Effects of Process Variables on Dynamic Relief Load Estimates for a Depropanizer and Debutanizer

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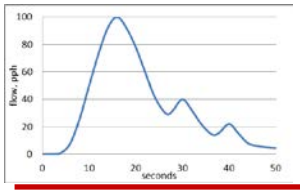

INTRODUCTION

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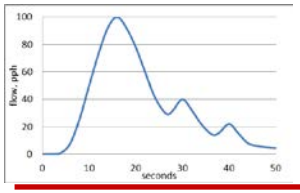
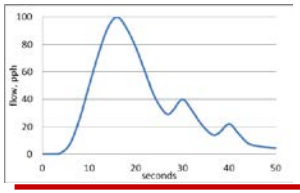


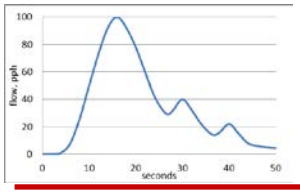
AGENDA

- Background
- Methodology
- Results
- Conclusions
- Future work
- Summary



BACKGROUND

- Why dynamic analysis is being used.
- How engineers/designers perform dynamic analysis.
- How initial assumptions are being handled.
- Why this is important to safety.

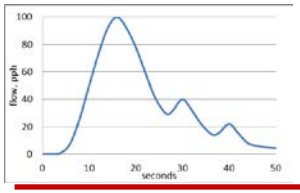


BACKGROUND [CONT.]

- Peak relief rates estimated by dynamic analysis tend to be lower than traditional methods.
- Initial assumptions can raise the peak rate.
- API requires that a sensitivity analysis be performed.

$$\dot{M}_{relief} = \frac{\dot{Q}_{reb}}{\Delta H_{vap}} \quad vs. \quad \dot{M}_{relief}\left(t, P_i, T_i, etc\right) = \frac{\dot{Q}_{reb}\left(t, P_i, T_i, etc\right)}{\Delta H_{vap}\left(t, P_i, T_i, etc\right)}$$

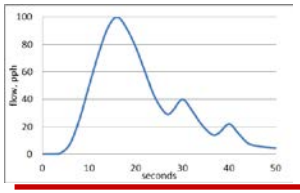
Theoretical equation, steady state vs. dynamic



BACKGROUND [CONT.]

From API 521 5th Ed. Sec 5.22:

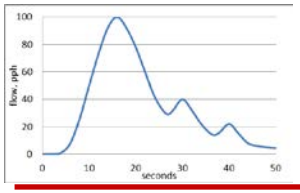
- "It can be necessary to **perform sensitivity analyses** with respect to control response in order to identify appropriate control response."
- "If dynamic simulation is used for column-relief-system design, it is necessary to **ensure that the model is conservative** with respect to calculating the maximum relief load."
- "These assumptions **shall** be checked by **sensitivity analyses** to assess their impact on the column-relief load."



METHODOLOGY

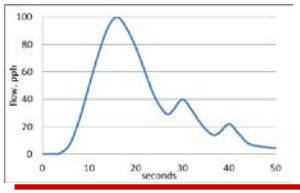
1. Column boilup was selected as the relief basis.

2. Three initial conditions were varied
   - Column liquid level
   - Feed temperature
   - Column pressure



METHODOLOGY [CONT.]

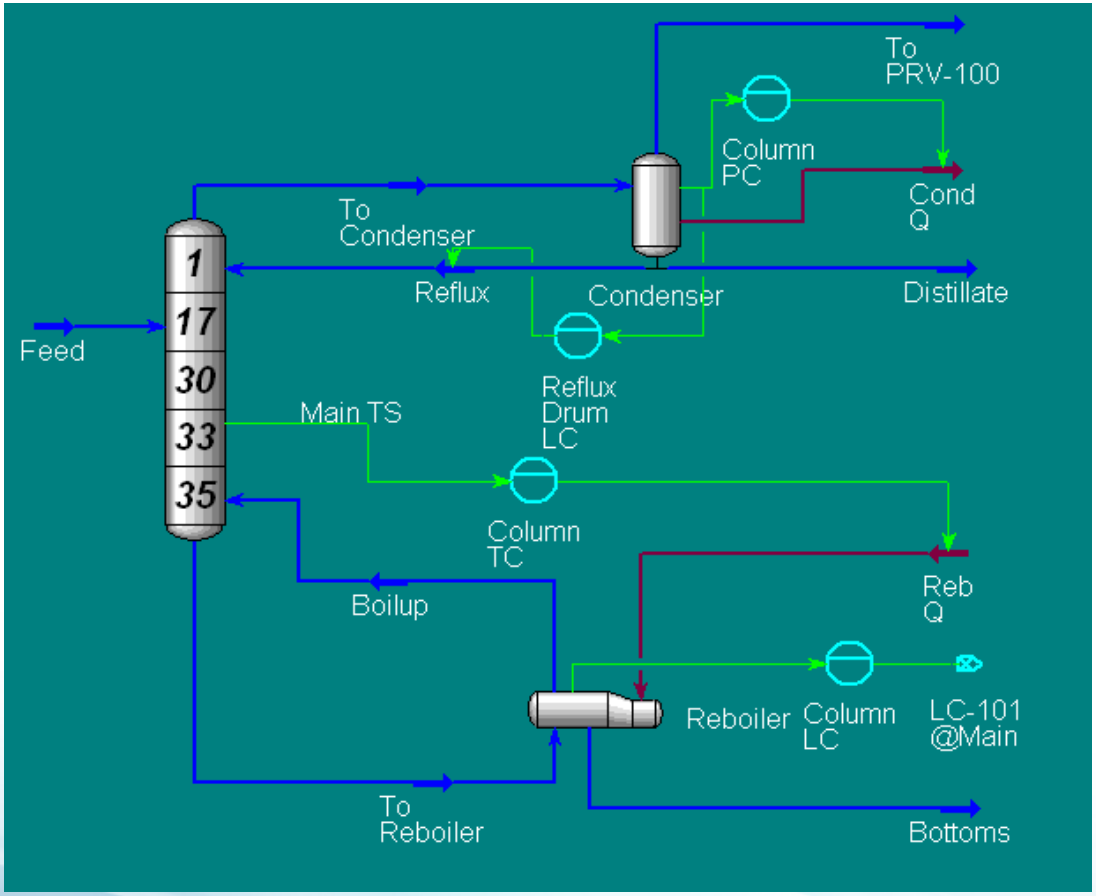
3. Three columns were analyzed
   - Depropanizer (Column temp range: **104-210°F**)
     - (4’ diameter, 21,600 lb/hr feed)
     - (8’ diameter, 32,400 lb/hr feed)
   - Debutanizer (Column temp range: **179-384°F**)
     - (10’ diameter, 623,000 lb/hr feed)



DYNAMIC RELIEF

PROCESS VARIABLES EFFECTS

METHODOLOGY [CONT.]



