



**2017
Master Brewers Conference**
October 12-14 • Atlanta, Georgia, U.S.A.

Utilizing predictive analytics to improve quality and increase capacity at Deschutes Brewery



Fermentation Phases

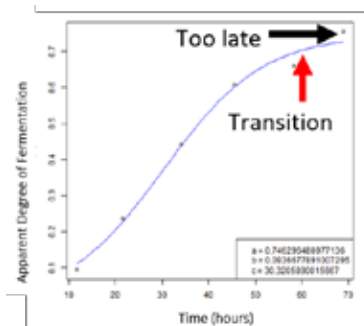
1. Filling
2. Fermentation
3. Free Rise
4. Diacetyl Rest
5. Cooling
6. Maturation
7. Ready to Transfer
8. Emptying
9. Empty



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Manual Fermentation Transitions

1. Filling
2. Fermentation
3. Free Rise
4. Diacetyl Rest
5. Cooling
6. Maturation
7. Ready to Transfer
8. Emptying
9. Empty



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ADF Transitions

1. Filling
2. Fermentation
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ADF

$$\text{ADF} = \frac{OG - CG}{OG} \times 100\%$$

$$\text{ADF} = \frac{OG - CG}{(OG - 1)} \times 100\%$$

OG = Original Gravity

CG = Current Gravity

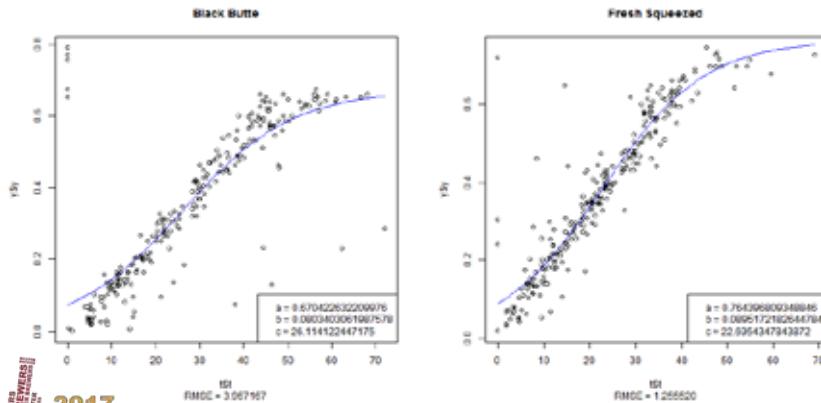


ADF Transitions

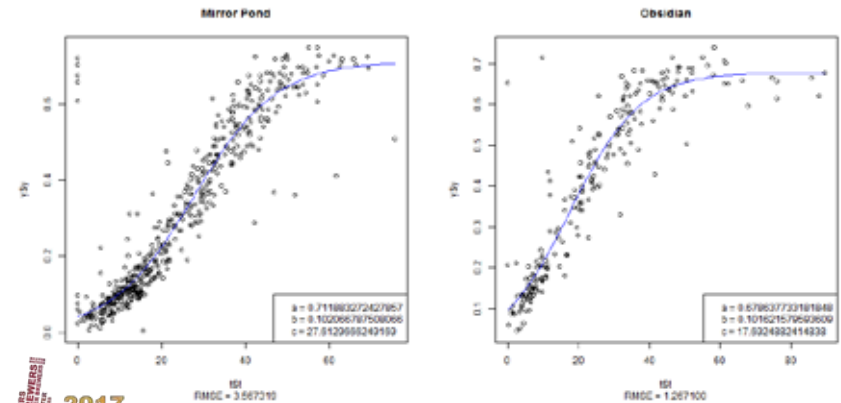
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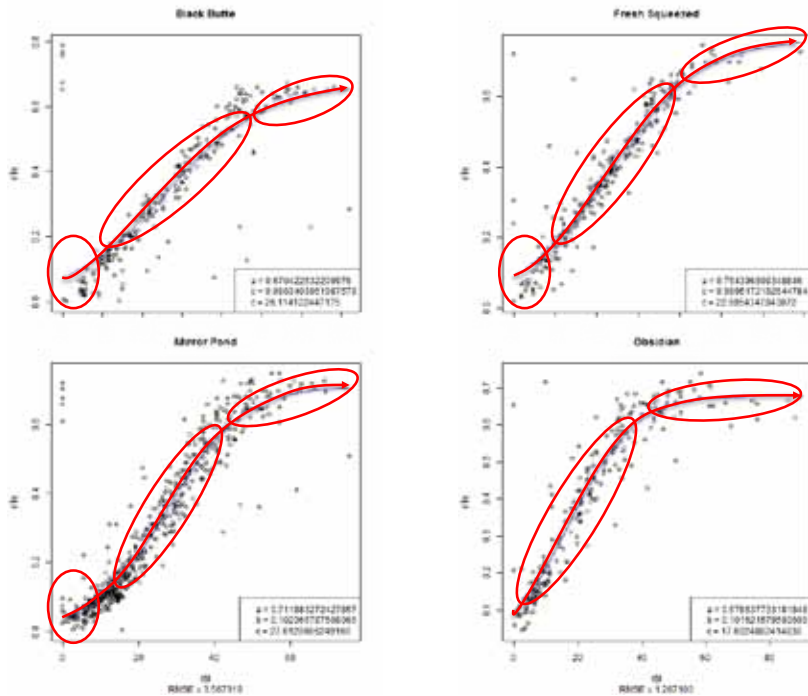


Black Butte, Fresh Squeezed ADF Plots



Mirror Pond, Obsidian ADF Plots





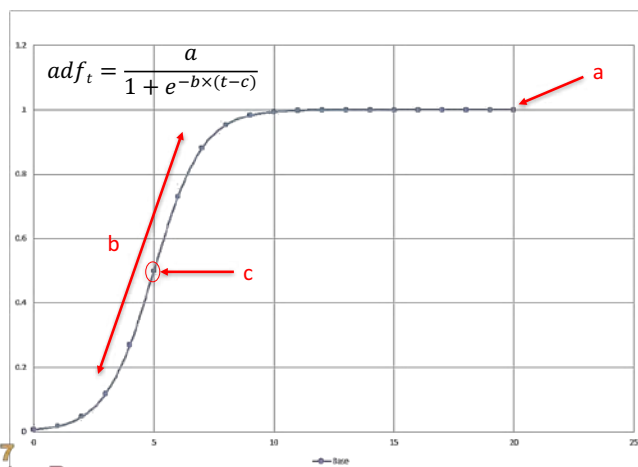
Logistic Function

$$adf_t = \frac{a}{1 + e^{-b \times (t-c)}}$$

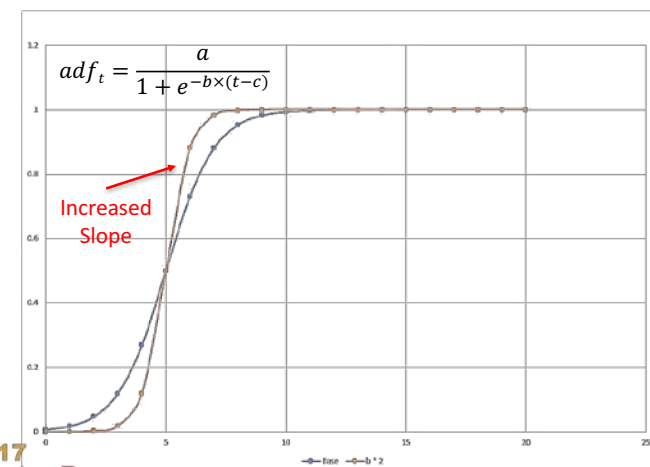
- adf_t – ADF at time t
- a – the curve's maximum value
- b – the steepness of the curve
- c – the x -value of the sigmoid midpoint
- t – time



