



Destruction Efficiency of Air-Assisted Flares

**American Flame Research Committee
Industrial Combustion Symposium
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Kauai, Hawaii**

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➤ *Outline*

- Typical Air Flare Designs and Arrangements
- Destruction Efficiency General Discussion
- Zeeco Air Flare Destruction Efficiency Testing and Results
- Air Flare Operating Recommendations
- Question/Answer



Typical Air Flare Designs & Arrangements

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➤ *Typical Air Flare Installations*

- **Gas Processing / Compression Plants**



► *Typical Air Flare Installations*

- LNG Facilities



➤ *Typical Air Flare Installations*



- Gas Gathering



➤ *Typical Air Flare Installations*

- Cold Climates and Remote Locations without Steam



➤ *Typical Air Flare Installations*

- Cold Climates and Remote Locations without Steam



➤ *Typical Air Flare Installations*

- Pipelines

Note: Some pipeline facilities only use flares for planned maintenance and shut them down after use, so there are no continuous flowrates and no continuous purge.



► *Tip Designs*



Triangular Arm



Drilled Spider

► *Tip Designs*



Tube Style



Air Ring



HPAAS

➤ *Typical Air Flare Installations*



-How are flares operated on a normal, day-to-day basis...

➤ *Typical Air Flare Installations*



-How are flares operated on a normal, day-to-day basis...purge only

➤ *Typical Air Flare Installations*

-Are there potential issues with over-aeration...



➤ *Typical Air Flare Installations*



-Are there potential issues with over-aeration... **ABSOLUTELY**

► *Typical Air Flare Installations*



➤ *Options for Blower Turndown*

- One Single Speed Blower
 - No air turndown capability



➤ *Options for Blower Turndown*

- One Two-Speed Blower
 - Turndown to 50% air flowrate



➤ *Options for Blower Turndown*

- One Two-Speed Blower + One Single Speed Blower
 - Turndown to 25% air flowrate



➤ *Options for Blower Turndown*

- One Blower with VIV Damper
 - Turndown ability is situational



➤ *Options for Blower Turndown*

- One Blower with VFD Control
 - Turndown to 4-8% air flowrate



➤ *Options for Blower Turndown*

- One VFD Controlled Blower + One Single Speed Blower
 - Turndown to 2-4% air flowrate





Destruction Efficiency General Discussion

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➤ *Flare Destruction Efficiency – HOT TOPIC*



Flare Destruction Efficiency

➤ *Flare Destruction Efficiency – HOT TOPIC*



Testing

- EPA/EER/CMA
- TCEQ
- Zeeco

Consent Decrees/Fines

Flare Destruction Efficiency

Regulations/Permitting

Product Development

- Flares
- PFTIR / AFTIR
- FLIR



➤ *Flare Destruction Efficiency – Background*

- 1983 – CMA Testing - McDaniel – Steam-Assisted Flare with propylene/N₂
- 1983 – CMA Testing - McDaniel – Air-Assisted Flare with propylene/N₂
- 1984 – Pohl – Pipe flare with propylene/N₂
- 1985 – EPA/EER - Pohl and Soelberg – Steam Assist, Air Assist, High Pressure, Non-Assisted Flares with propane/N₂
- 2010 – TCEQ – University of Texas – Steam-Assist and Air-Assisted Flares – Mix of Propylene, Natural Gas, and Nitrogen
- 2011 – Zeeco – Steam Assisted Flare with Natural Gas and Natural Gas / N₂ Mix



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► *Flare Destruction Efficiency – Background*

- 1983 – CMA Testing - McDaniel – **Air Flare Testing**
 - 4" drilled spider tip
 - 7.5HP Blower
 - Propylene or Propylene diluted with Nitrogen
 - Main Focus was on gas flowrates above purge
 - Large heat release pilots (2 pilots at 226,300 Btu/hr each) may have masked results at low flare gas flowrates.



