can be observed with the white (level) and purple (pH) trends. As soon as biomass was fed into the liquefaction tank, the pH 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. The green line spiking through the run corresponds to the speed of the pump, which was adjusted automatically to maintain the desired level in the tank.

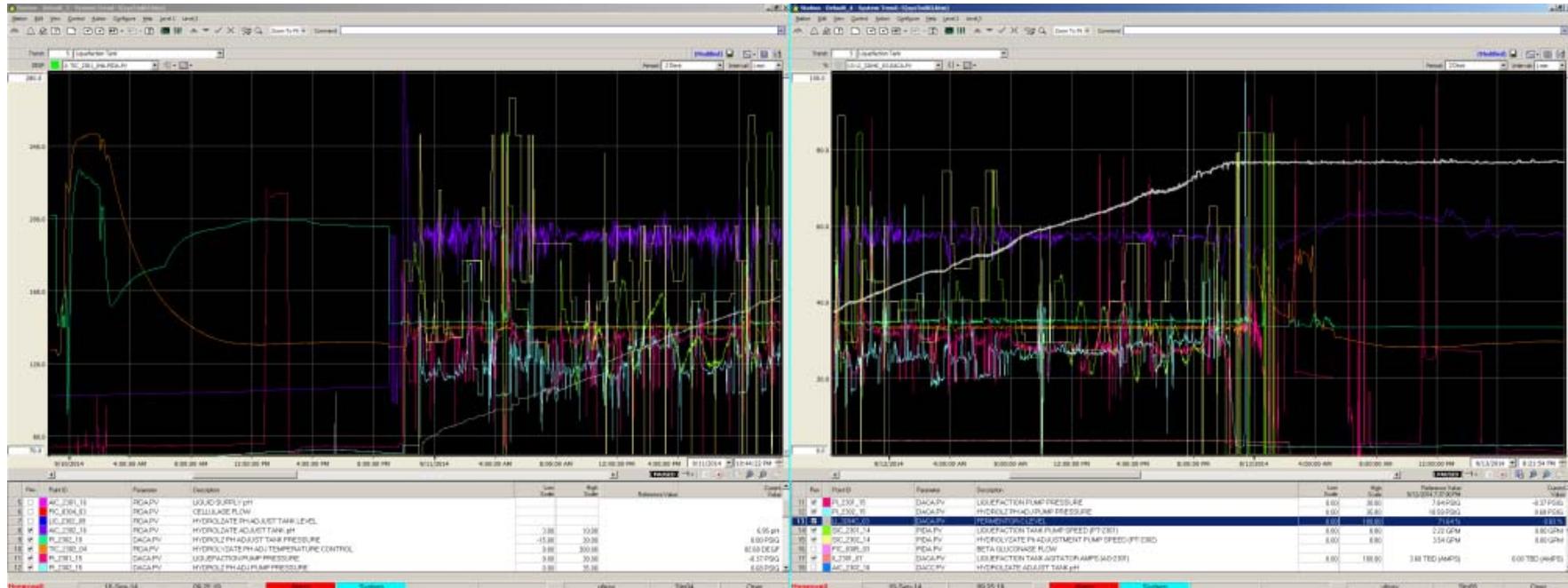


Figure 7. pH Adjustment Tank trend. The level in the pH Adjustment tank was maintained manually this run. The level probe was covered in slurry at the beginning of the campaign and the level was controlled manually after that. The pH was adjusted to 7.0 before going out to the fermentor.