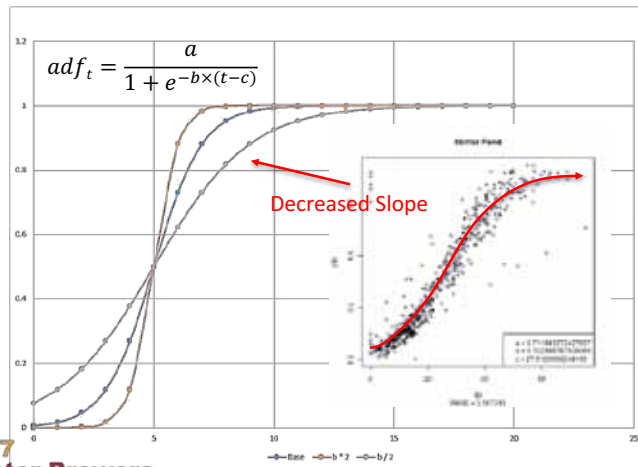
Logistic Function



Logistic Function Increase b



Logistic Function Decrease b



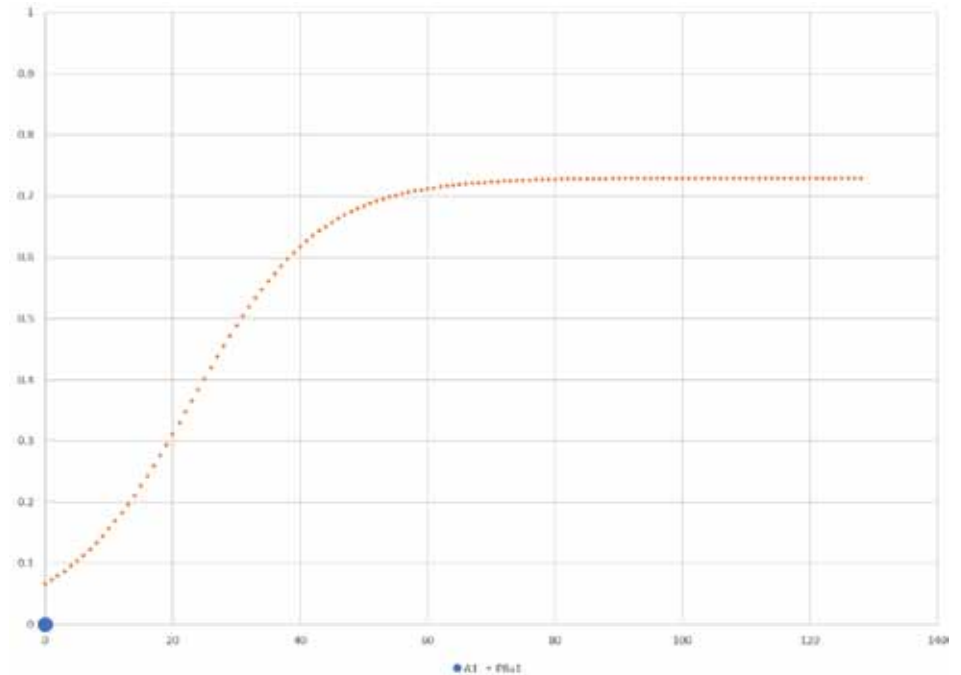
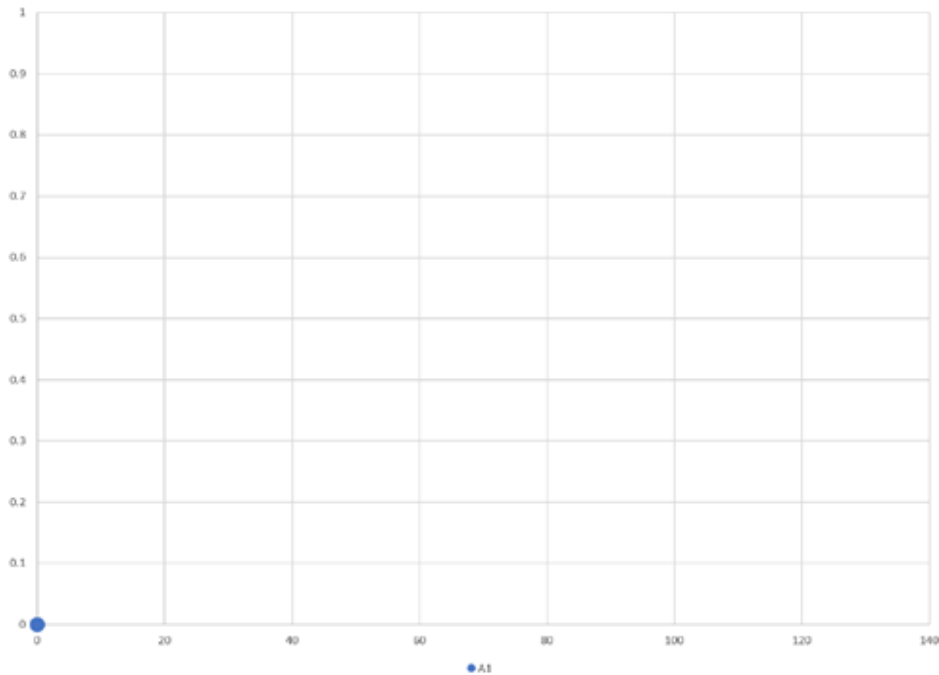
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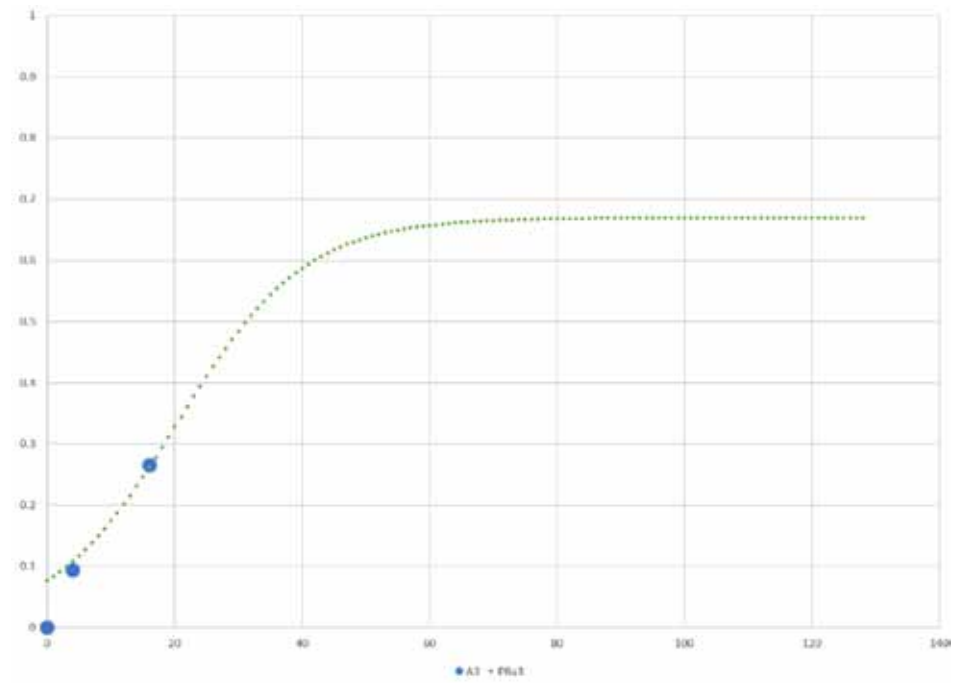
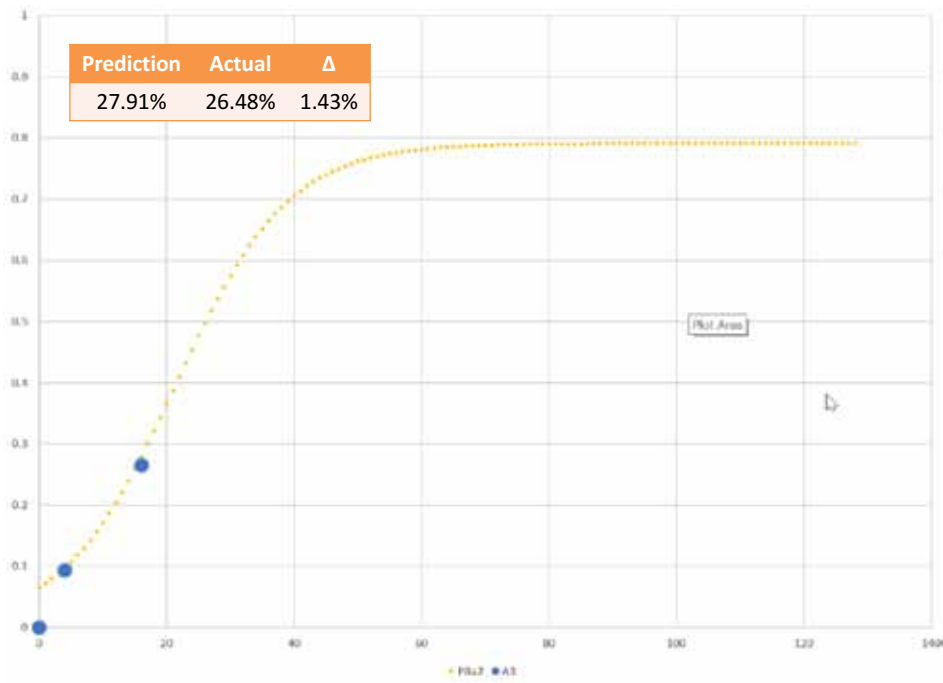
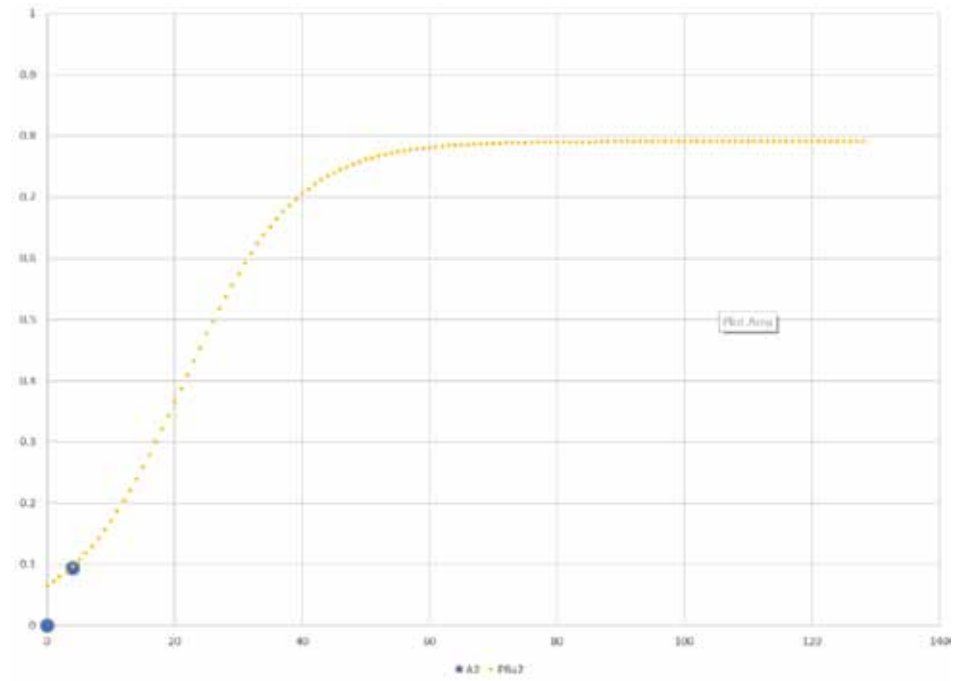
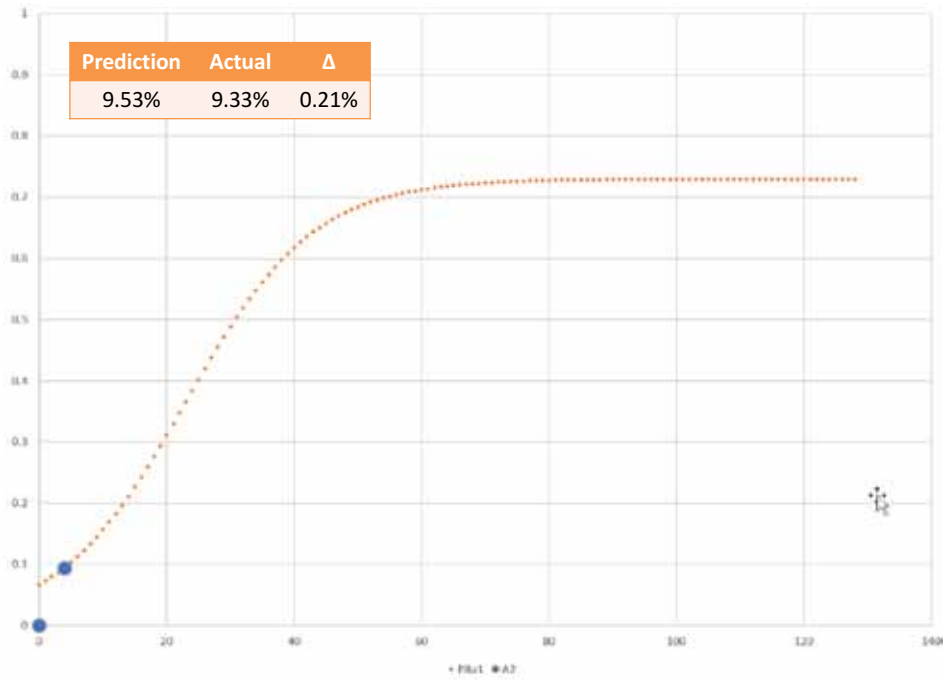
Logistic Function