Typical Drilled Spider Tip

➤ *Flare Destruction Efficiency – Background*

- 2010 – TCEQ – University of Texas – **Air-Assisted Flare**
 - 24" triangular arm style tip
 - Mix of Propylene and Natural Gas diluted with Nitrogen
 - **Primarily focused on higher flowrates ~10-30 times normal purge rate**



Photo and Data from TCEQ Report

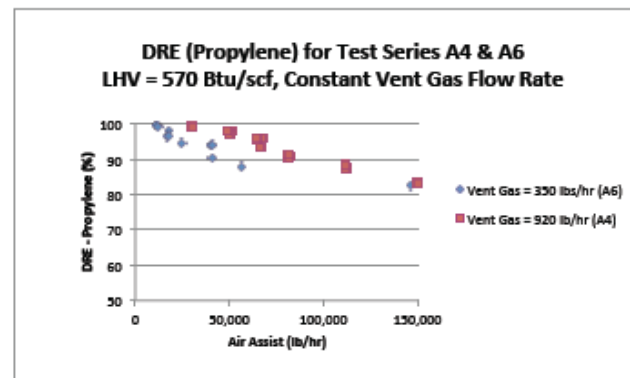


Figure 5-23a. DRE vs Air Assist for Test Series A4 and A6



Typical Triangular Arm Tip

➤ *Previous Testing – What is Missing?*



What about air flares operating at purge rate burning natural gas...

➤ *Previous Testing – What is Missing?*



What about air flares operating at purge rate burning natural gas...where has this been tested?

➤ *Previous Testing – What is Missing?*



What about air flares operating at purge rate burning natural gas...where has this been tested? Nowhere!!!!



Zeeco Air Flare Destruction Efficiency Testing and Results

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➤ *Zeeco Testing - Goals*

- Fill in the gaps from previous tests.
- Better understand impact of blower turndown options.
- Operating guidelines for high DRE