Propagation

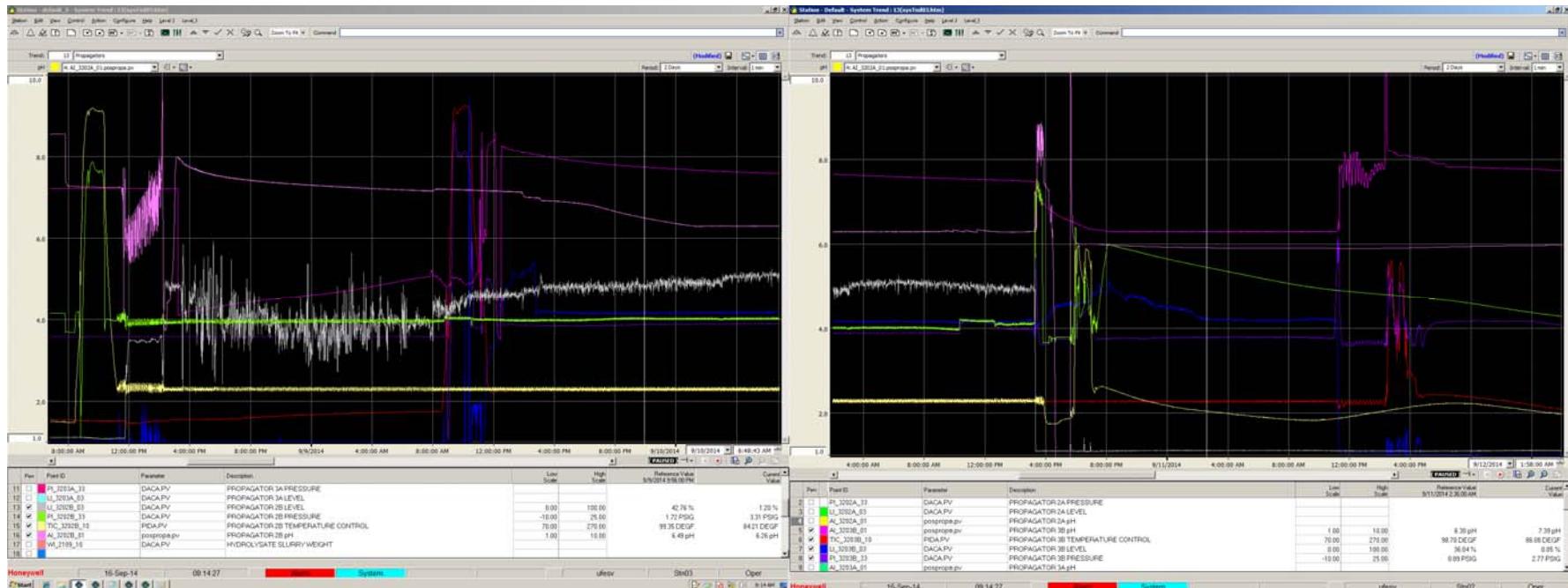


Figure 8. Trend for propagators 2B and 3B. After sterilizing each propagator, the hydrolysate and water were added and the pH was adjusted to 8.0. The diluted hydrolysate was incubated overnight at 98.6 °F. Propagator 2B was inoculated with 7.6 L of media grown in the lab through a side port in the propagator itself. Propagator 3B was inoculated by discharging the entire contents of Propagator 2B. After 20 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

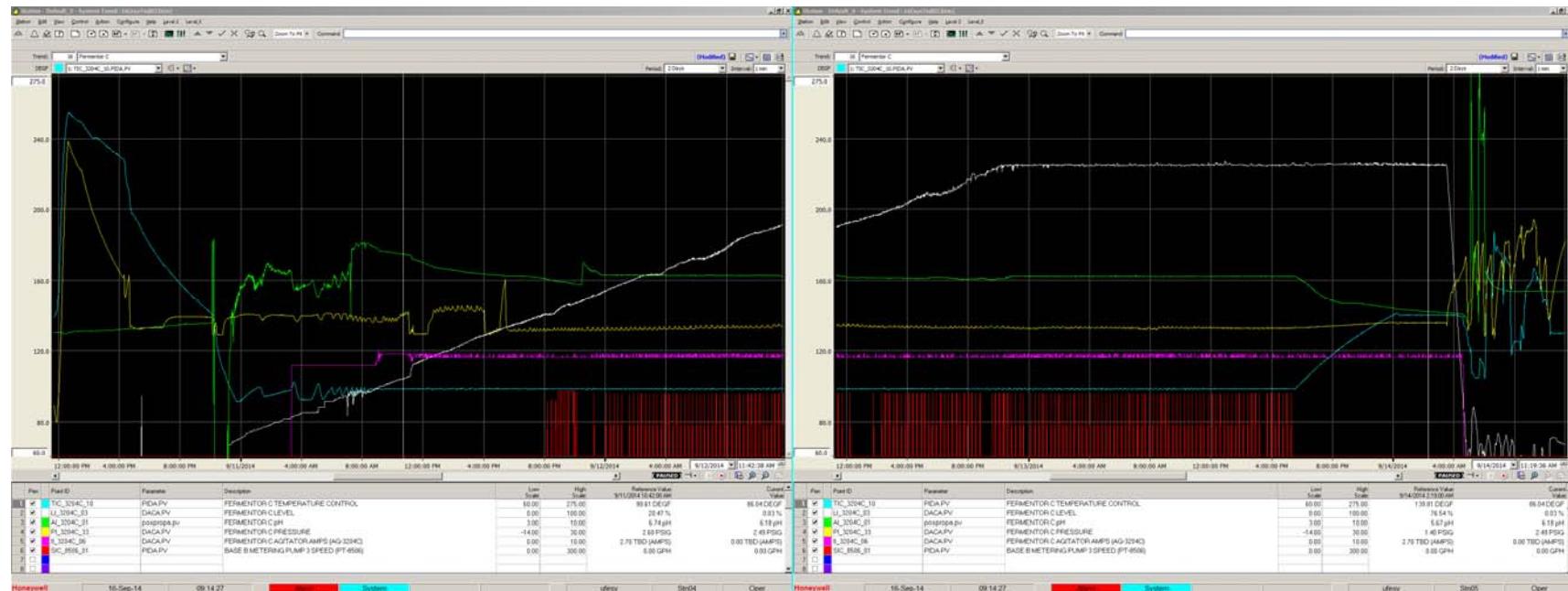


Figure 9. Fermentor C trend. After autoclaving, slurry from the liquefaction tank was added through the pH adjustment tank. After ~46 h of adding slurry to the fermentor, the entire contents of Propagator 3B were added to the Fermentor C as inoculum. This step is marked by the change in the pH trend 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 (54 h), and then it was increased to 140 °F for 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)