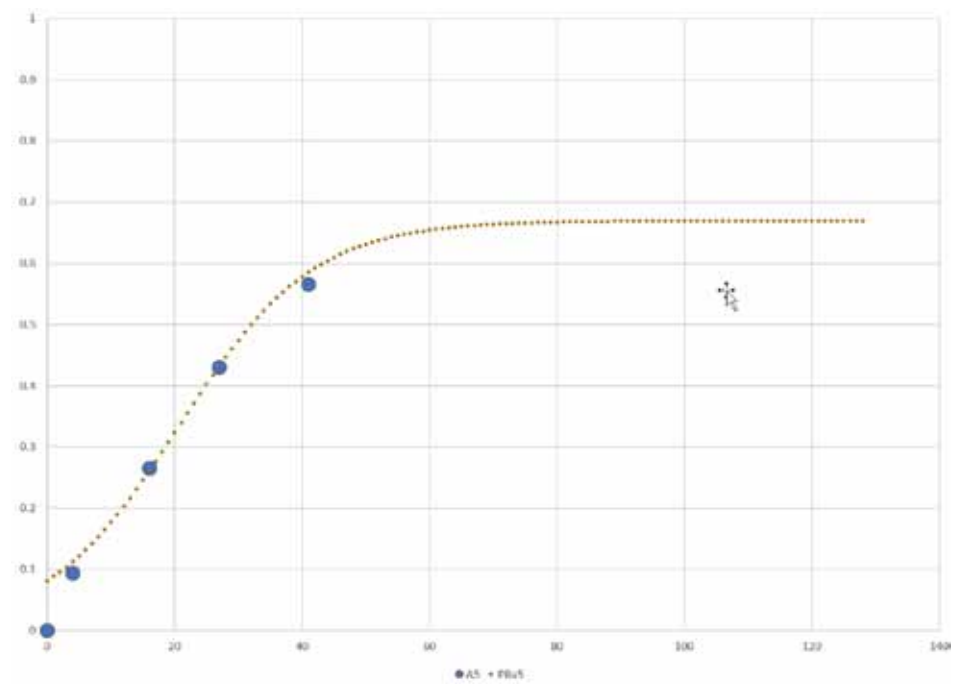
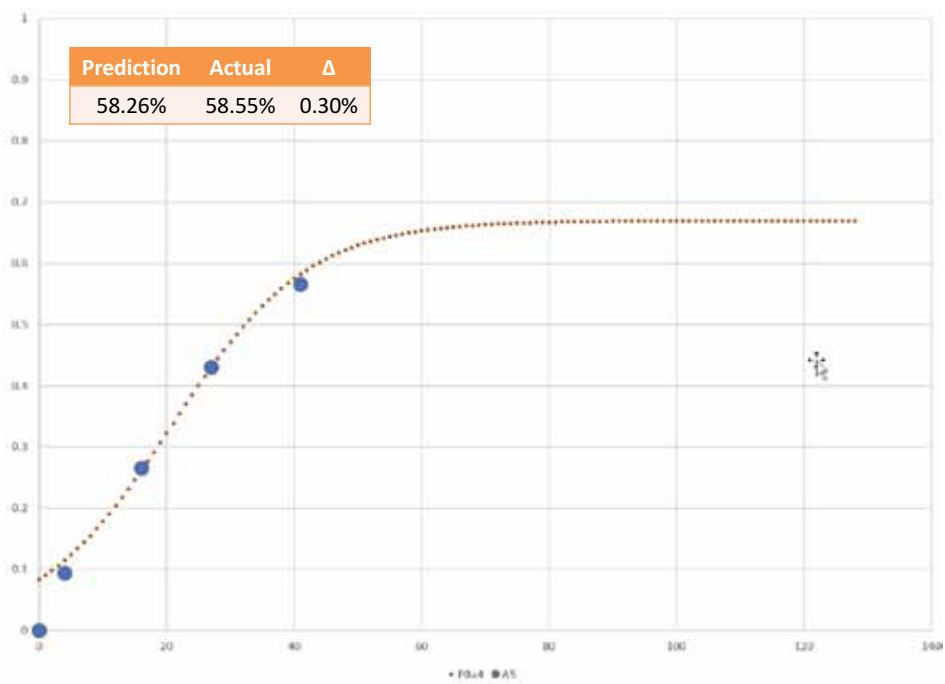
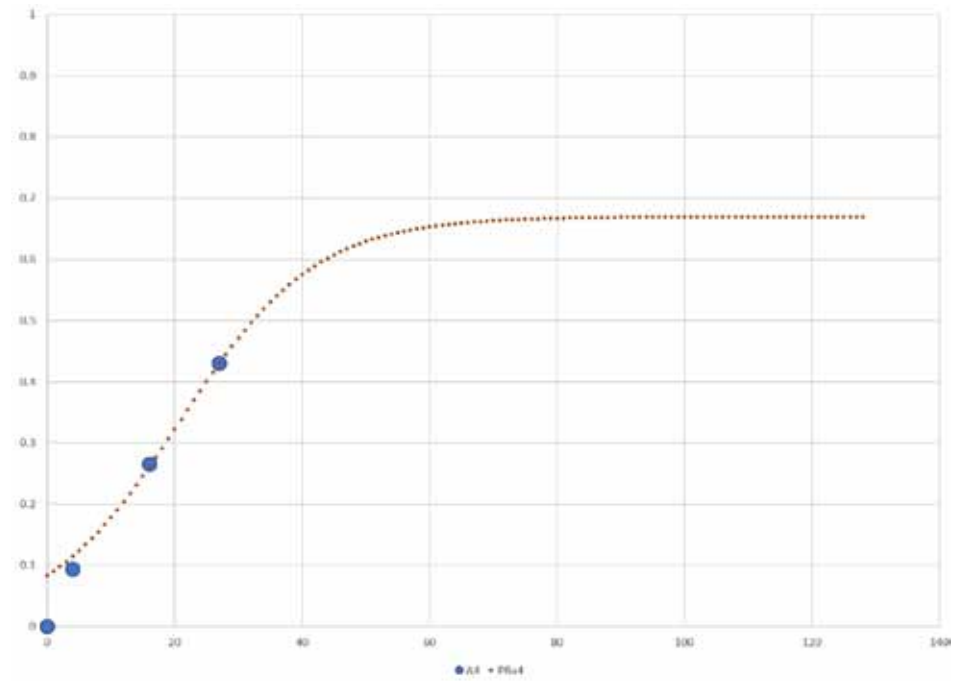
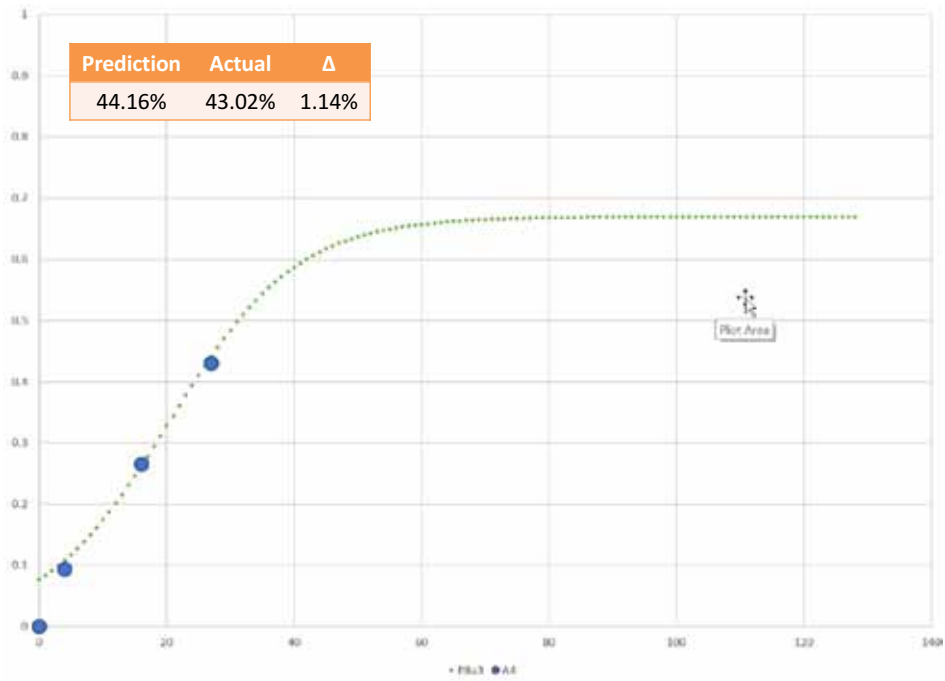
$$adf_t = \frac{a}{1 + e^{-b \times (t-c)}}$$