► Zeeco Testing - Setup



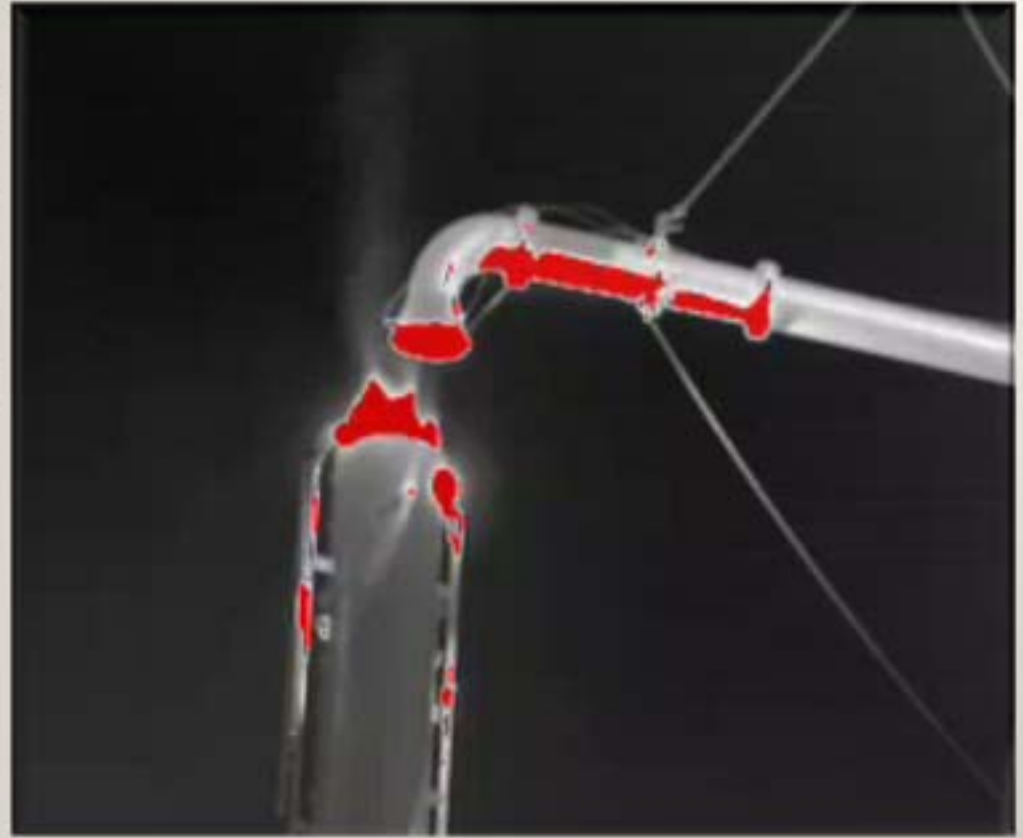
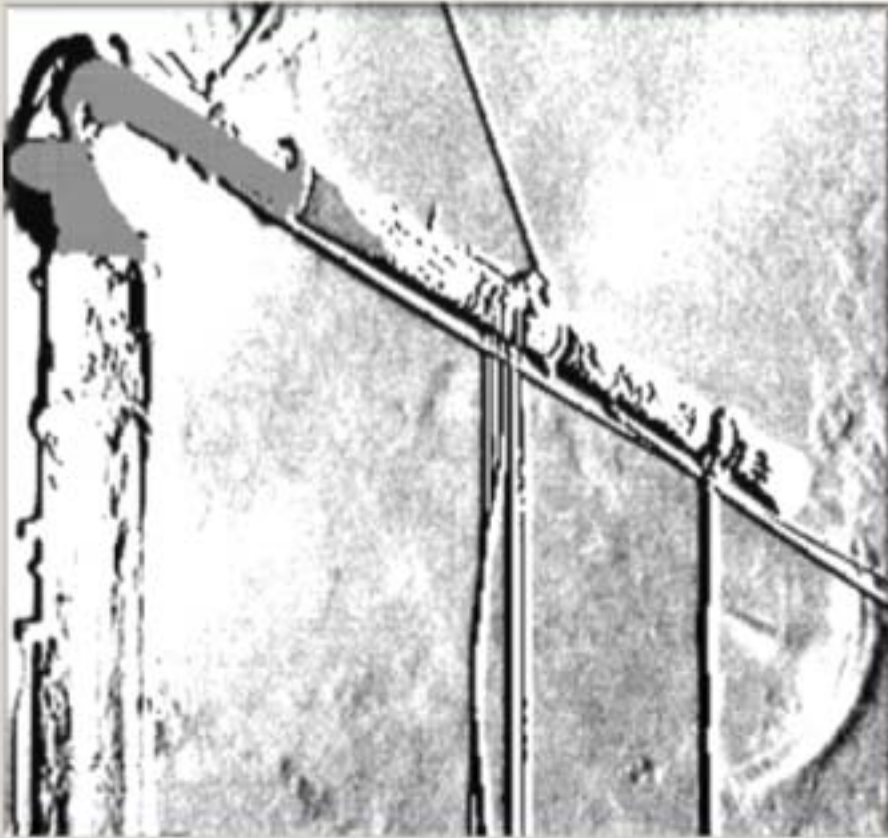
Air Velocity Plot