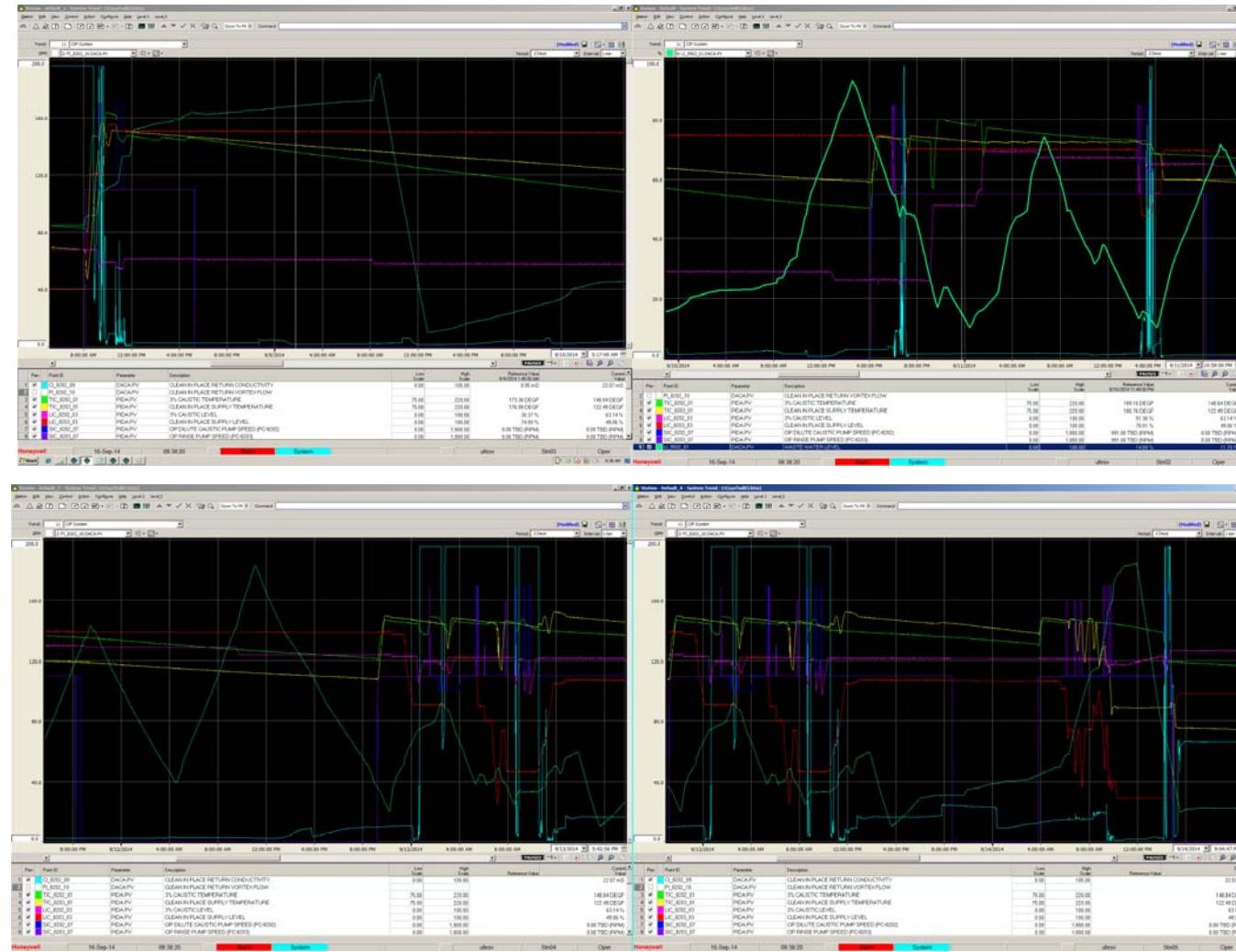


Figure 10. Clean-In-Place system trend. Once the set temperature (green and yellow trends) was reached in the rinse and caustic tanks, the CIP cycle was started. The conductivity trend (light blue) starts to spike during the caustic clean-up of the tank.

Scrubbers

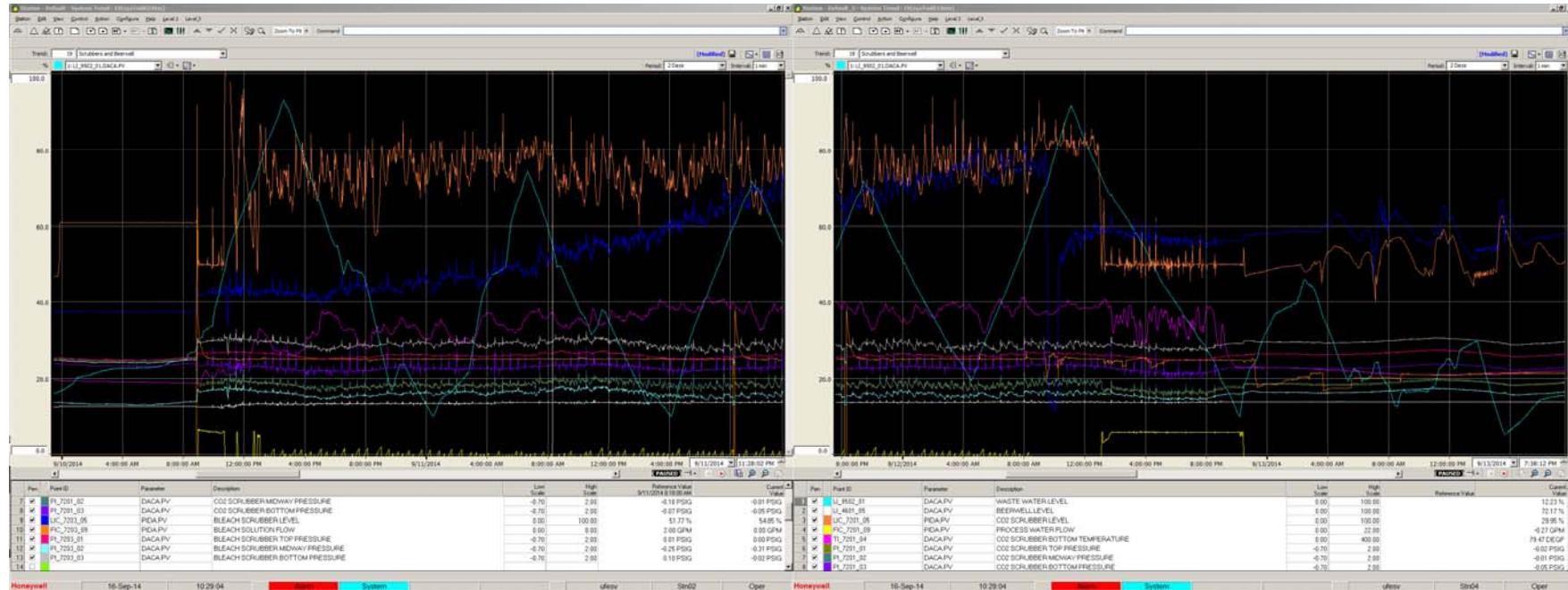


Figure 11. Trends for the scrubber system. Once pretreatment was started, the CO₂ Scrubber was started as well (the bleach scrubber had already been operational due to propagation taking place). The spikes observed in some of the trends are caused by the steam released from the pretreatment every time 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