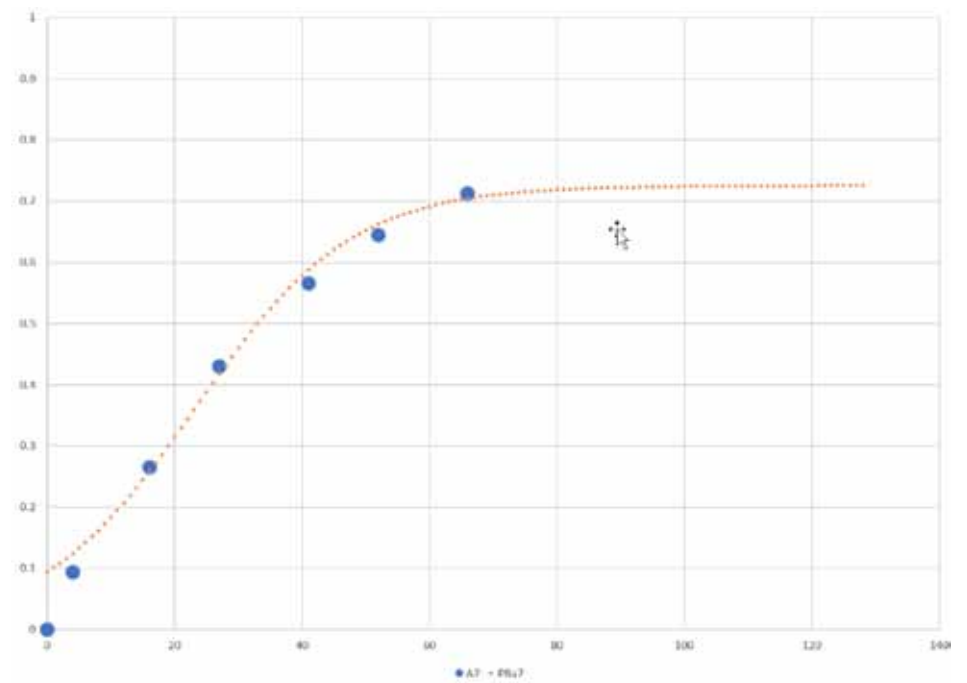
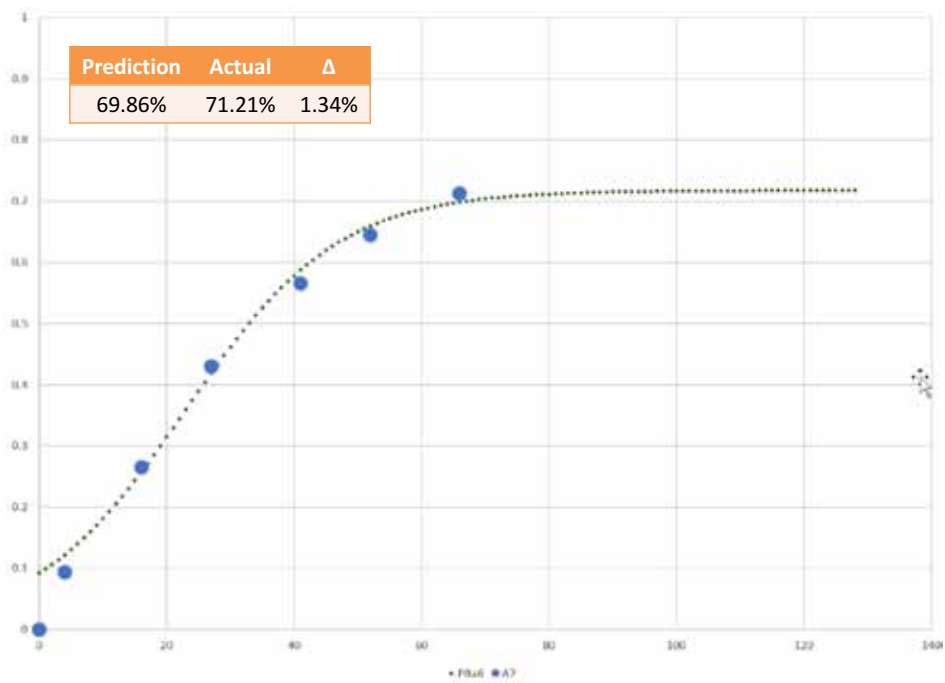
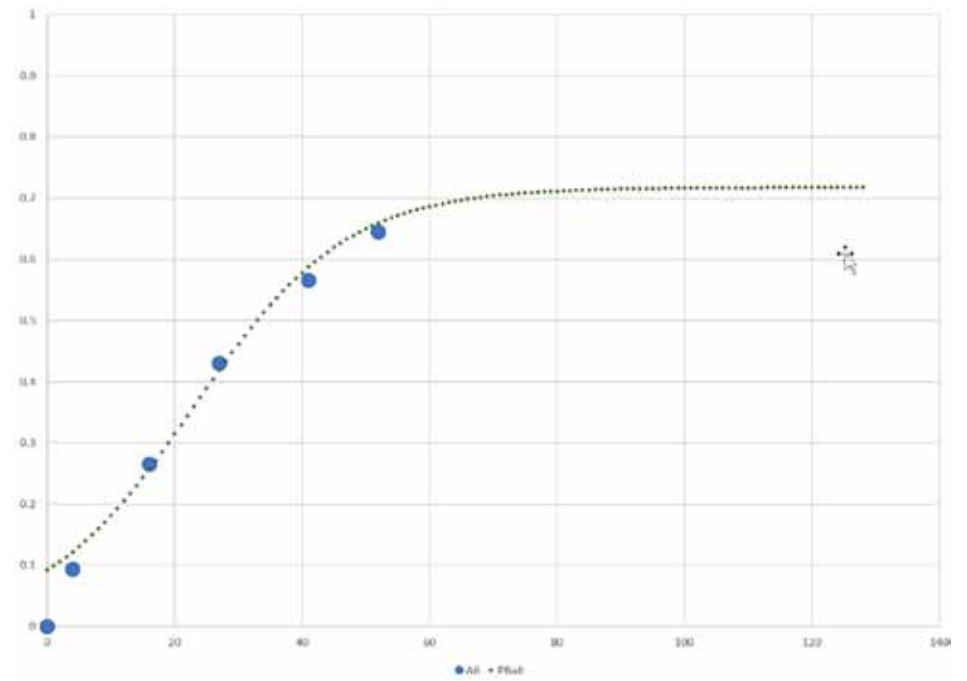
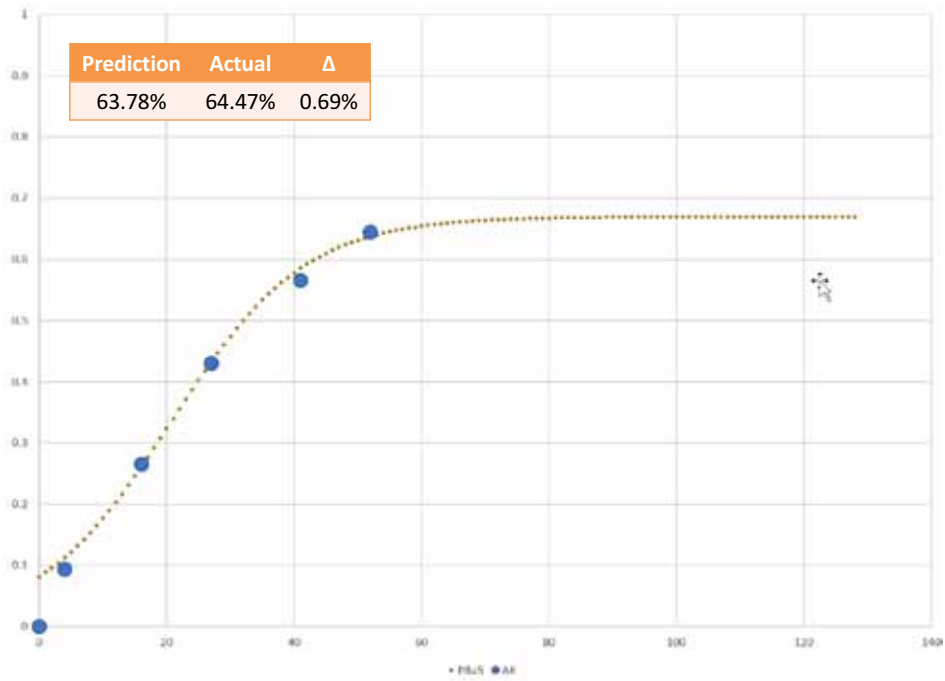
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- a – the curve's maximum value
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- c – the x -value of the sigmoid midpoint
- t – time