➤ *Zeeco Testing - Setup*



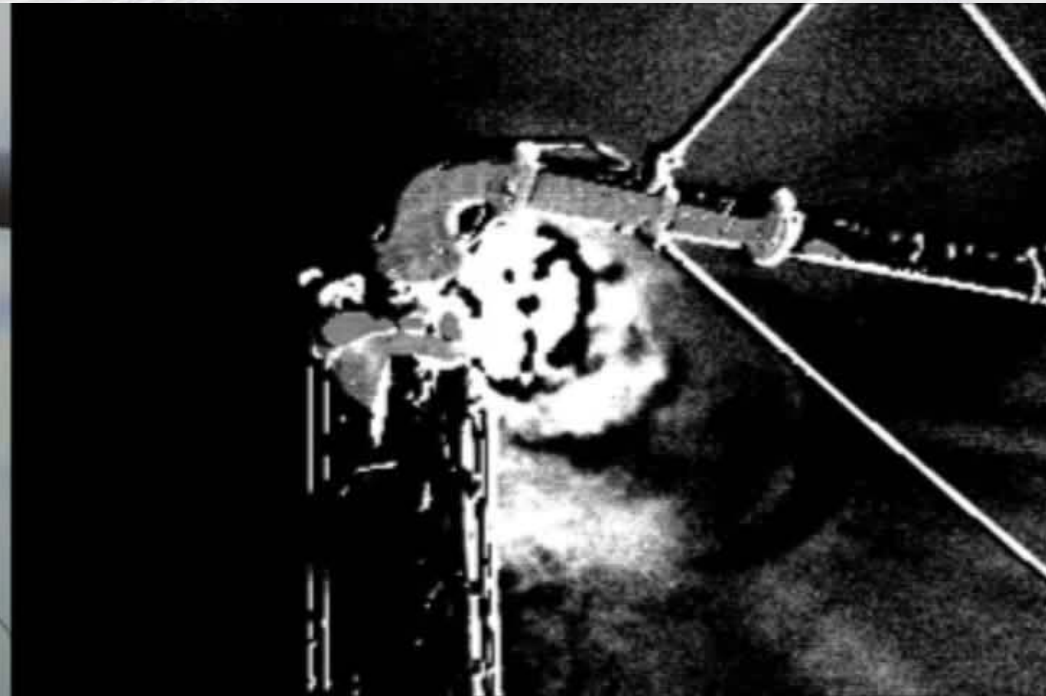
➤ *Zeeco Testing - Setup*



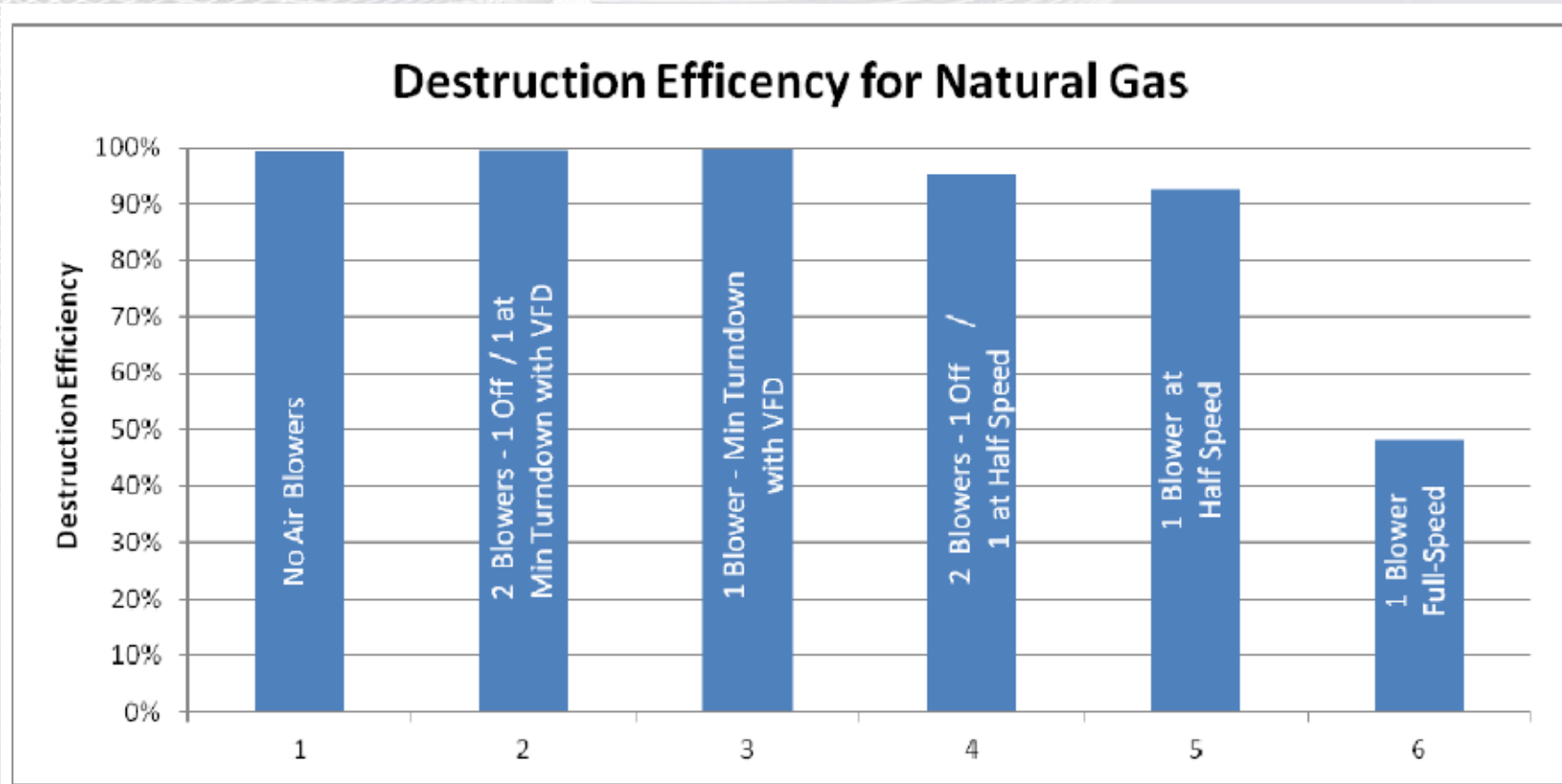
► *Zeeco Testing – Completed in June 2013*