Column PFD for the depropanizer

4. Steady state columns
5. Dynamic mode was initiated
6. PID controllers were created
   - Column Pressure
   - Column Temperature
   - Reflux Drum Liquid Level
   - Column Liquid Level
   - Distillate Flow Rate

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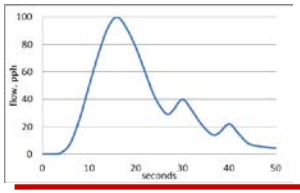
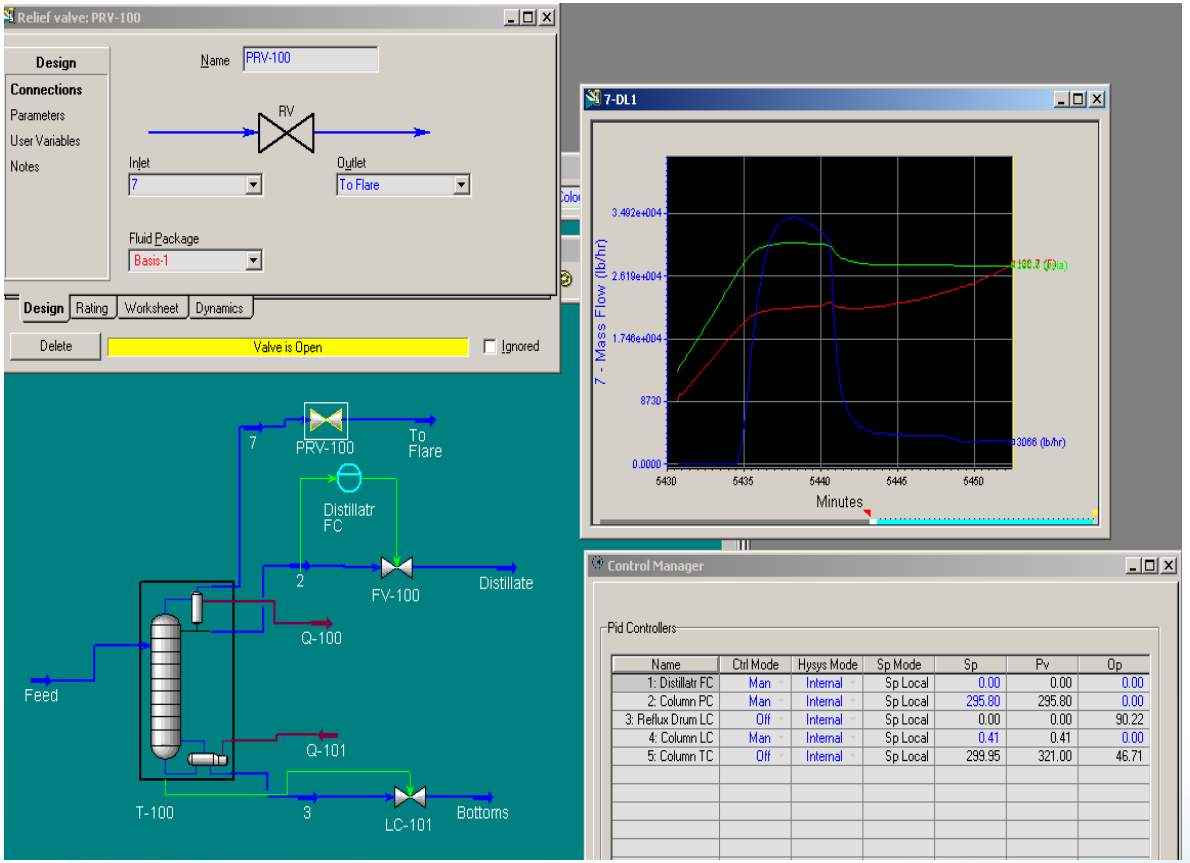


DYNAMIC RELIEF

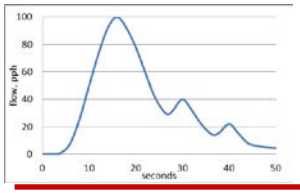
PROCESS VARIABLES EFFECTS

METHODOLOGY [CONT.]

7. Steady state was reached in dynamics mode
8. A PRV was added to the vapor overhead
9. Relief scenario was started
10. Simulation data was recorded



Collecting data for the depropanizer



DYNAMIC RELIEF

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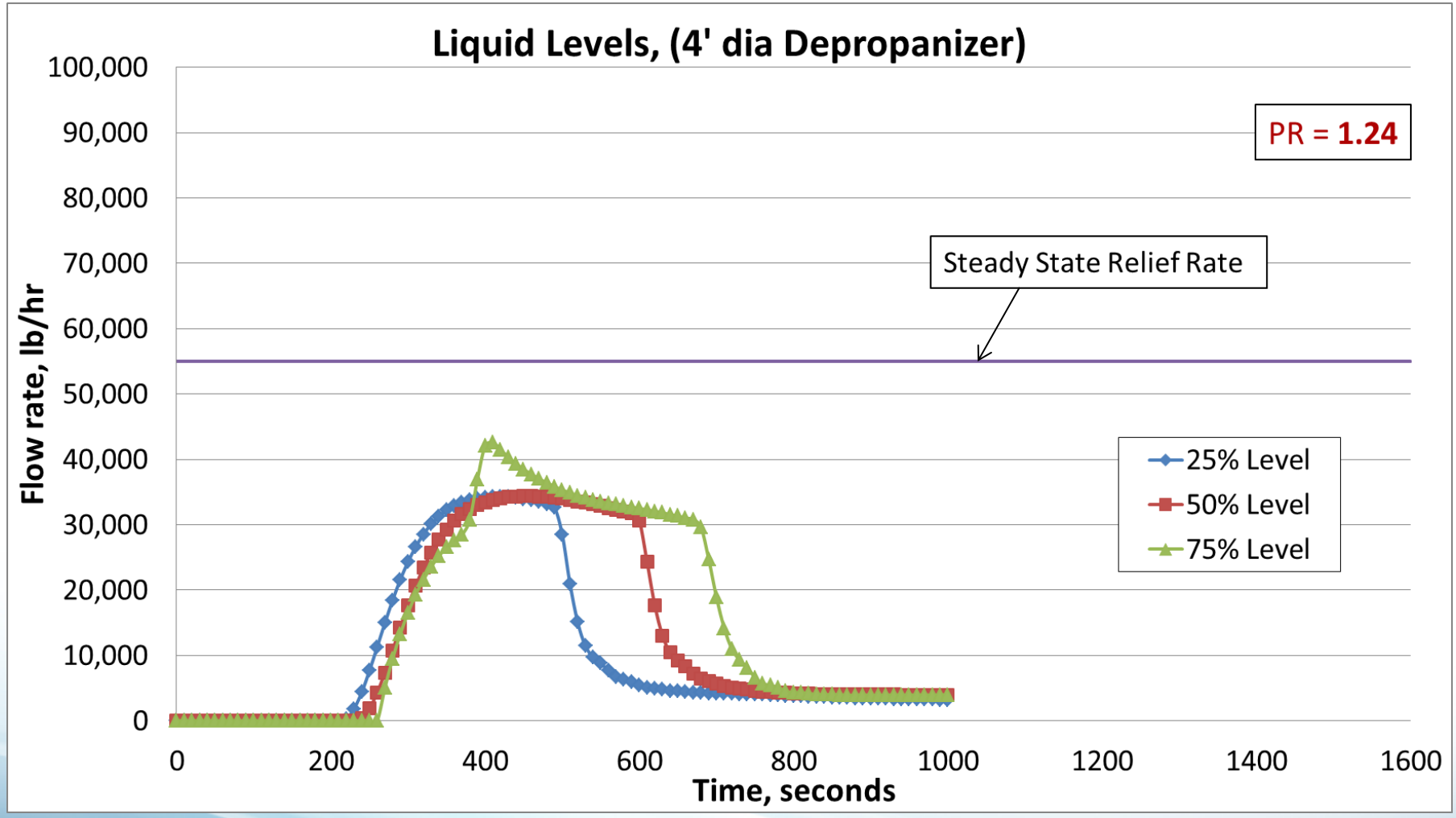