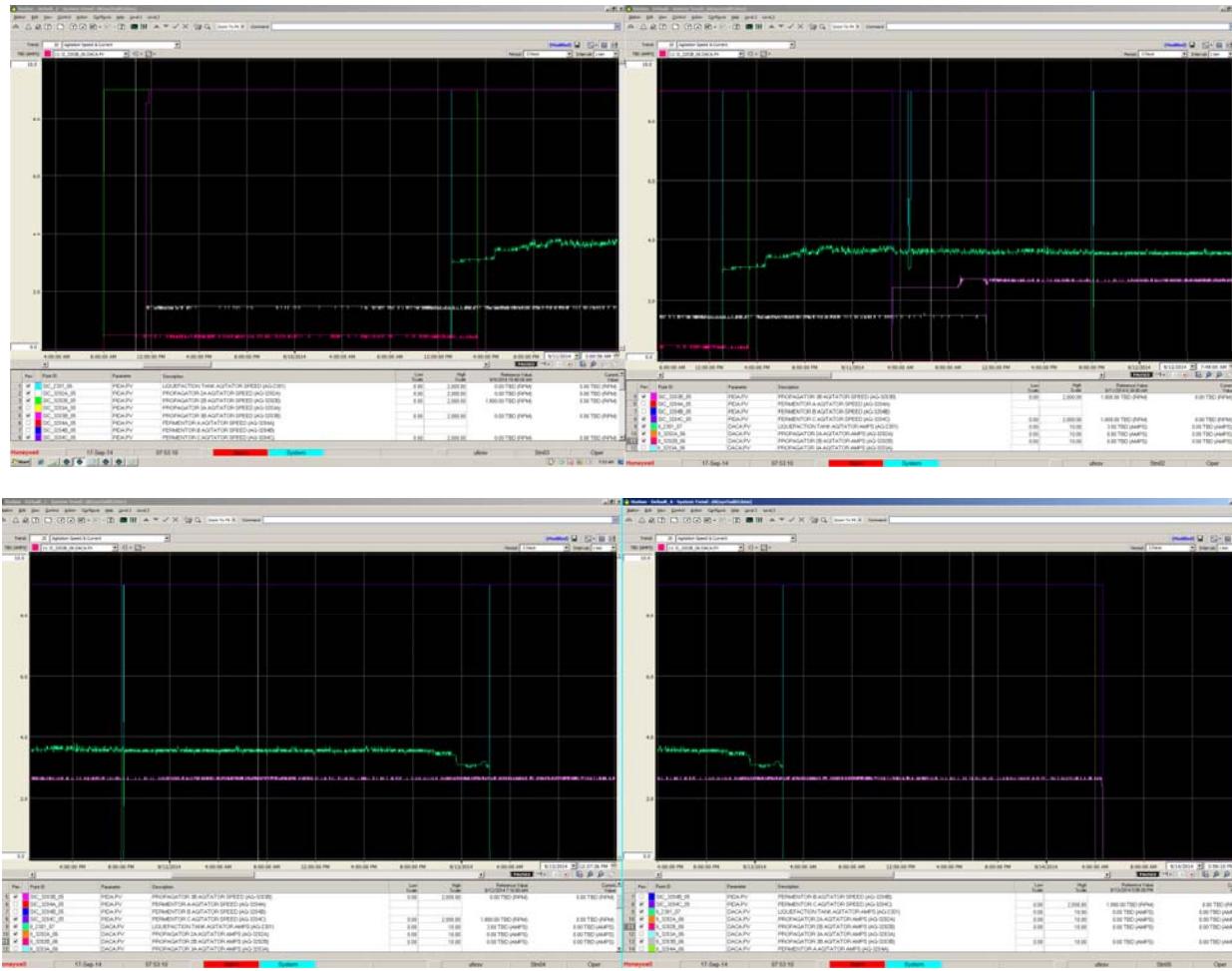
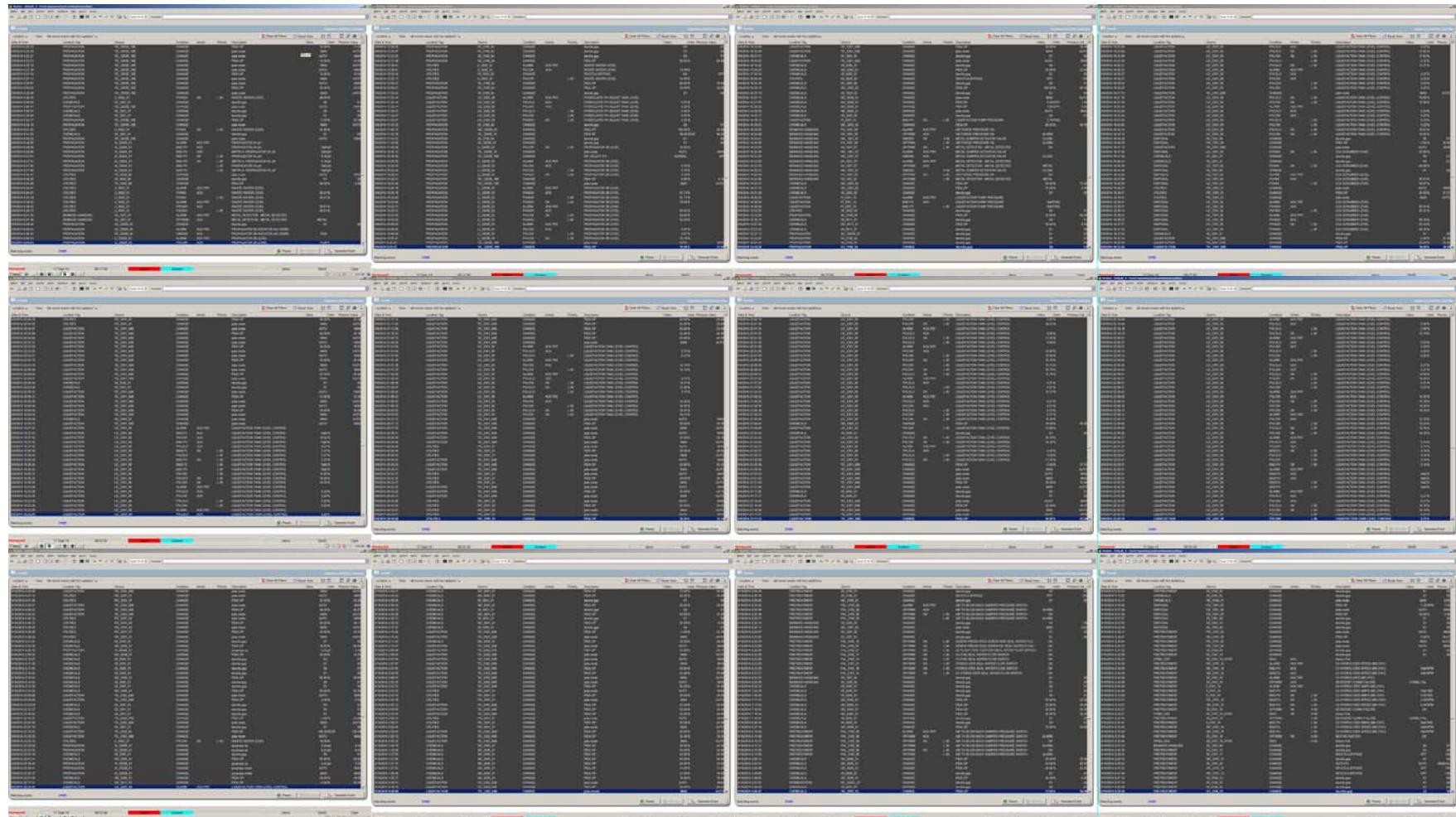