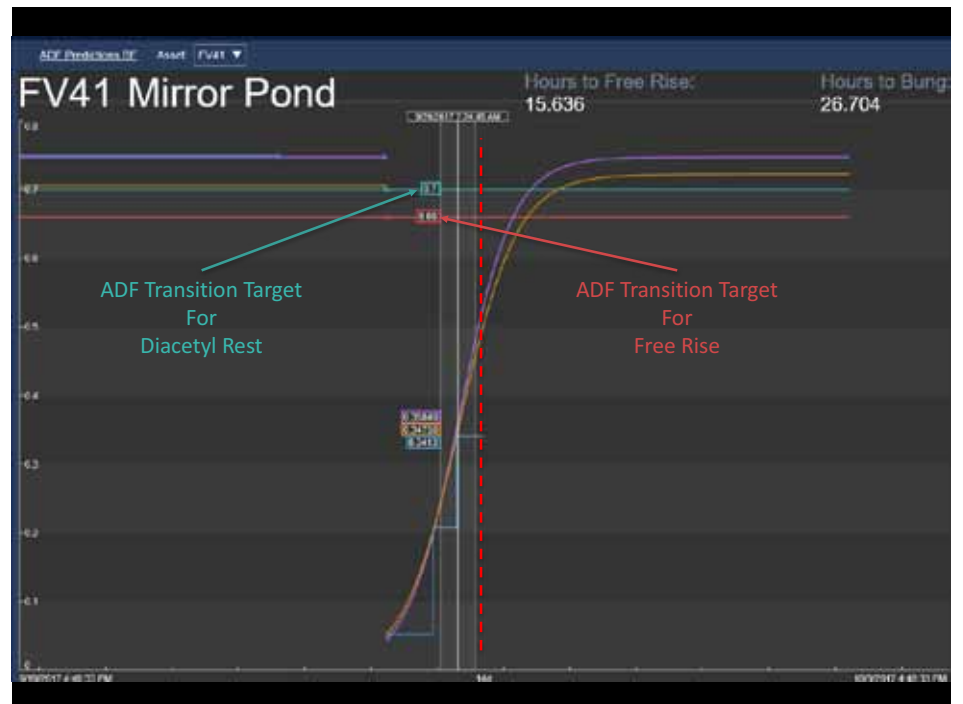
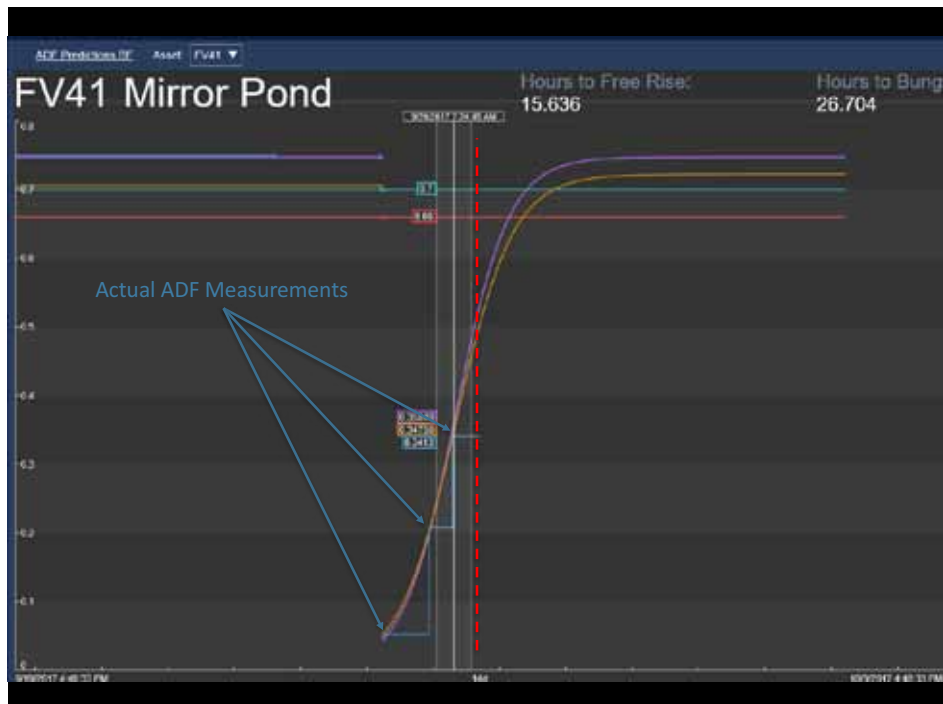
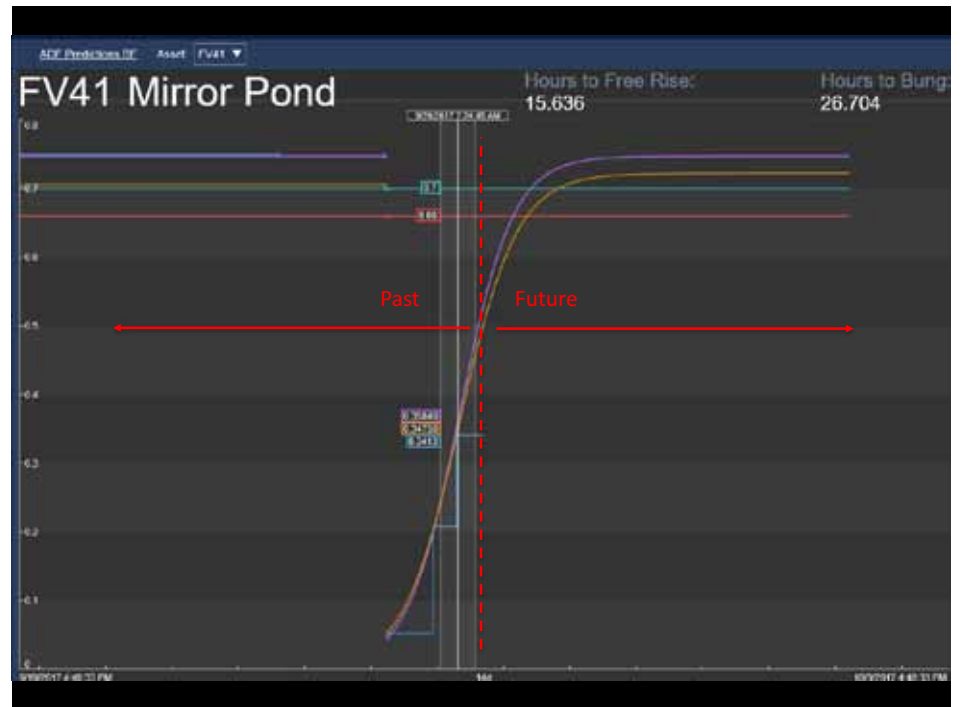
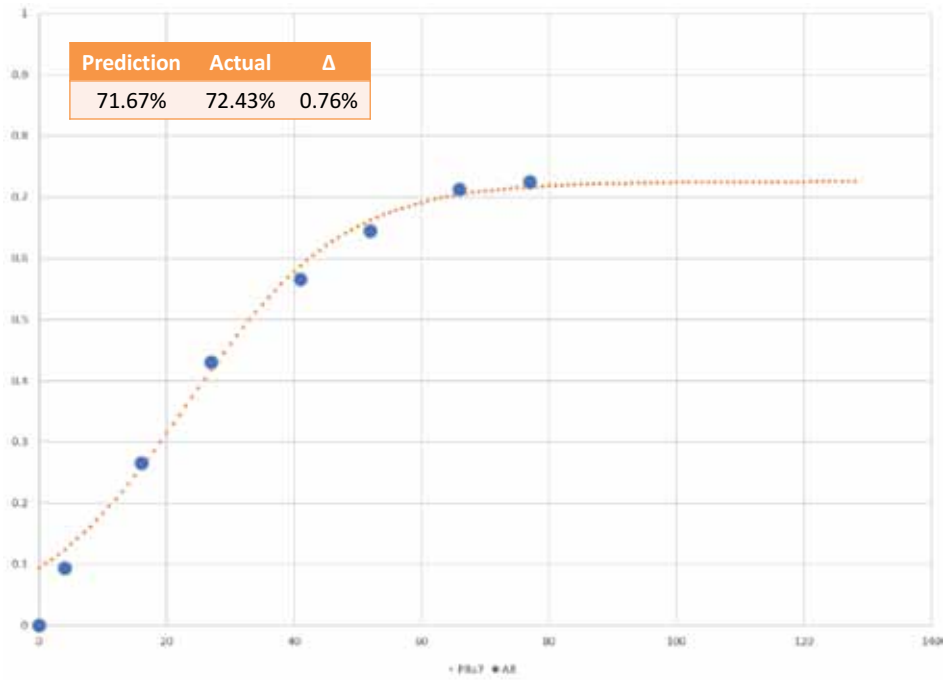