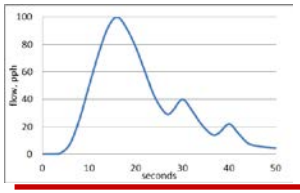

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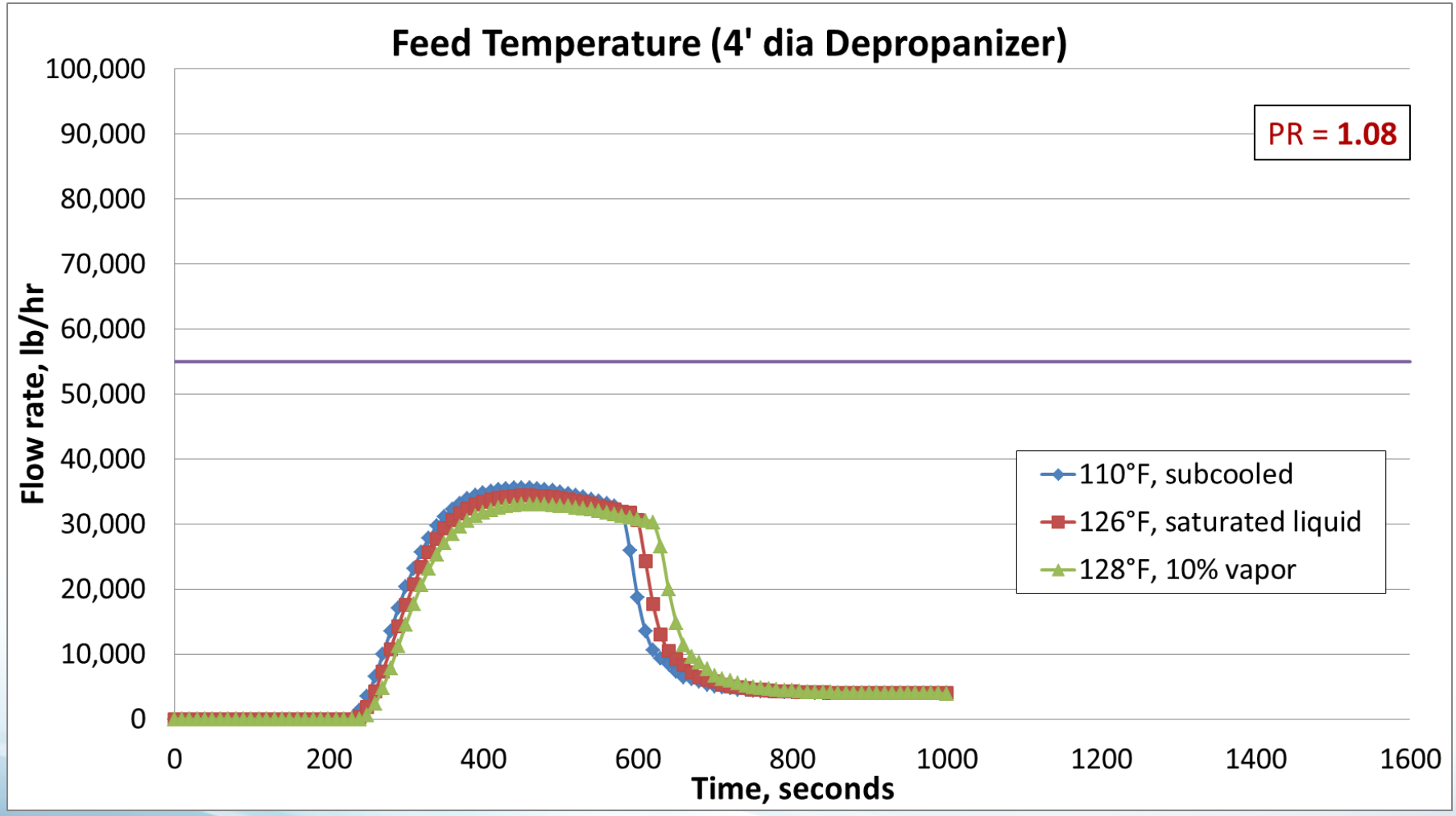

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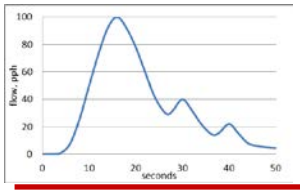