Figure 12. Agitation speed and current load. The liquefaction load was the only one with considerable variation in the load probably due to the agitator configuration (it is the only one with two-stage impellers) and the nature of the process.

Event Log



The image displays a 3x4 grid of 12 computer screenshots, likely from a terminal or log viewer application. Each screen shows a dark background with white text, representing a large volume of data or logs. The content is mostly illegible due to the sheer volume of text, but some recognizable words and patterns can be seen in the center of each screen, such as 'INFO', 'WARN', 'ERROR', and various system names like 'node1', 'node2', 'node3', etc. The screens are arranged in three rows and four columns, providing a comprehensive view of the data across multiple nodes.

The image consists of a 3x8 grid of 24 individual screenshots, likely from a software application. Each screenshot displays a table with numerous columns and rows of data, primarily consisting of numerical values. The data is organized into several distinct sections, each with its own header. The overall layout suggests a complex data analysis or monitoring tool. The screenshots are arranged in three horizontal rows, with each row containing eight screenshots side-by-side.

The image consists of a 3x8 grid of 24 screenshots, likely from a video recording, showing a software interface. The interface features a large central text area displaying a grid of binary digits (0s and 1s). Above this text area, there is a toolbar with various icons and a menu bar. The windows have a standard title bar and scroll bars on the right side. The content in the text area remains mostly static across all frames, suggesting a continuous view of the same data over time.

The image consists of a 3x8 grid of 24 screenshots, each showing a computer terminal window. The windows are filled with dense, monochromatic data, likely binary or hex code, arranged in a grid pattern. The data is organized into columns and rows, with some horizontal lines separating different sections of the code. The terminal windows have standard operating system window frames, including titles and scroll bars. The overall appearance is that of a technical or forensic analysis environment.

The image displays a 3x8 grid of 24 computer monitor screenshots, each showing a terminal window with a large amount of binary code (hexadecimal data). The windows are arranged in three rows and eight columns. Each window has a title bar that includes the text "Terminal" and "File Edit View Insert Cell Window Help". The binary data is organized into several distinct sections, some of which contain readable text. For example, one section contains the word "binaries" and another contains "binaries are". Other sections appear to be random binary patterns or specific command-line outputs. The overall appearance is that of a network monitoring or forensic tool displaying captured data.

The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with a large amount of binary code. The code appears to be a repeating sequence of characters, possibly a test pattern or a specific type of data being processed. The screens are arranged in three rows and four columns, providing a comprehensive view of the data across multiple terminals.

The image displays a 3x4 grid of 12 computer monitor screenshots, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to file analysis or system monitoring. The text is mostly illegible due to the small font size and the nature of the data.

The image consists of a 3x8 grid of 24 screenshots, each showing a terminal window with a large amount of binary data. The data is presented in a grid-like pattern, likely representing a memory dump or a large file being viewed in hex mode. The terminal windows have dark backgrounds with white text, and the data is organized into a grid of small squares. The grid is composed of approximately 10 columns by 10 rows of these squares.