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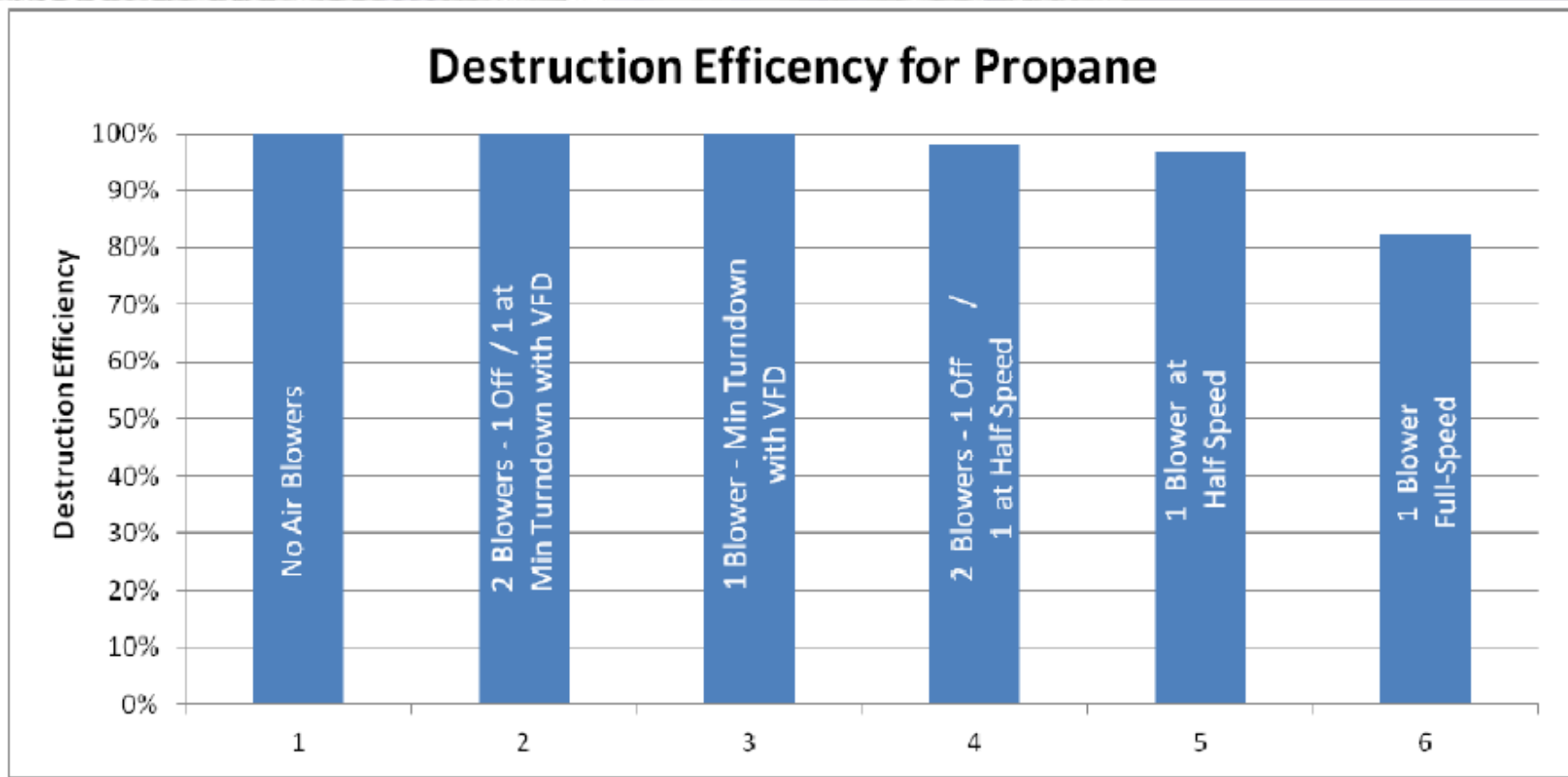