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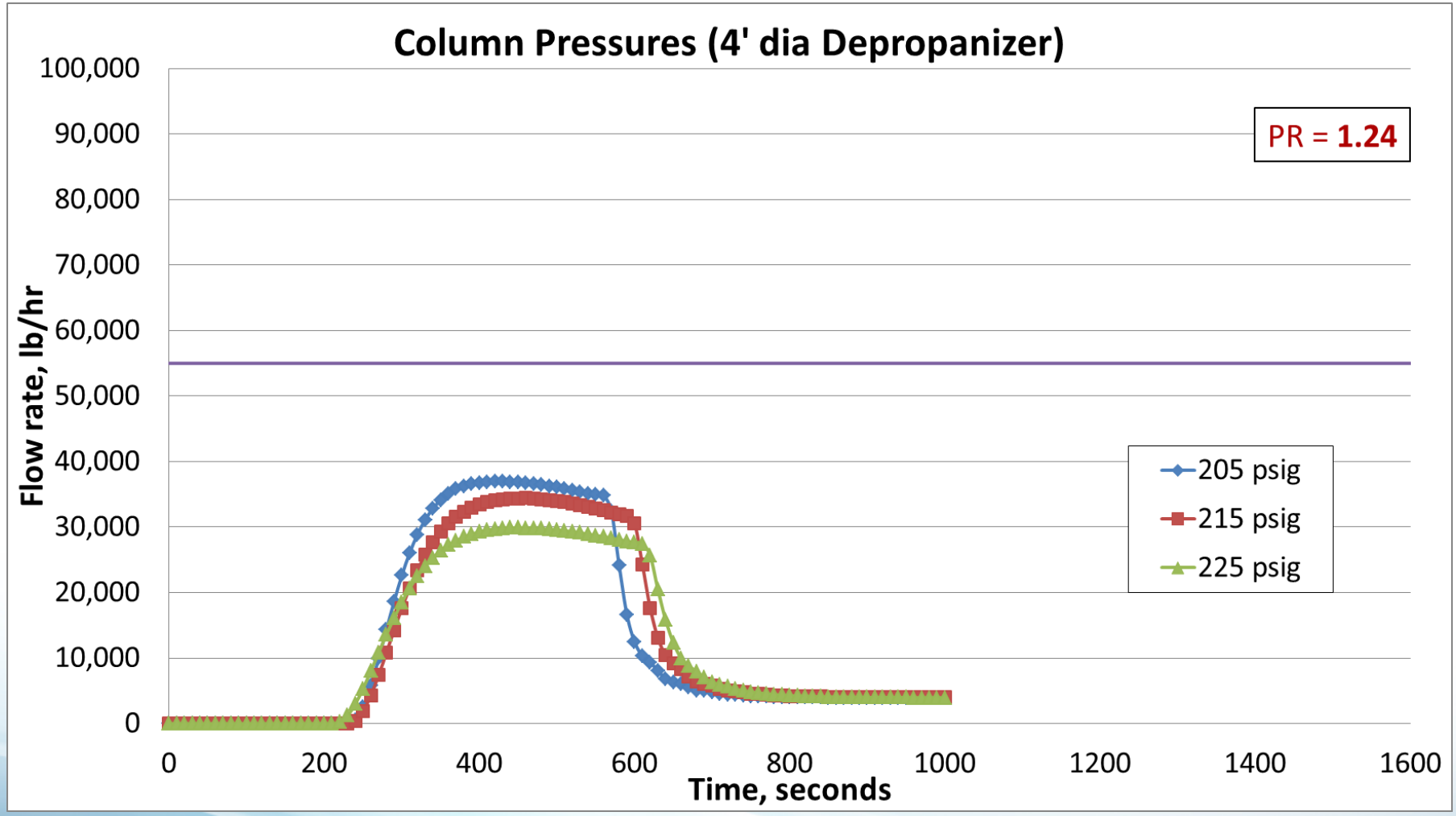

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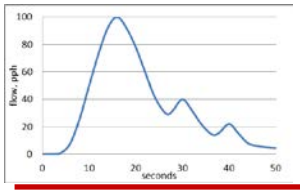

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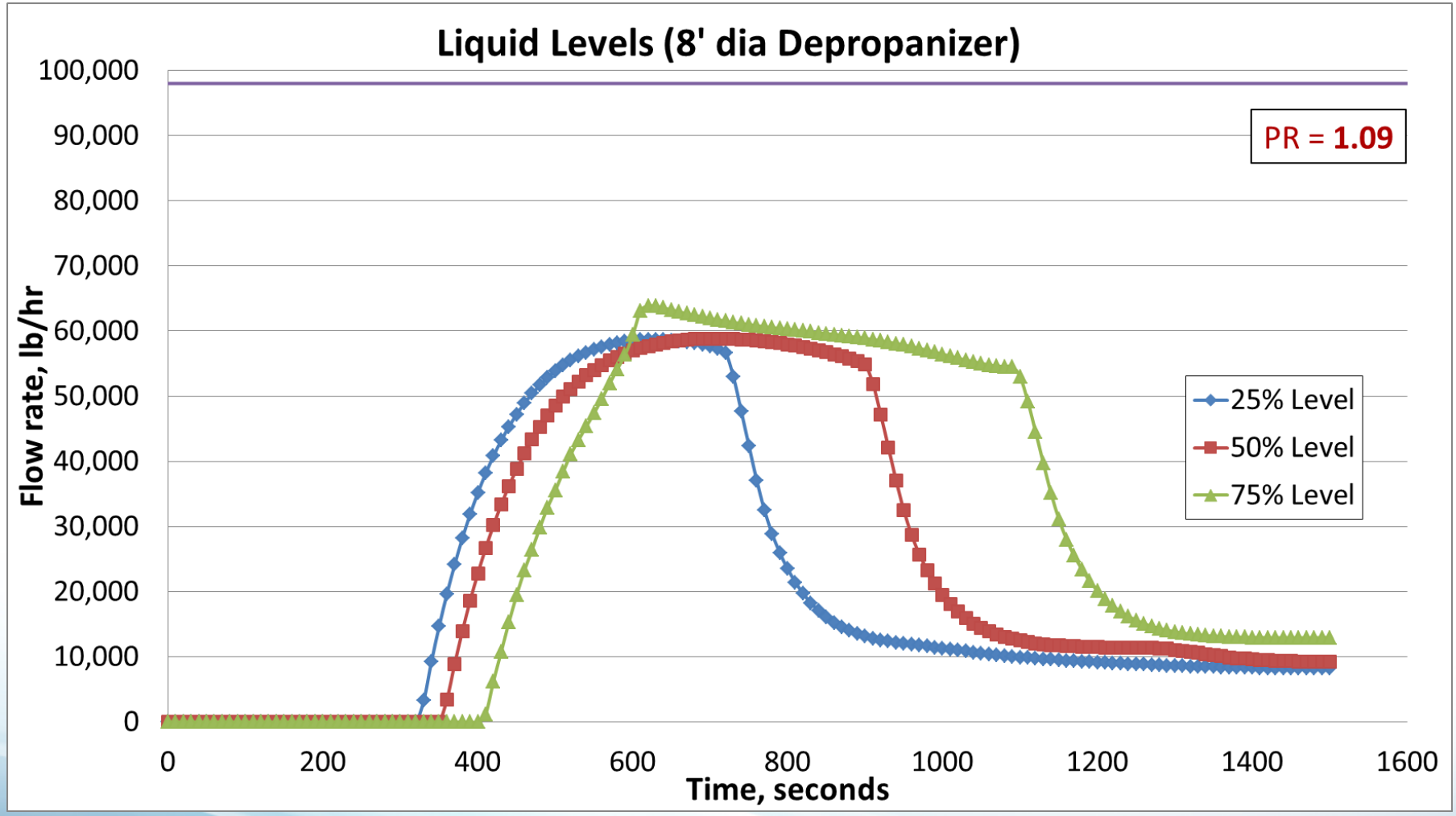