The image displays a 3x4 grid of 12 computer monitor screenshots, each showing a terminal window with a large amount of text, likely log files or command-line output. The text is mostly in black on a white background, with some red and blue highlights. The windows have standard operating system taskbars at the top.

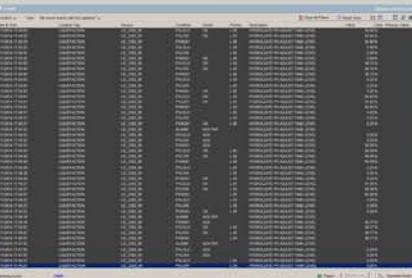
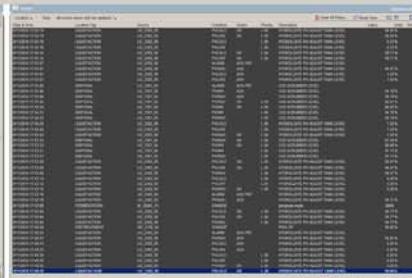
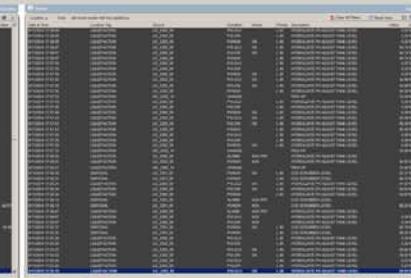
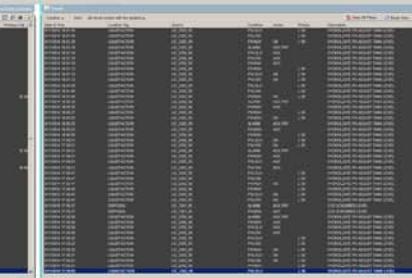
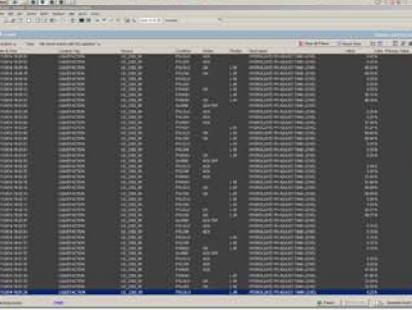
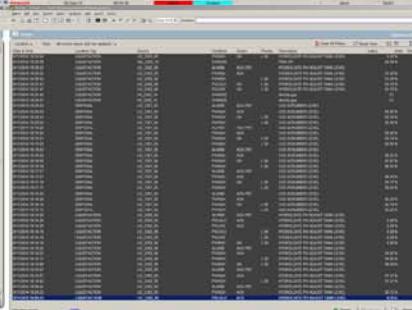
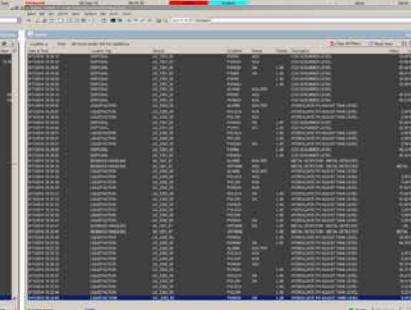
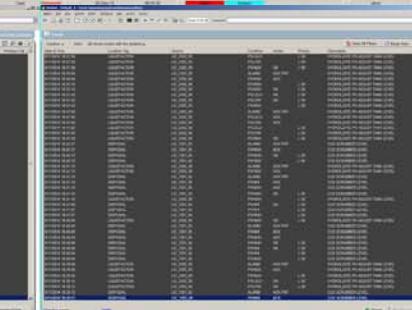
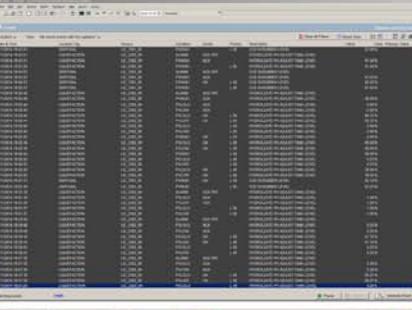
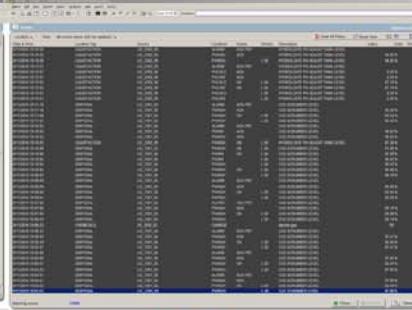
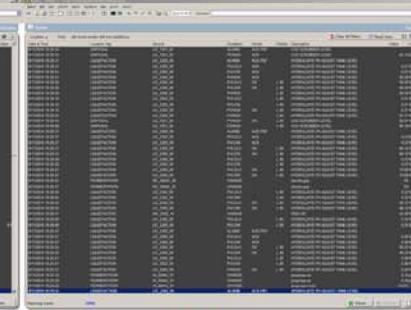
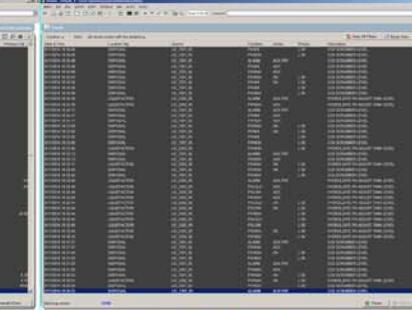
The image consists of a 3x8 grid of 24 screenshots, each showing a terminal window with binary data. The data appears to be a sequence of characters, possibly ASCII or a specific binary format. The windows are arranged in three rows and eight columns. Each window has a title bar at the top with the word "Terminal". The content of the windows is mostly identical, showing the same sequence of characters.