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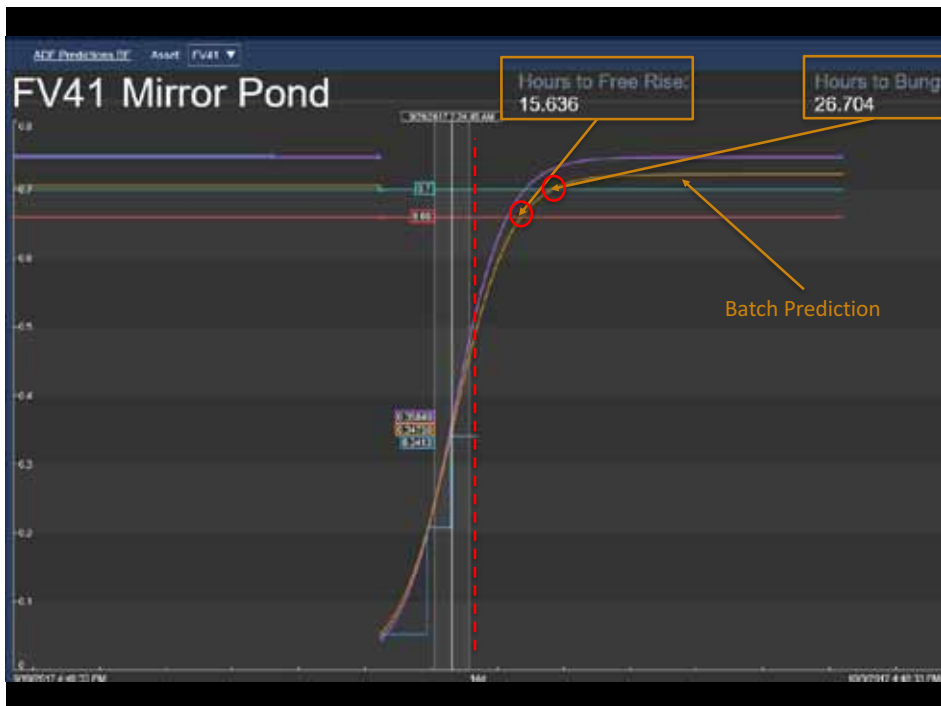
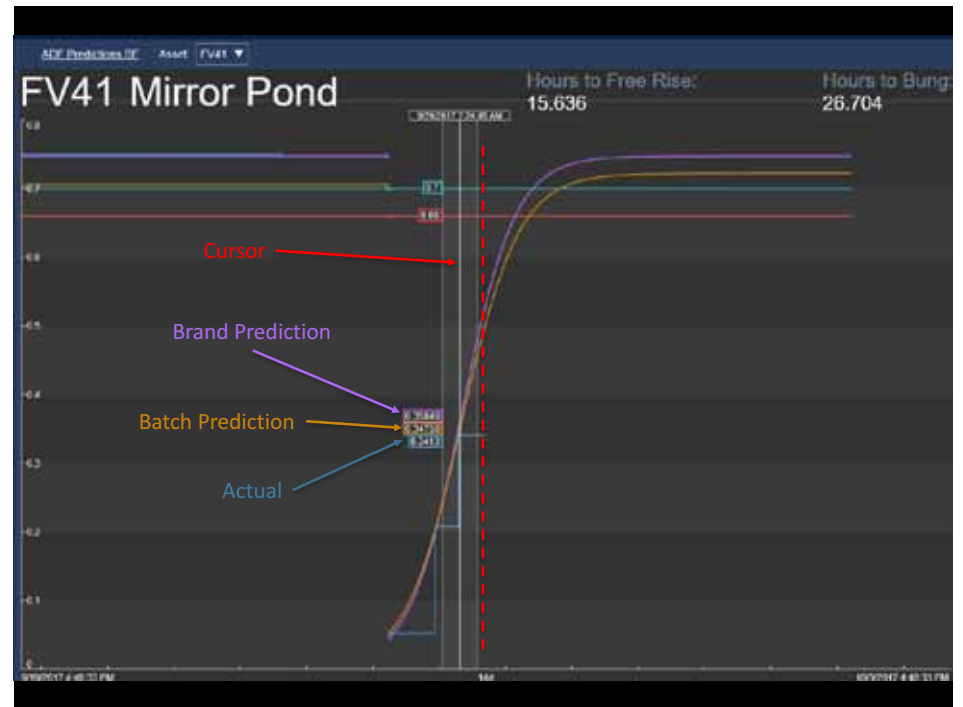
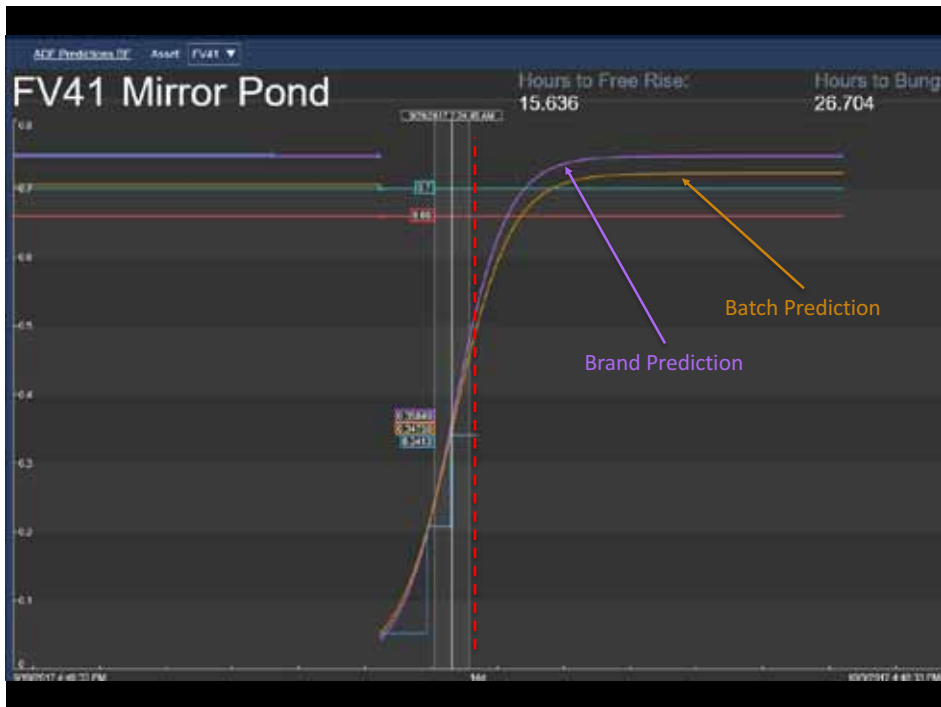