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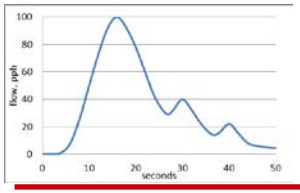

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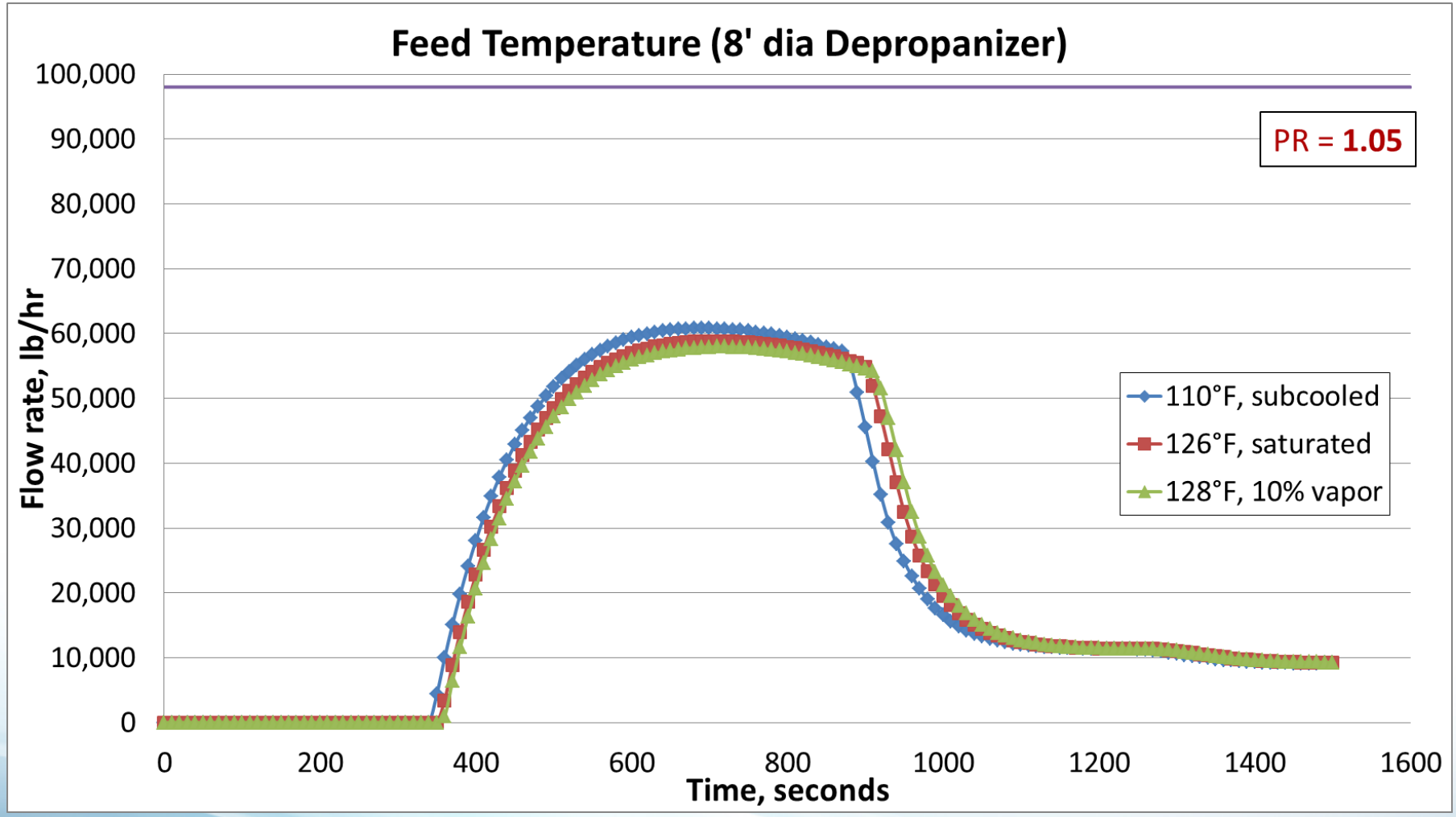

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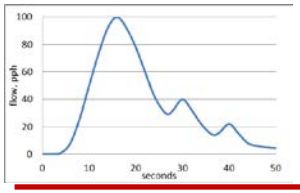