The image displays a 3x4 grid of 12 screenshots, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to network monitoring or system logs. The text is mostly illegible due to the small font size and the nature of the log output.

The image displays a 3x4 grid of 12 computer monitor screenshots, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to network monitoring or system logs. The text is mostly illegible due to the small font size and the nature of the log output.

The image consists of a 3x8 grid of 24 screenshots, each showing a computer terminal window. The windows are identical, displaying a large amount of binary or hex data in a monospaced font. The data appears to be a continuous sequence of characters, likely a file dump or a memory dump. The terminal windows have standard operating system toolbars at the top, including buttons for file operations and window control.

The image displays a 3x4 grid of 12 computer monitor screenshots, each showing a terminal window with a large amount of text data. The data appears to be log files or system outputs, characterized by long lines of text and numerical values. The windows are arranged in three rows and four columns, providing a comprehensive view of the data across multiple screens.

The image displays a 3x4 grid of 12 screenshots, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to network monitoring or system logs. The windows are arranged in three rows and four columns, showing consistent data across all instances.

The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with command-line data. The data appears to be a log or output from a system, likely related to network monitoring or security analysis. The screens show various lines of text, including numerical values, names, and status indicators. The interface includes a top menu bar and a bottom toolbar with icons.

A grid of 12 computer screens, arranged in a 3x4 layout, each displaying a terminal window with command-line data. The data appears to be a log or output from a process, likely related to network monitoring or system logs. The screens show various lines of text, some with red and blue highlights, indicating specific events or errors. The windows have standard operating system taskbars at the top.

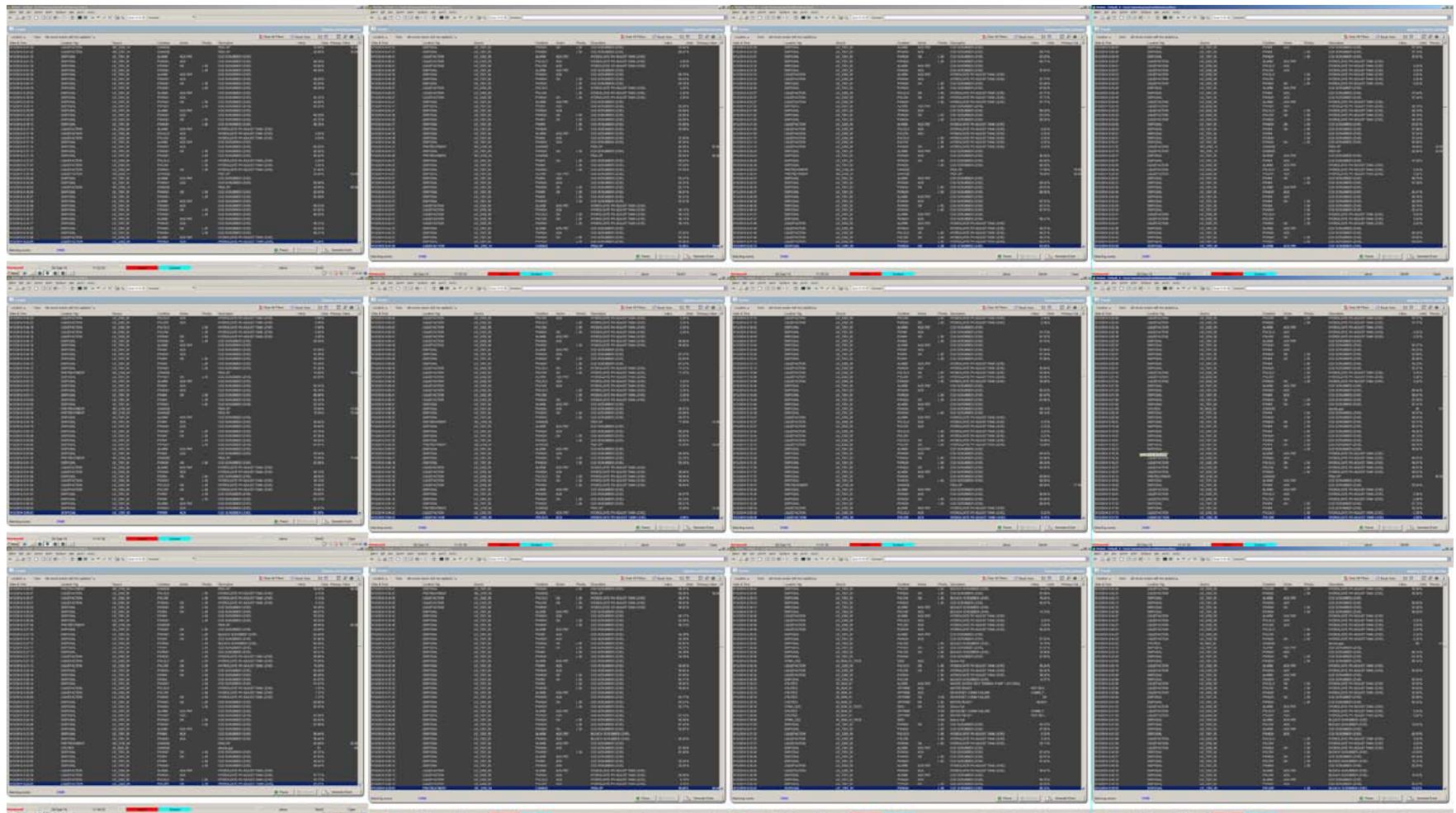
The image consists of a 3x8 grid of 24 screenshots of a terminal window. The terminal is displaying a large amount of binary data, likely hex dump output, which appears as a series of numbers. At the top of each terminal window, there is a small amount of text, possibly command-line input or status information. The windows are arranged in three rows and eight columns.