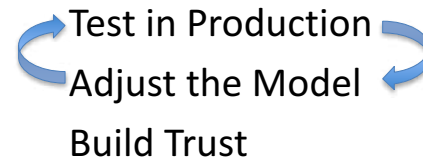




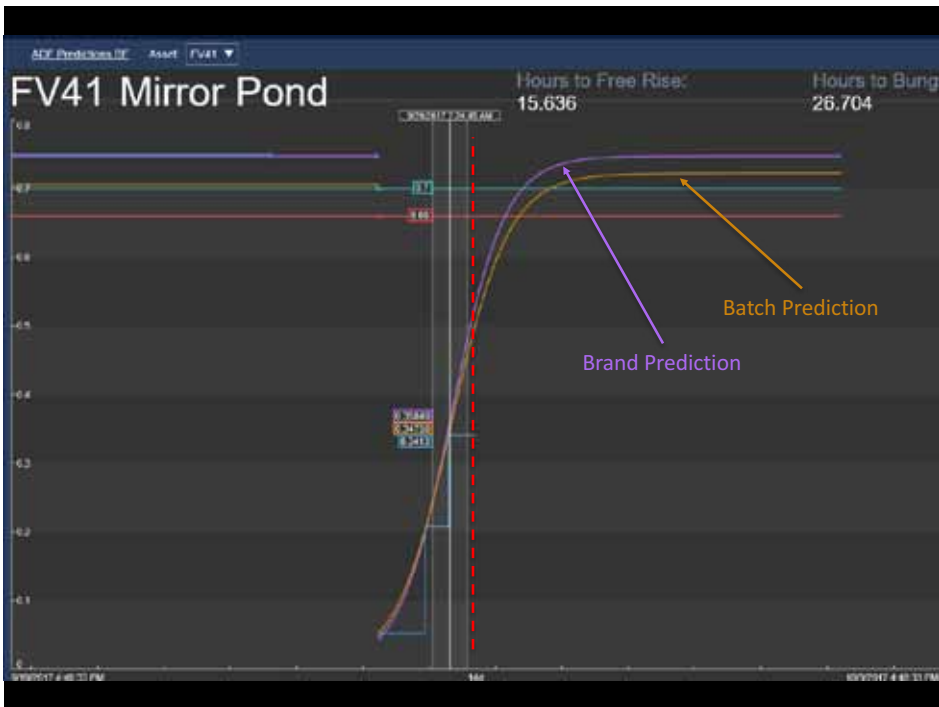




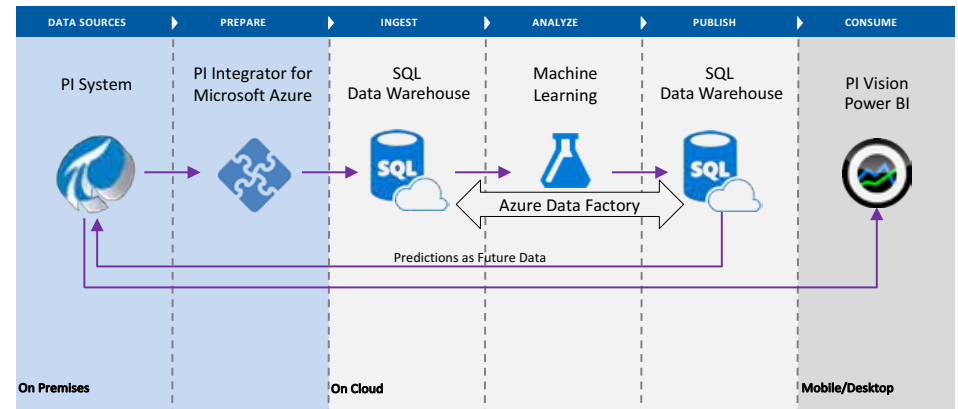
Operationalize



*It's just another Tool to help us
make Better Beer more
Efficiently*



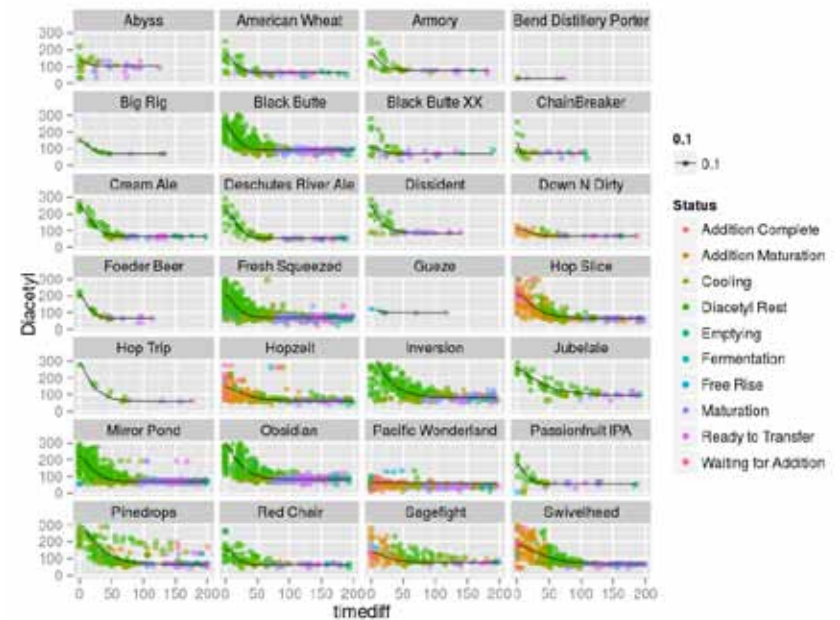
Architecture



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Transition to Cooling

1. Filling
2. Fermentation
3. Free Rise
4. Diacetyl Rest
5. Cooling
6. Maturation
7. Ready to Transfer
8. Emptying
9. Empty



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Diacetyl Predictions

J. Inst. Brew., May–June, 1994, Vol. 100, pp. 179–183

MODELLING OF DIACETYL PRODUCTION DURING BEER FERMENTATION

By ANA I. GARCÍA*, LUIS A. GARCÍA AND MARIO DÍAZ

(Department of Chemical Engineering, University of Oviedo, 33071 Oviedo, Spain)

Received 16 October 1993

Experimental brewing in stirred tanks has been carried out at different temperatures, pH's and agitation characteristics. A model based on biochemical pathways has been developed. The parameters have been evaluated to fit the results of diacetyl concentration evolution throughout fermentation. The resulting model has proved itself to be useful in predicting results in industrial cylindrical-conical fermenters when delay due to non-agitation during the first few days is considered.

INTRODUCTION

Diacetyl concentration is possibly the best known quality parameter of brewing; one of the most important biotechnological industries from an economic standpoint. To be able

The generally accepted classification of amino acids into groups depending on their uptake by the yeast is as follows^{1,3,6}. Group A—glutamate, glutamine, aspartate, asparagine, serine, threonine, lysine and arginine. Group B—histi-



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Diacetyl Predictions

$$ac2_t = (a - d) \times e^{(-b \times tc)} + d$$

$ac2_t$ – Diacetyl at time t

a – the curve's maximum value

b – the curve's "heel"

c – the steepness of the curve

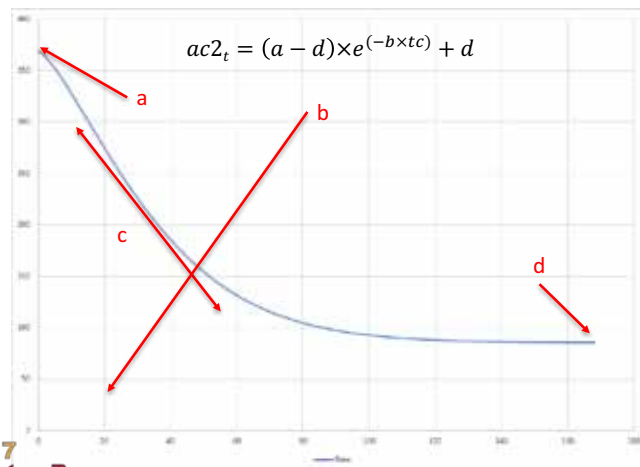
d – the curve's minimum value

t – time



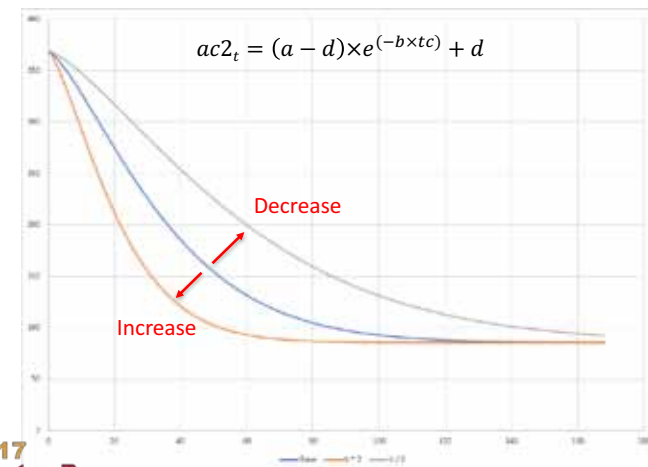
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Diacetyl Prediction Function



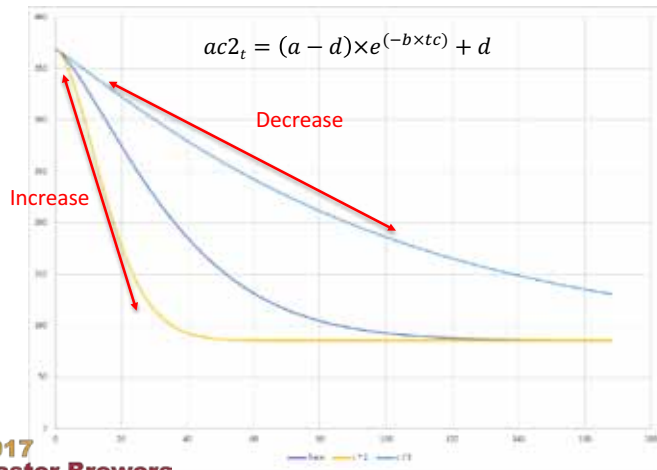
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Diacetyl Prediction Function Impact of b



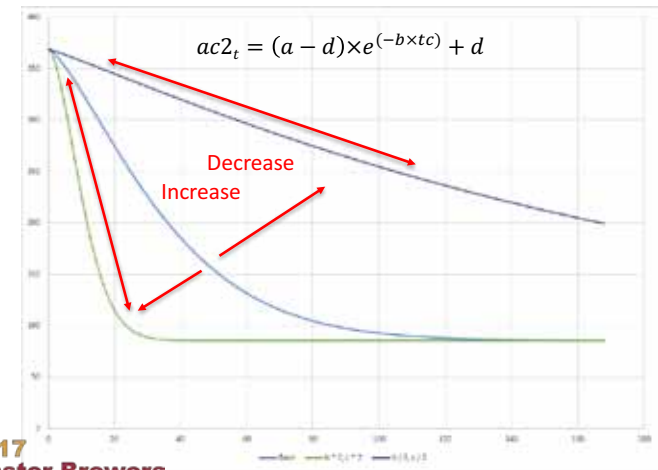
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Diacetyl Prediction Function Impact of c