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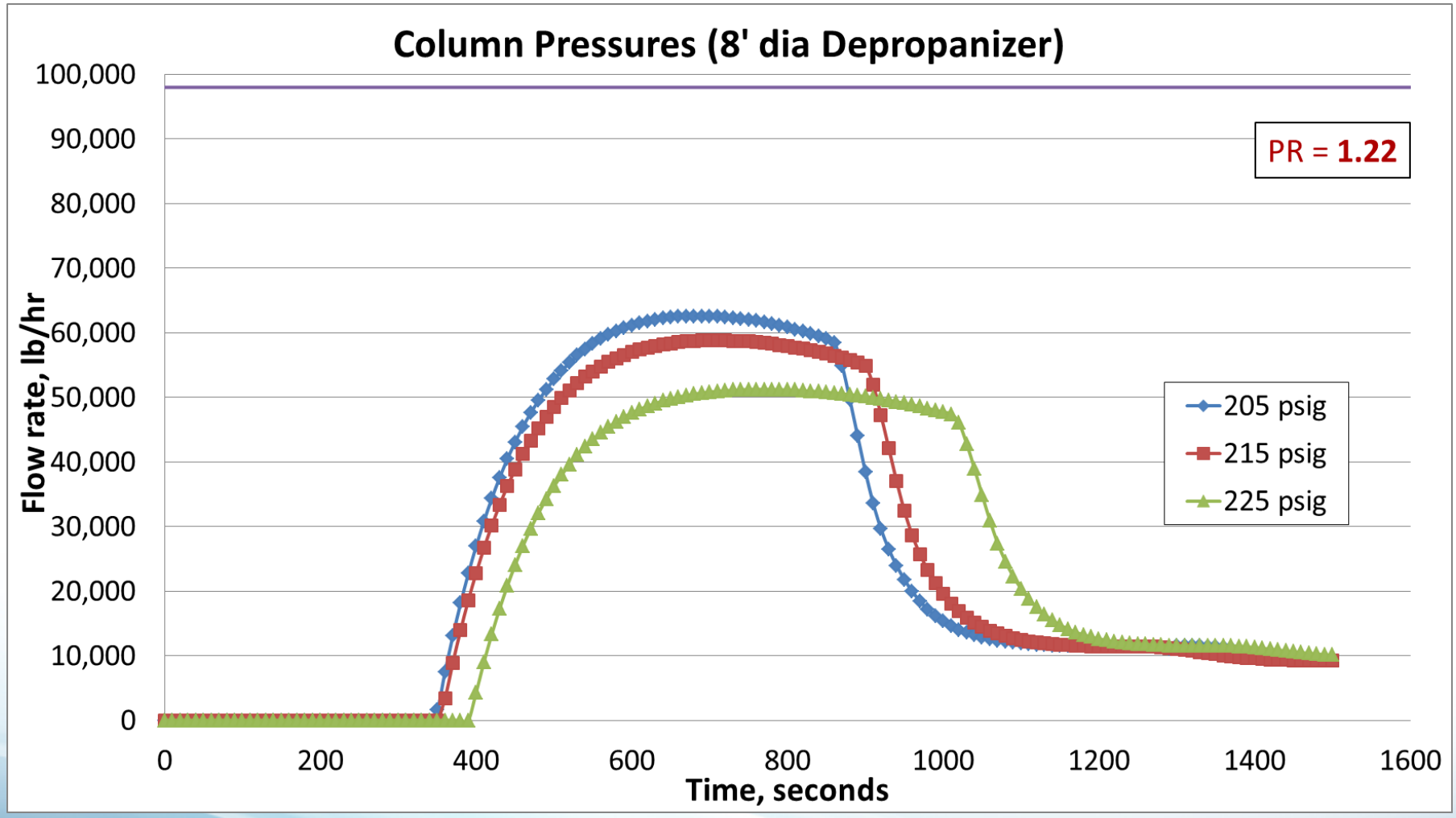

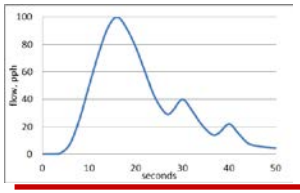

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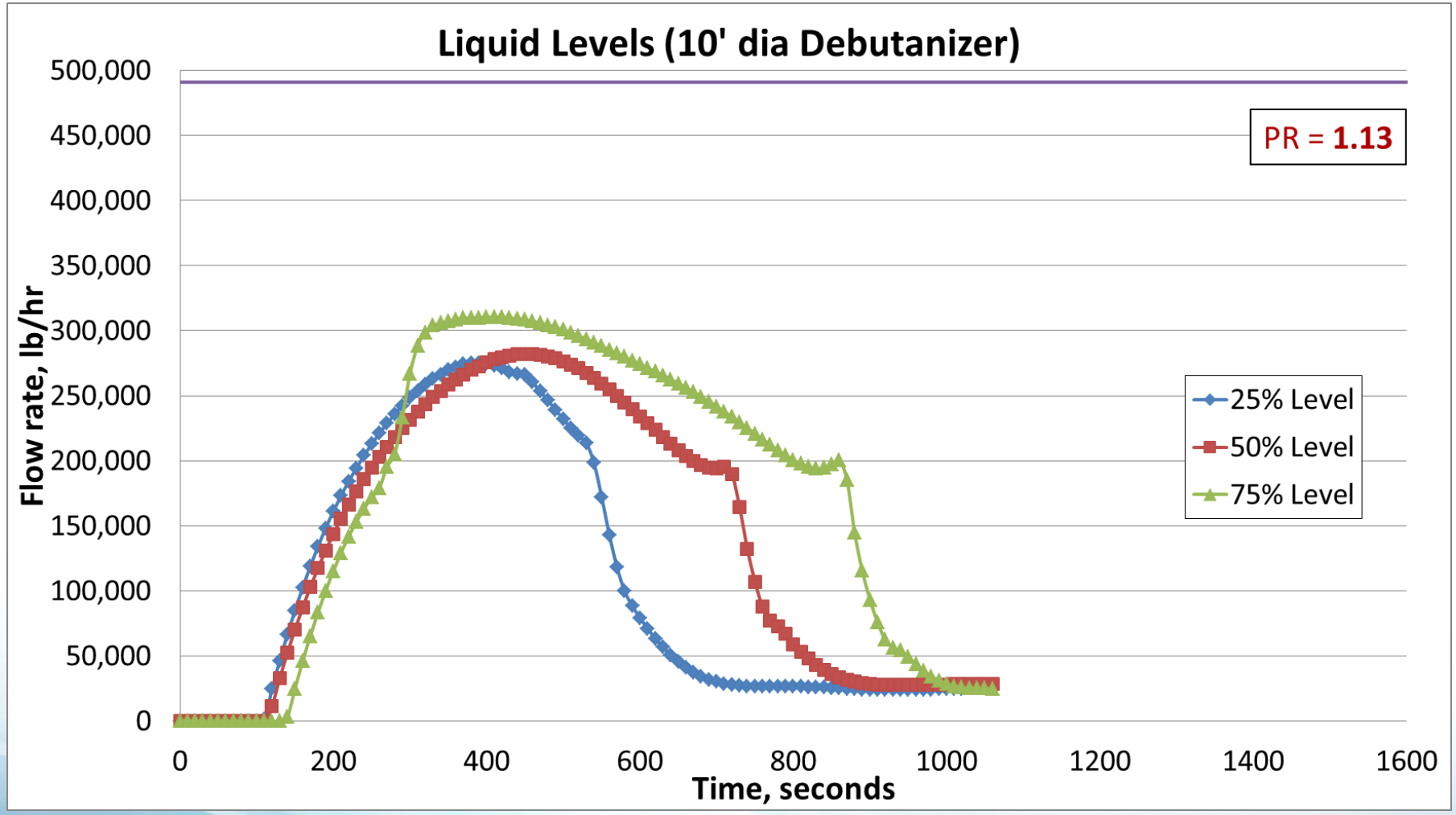