The image consists of a 3x8 grid of 24 screenshots of a computer terminal window. The terminal is displaying a large volume of text, which appears to be a log file or a transcript of a session. The text is mostly in white or light gray on a black background. Some lines of text are highlighted in red, blue, or green, indicating specific events or errors. The terminal window has a standard title bar at the top and a scroll bar on the right side. The overall appearance is that of a technical or forensic investigation tool.

The image consists of a 3x8 grid of 24 screenshots, each showing a terminal window with a large amount of binary data. The data is presented in a grid-like pattern, where each cell contains a single row of binary digits (0s and 1s). The windows are arranged in three rows and eight columns, creating a visual representation of a large dataset or memory dump.

The image consists of a 3x8 grid of 24 screenshots, each showing a terminal window with a large amount of binary data. The data is presented in a grid-like format, where each cell contains a single byte value. The grids are arranged in three rows and eight columns. The data appears to be a repeating sequence of values, likely a memory dump or a specific data pattern being analyzed.

The image displays a 3x4 grid of computer monitors, each showing a terminal window with command-line text. The text appears to be a log or output from a system, possibly related to network monitoring or system logs. The content is mostly technical and repetitive, with some human-readable text interspersed. The monitors are arranged in three rows and four columns.



The image consists of a 3x8 grid of 24 screenshots of a terminal window. Each screenshot shows a large amount of text output, likely from a command such as 'cat /proc/meminfo' or 'top'. The text is displayed in a monospaced font on a black background with white text. The content is highly compressed and illegible due to the small font size and the large volume of data. The terminal interface includes a title bar, a menu bar, and a scroll bar.

The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with a black background and white text. The text consists of binary code (0s and 1s) and some human-readable text. The human-readable text includes:

- "The file has been loaded successfully."
- "File has been loaded successfully."

Each screen also features a red and blue progress bar at the bottom.

The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with a large amount of binary code. The code consists of long strings of 0s and 1s, with occasional human-readable text interspersed. The screens are arranged in three rows and four columns. Each screen has a standard operating system window title bar at the top.

The image consists of a 3x8 grid of 24 individual screenshots, likely from a video recording of a computer monitor. Each screenshot displays a software application window with a dark background and a light-colored table or list of data. The data is organized into columns, though the specific labels for these columns are not clearly legible. The windows are arranged in three rows and eight columns. A vertical red bar is visible on the far left edge of the grid, and a horizontal red bar is located at the top center of the grid area.

The image consists of a 3x8 grid of 24 screenshots of a terminal window. The terminal has a black background with white text. The top portion of the screen is filled with a large amount of binary data, appearing as a series of '0's and '1's. In the middle of this binary data, there are several lines of text in a standard monospaced font. The text includes some numbers and what appears to be command-line output or error messages. The bottom portion of the screen also contains binary data. The terminal window has a standard Windows-style title bar at the top.

The image displays a 3x8 grid of 24 computer monitor screenshots, each showing a terminal window with a large amount of binary data. The data consists of numerous small, dark characters, likely representing binary code or raw data. The terminal windows have standard operating system toolbars at the top, including file, edit, and search functions. The data is organized into several distinct vertical columns, suggesting multiple parallel processes or data streams being displayed simultaneously.

The image displays a 3x8 grid of 24 computer monitor screenshots, each showing a terminal window with command-line data. The data appears to be a series of log entries or system status reports, likely from a network monitoring tool. The logs include various numerical values, dates, and descriptive text such as "Filebeat is up", "Filebeat is down", and "Filebeat is healthy". The windows have standard operating system taskbars at the top, and the overall layout suggests a distributed monitoring environment.

The image displays a 3x4 grid of 12 screenshots, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to file analysis or system monitoring. The text is mostly in black on a white background, with some red and blue highlights. The windows are arranged in three rows and four columns.

The image displays a 3x4 grid of 12 computer monitor screenshots, each showing a terminal window with a large amount of binary code (hexadecimal data). The windows are arranged in three rows and four columns. Each terminal window has a title bar, a menu bar, and a scroll bar. The binary data is organized into several distinct sections, some of which contain readable text or specific patterns. The overall appearance is that of a network monitoring or forensic analysis tool.

The image consists of a 3x8 grid of 24 screenshots of a terminal window. The terminal has a black background with white text. The top portion of the screen is filled with a large amount of binary data, consisting of mostly zeros and ones. In the middle of the screen, there are several lines of text in a standard font. The text appears to be a mix of random characters and some structured data or code. The bottom portion of the screen also contains binary data. The terminal window has a standard window frame with a title bar and scroll bars.

The image displays a 3x4 grid of 12 computer screens, each showing a terminal window with command-line data. The data appears to be a log or output from a process, likely related to network monitoring or system logs. The screens are arranged in three rows and four columns, providing a comprehensive view of the data across multiple terminals.

The image displays a 3x4 grid of 12 computer screen captures, all showing the same terminal window. The terminal window has a dark background and contains a massive amount of data, likely a binary dump or a log file, with text appearing in small white and light gray characters. The data is organized into several vertical columns. At the top of the terminal window, there is a header bar with various icons and text, including 'File', 'Edit', 'View', 'Search', 'Help', and some status information like 'File: /tmp/testfile'. Below the header, there is a scroll bar on the right side of the terminal window.

The image displays a 3x4 grid of 12 computer screen captures, each showing a terminal window with a dark background and white text. The text consists of numerous lines of code, logs, or command-line output, which are mostly illegible due to their small size and density. The windows are arranged in three rows and four columns, with thin white borders separating them.