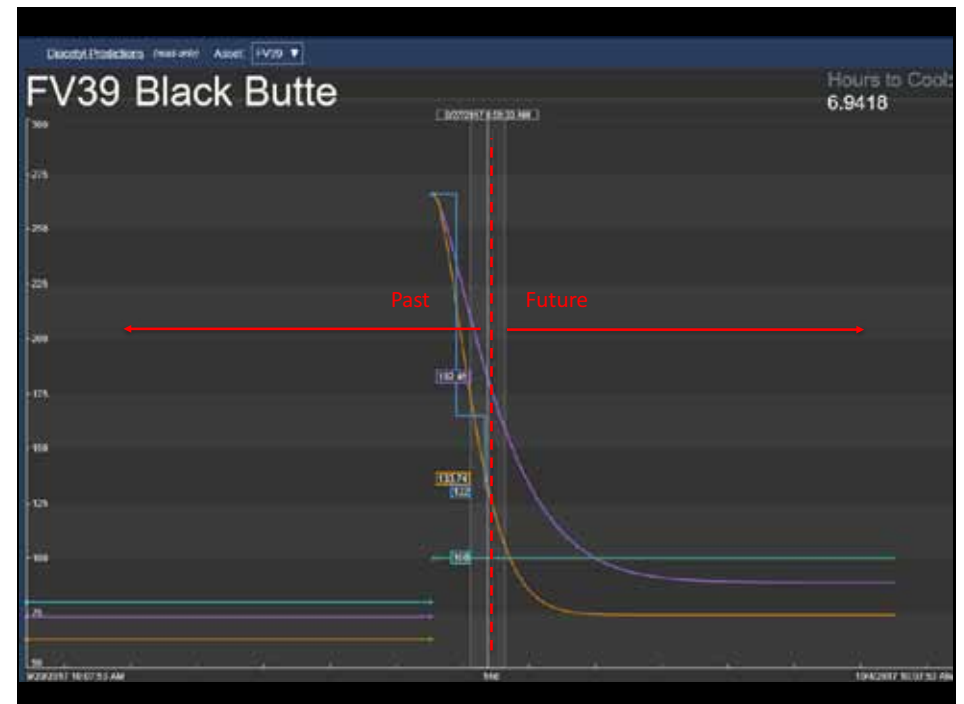
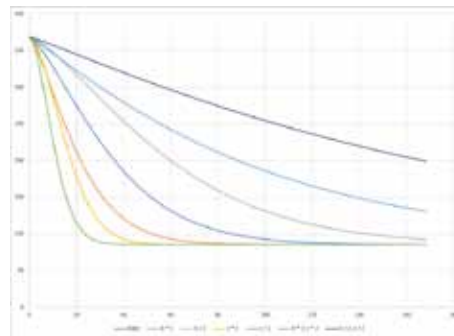
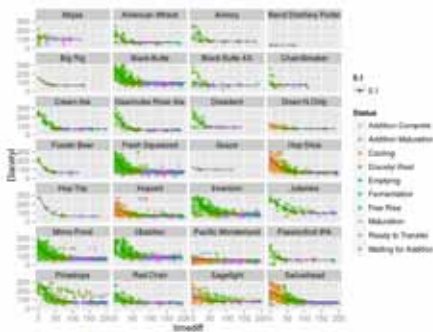
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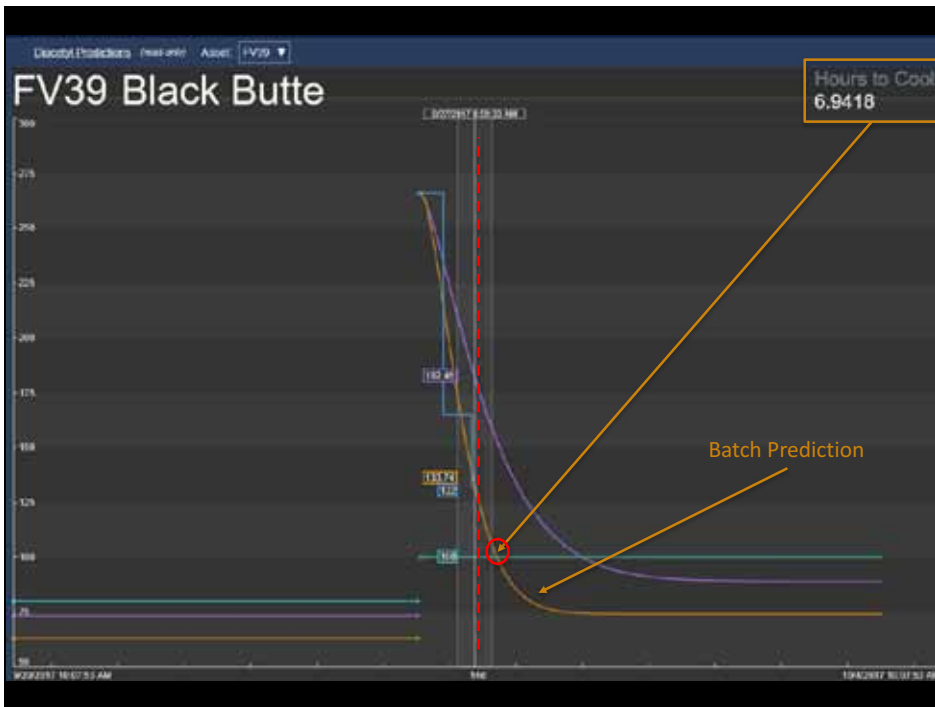
Diacetyl Prediction Function Impact of b and c



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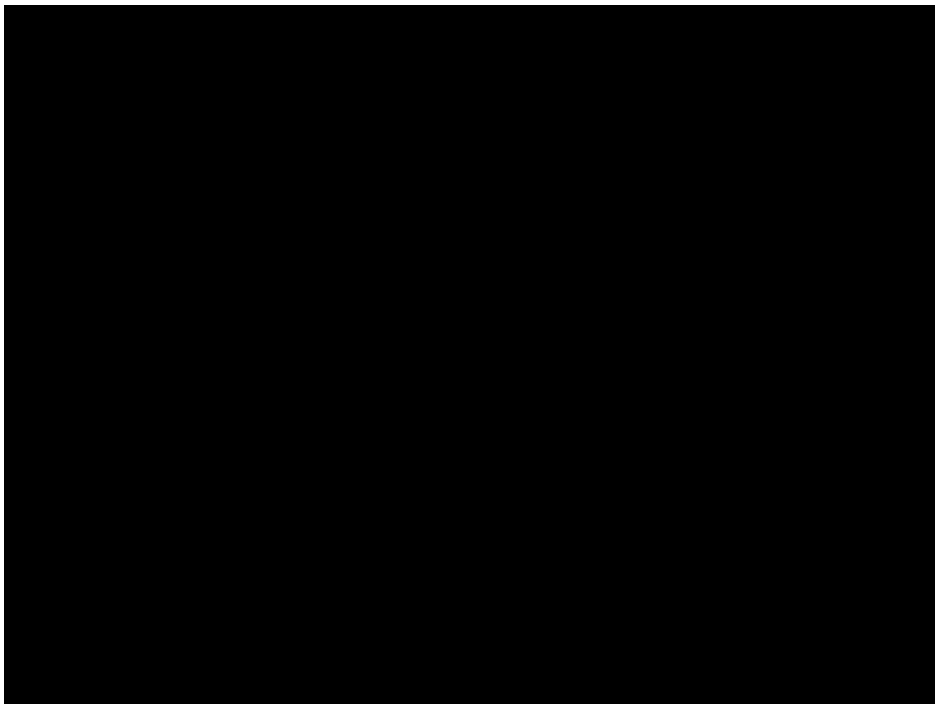
Actual Data vs. Modeling Capabilities





Future Opportunities

1. Filling
 2. Fermentation
 3. Free Rise
 4. Diacetyl Rest
 5. Cooling
 6. Maturation
 7. Ready to Transfer
 8. Emptying
 9. Empty
-
- A. Preventative Maintenance
 - B. Lautering Logic
 - C. GCMS (Big) Data



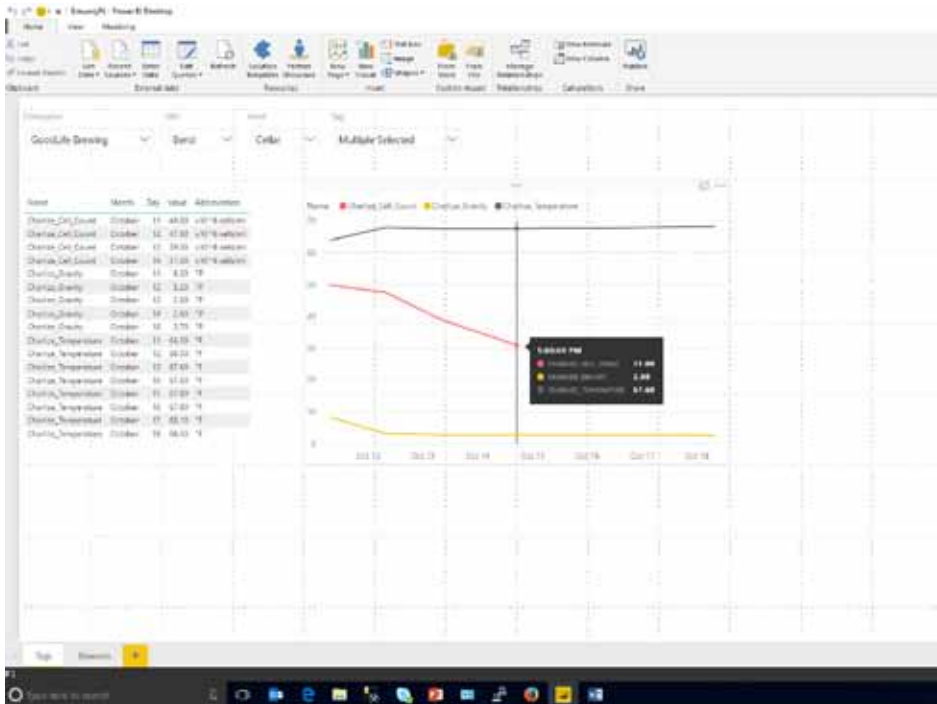
Data Recording Methods Paper

Pros

- Easy
- Cheap
- Free Form

Cons

- Structure
- Accessibility & Storage
- Aggregation / Reporting



Thank You

Acknowledgements

Brewery Pi

Kyle Kotaich

Curtis Nelson

Sean Garvin

Jeremiah Beisner

Tim Alexander

Kyle Kotaich

Tim Alexander

Brian Faivre

bfaivre@deschutesbrewery.com



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