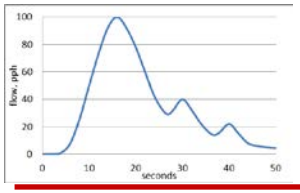

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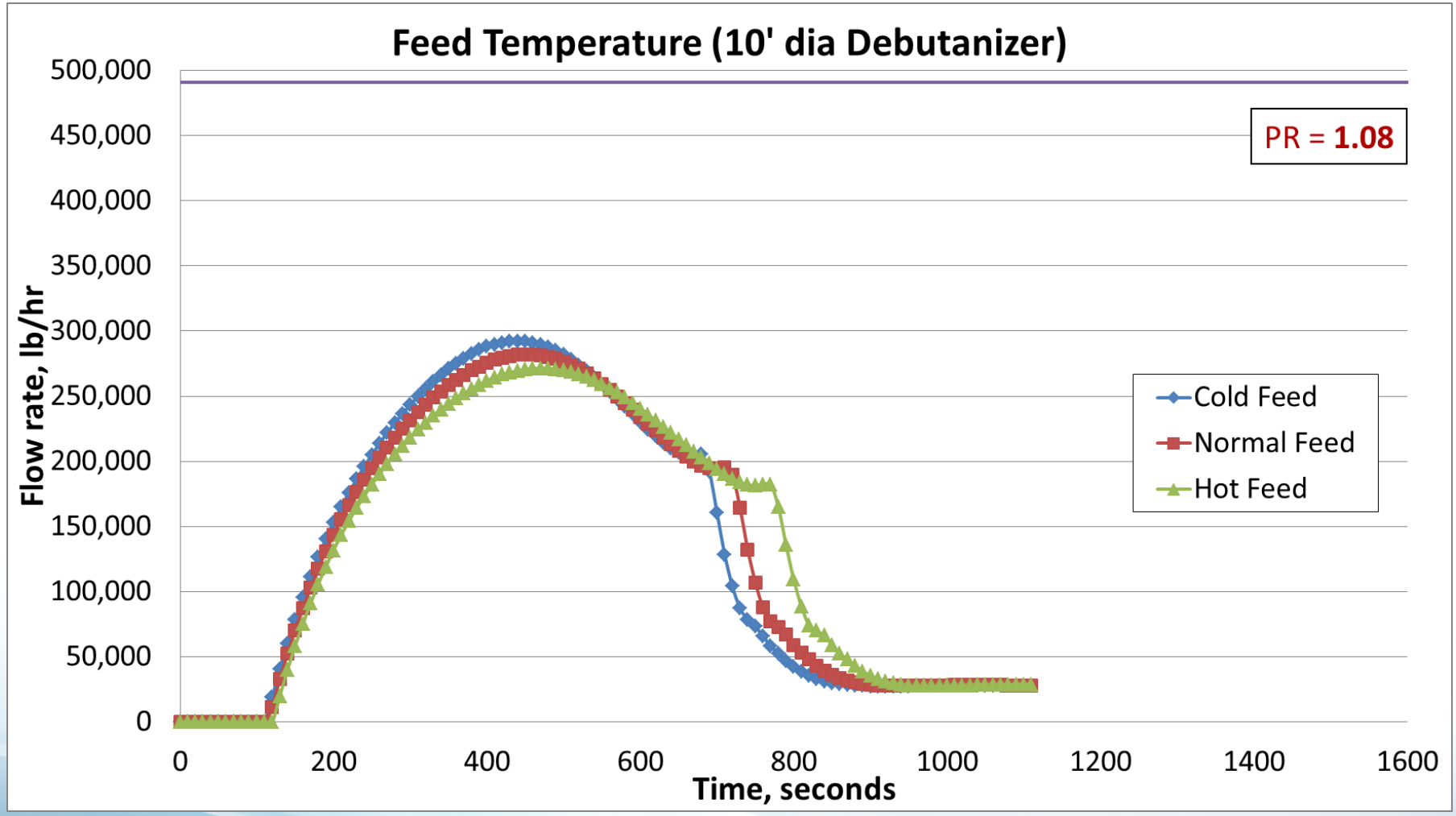

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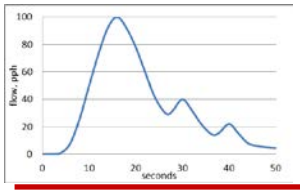

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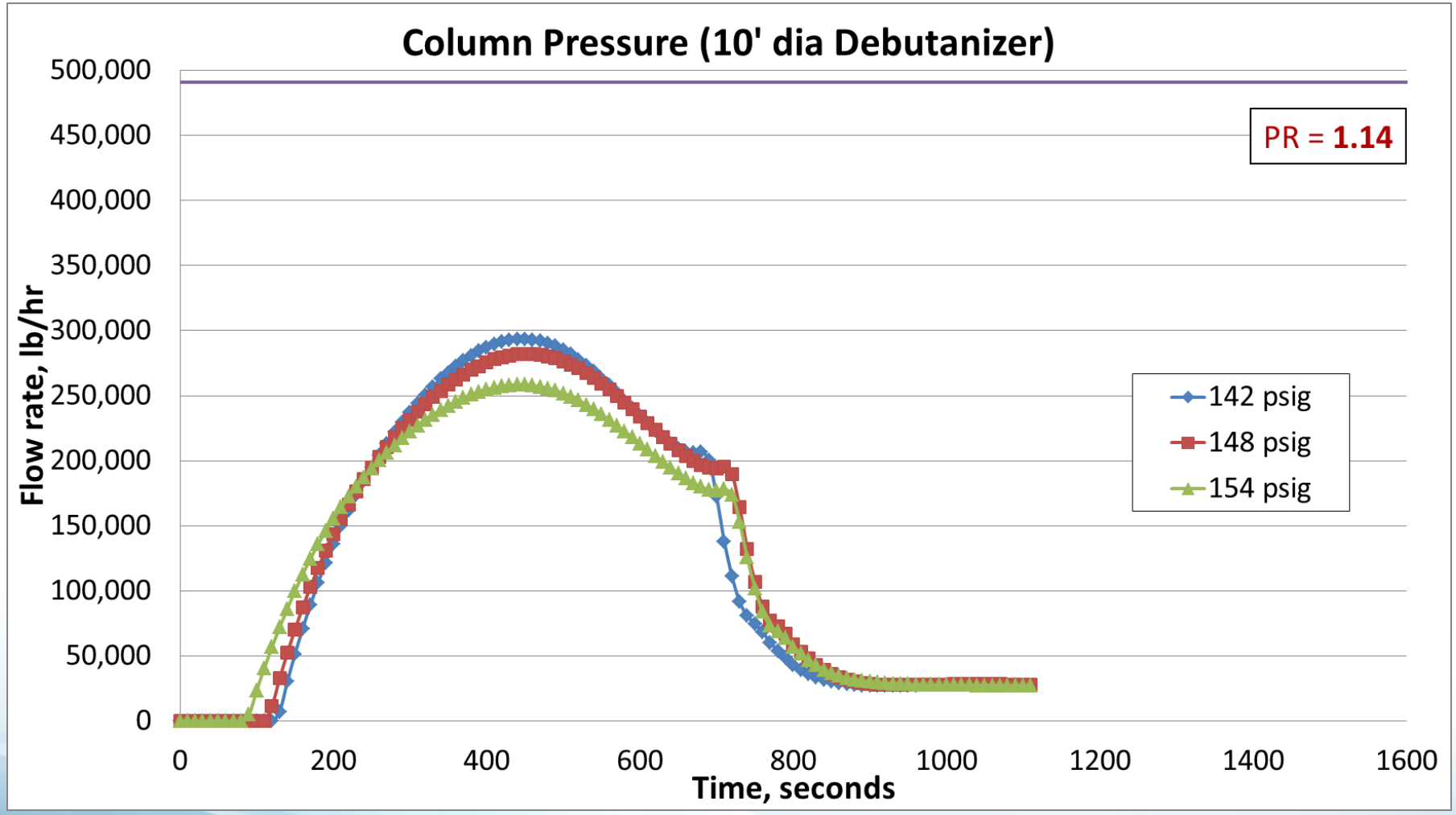
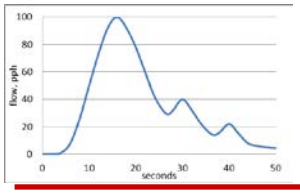
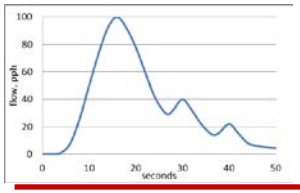




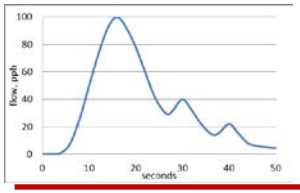
CONCLUSIONS

1. Some process variables had more impact on the peak flow rate.
2. Process variables affect
   - Time to initial relief
   - Peak rate
   - Duration
3. Analysis can be time consuming.
4. Cost of analysis vs. savings.



FUTURE WORK

1. Review other scenarios.
2. Review additional variables.
3. Understanding the impact on flare sizing.
4. Determine if the effects are cumulative.



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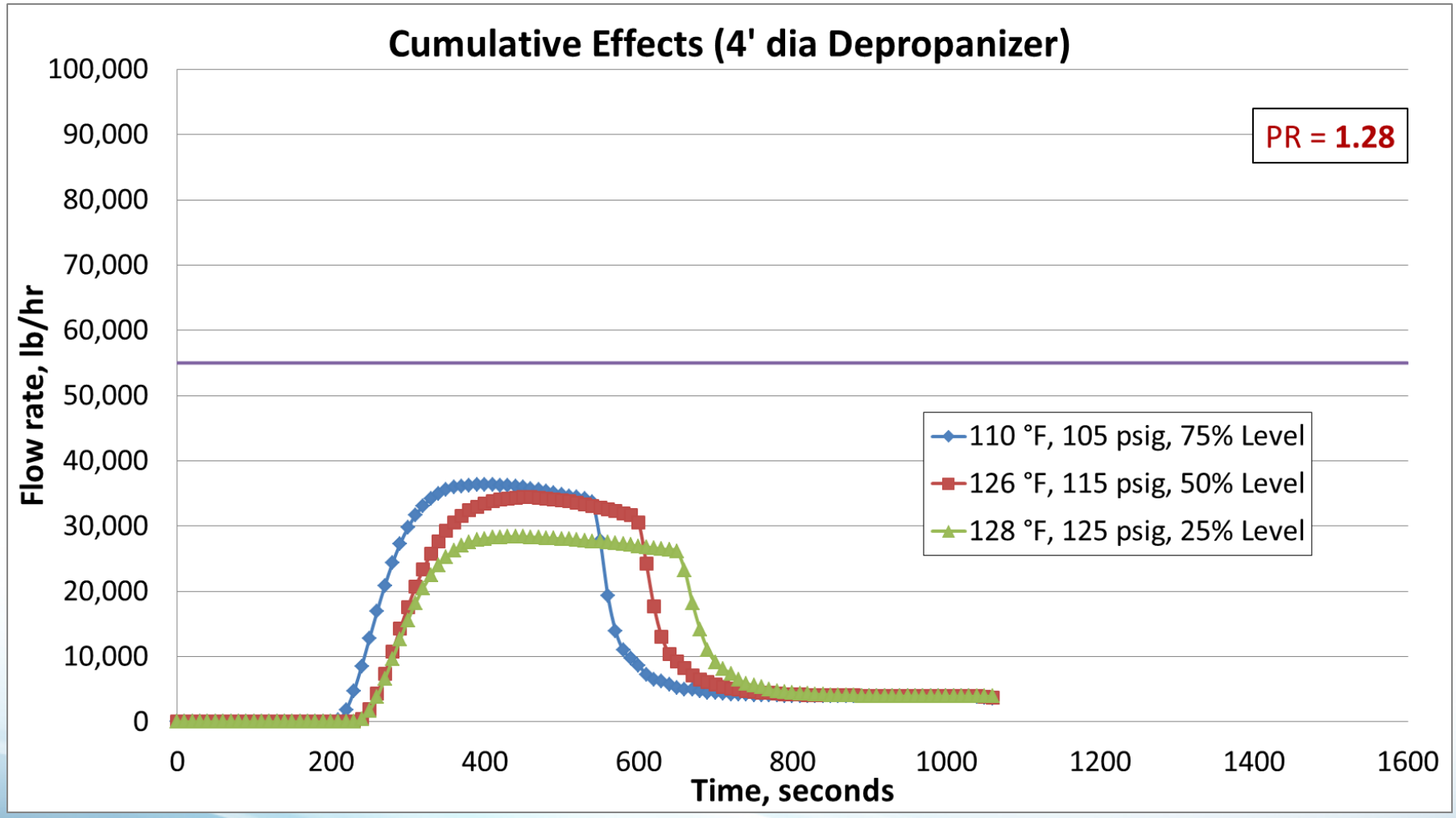

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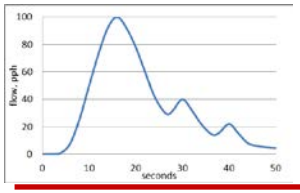

SUMMARY

Table of PR values

Variable\Column	4' dia Depropanizer	8' dia Depropanizer	10' dia Debutanizer
Liquid Level	1.24	1.09	1.13
Temperature	1.08	1.05	1.08
Pressure	1.24	1.22	1.14

1. Sensitivity analyses must be performed for dynamic simulations.
2. Some assumptions impact the peak relief load.
3. Sensitivity analyses can be costly.
4. More work is required to analyze these effects.