➤ Zeeco Testing – Results



Purge Rate Destruction Efficiency - Example

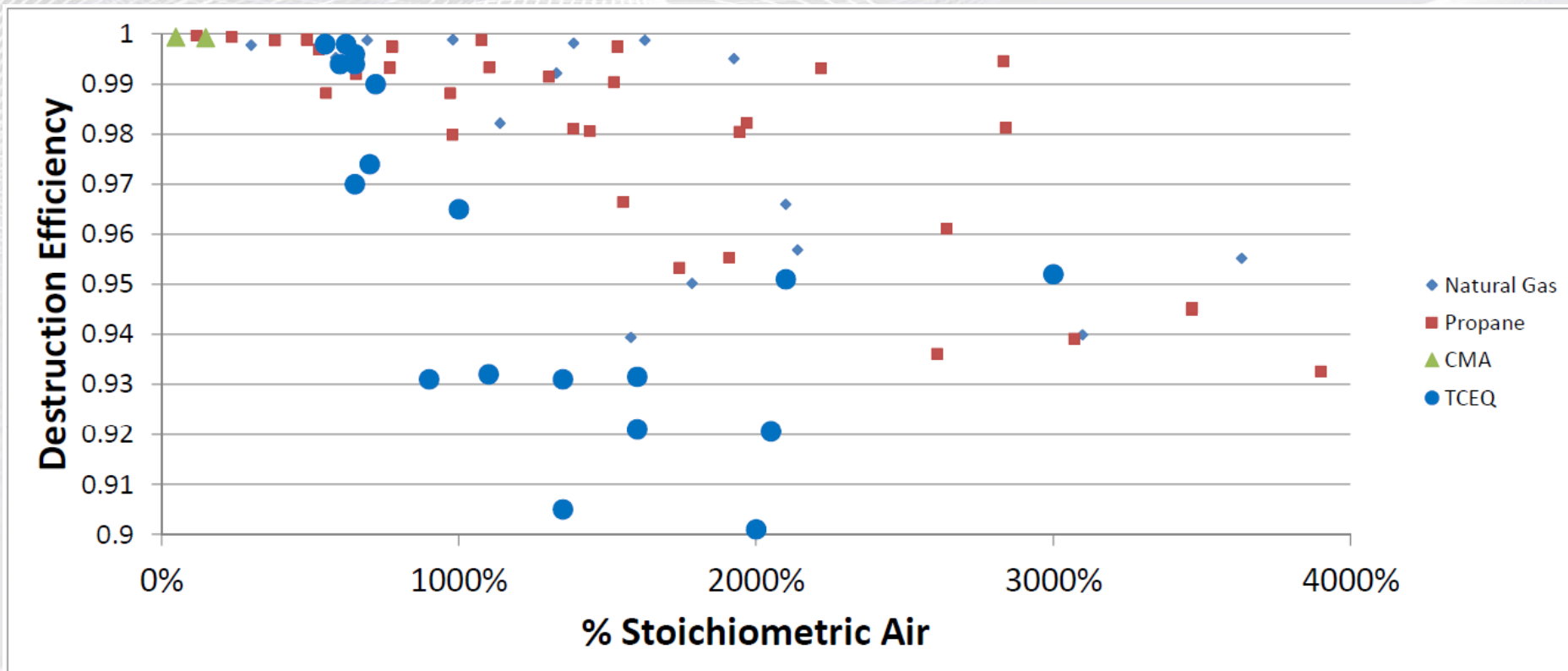
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Purge Rate Destruction Efficiency - Example

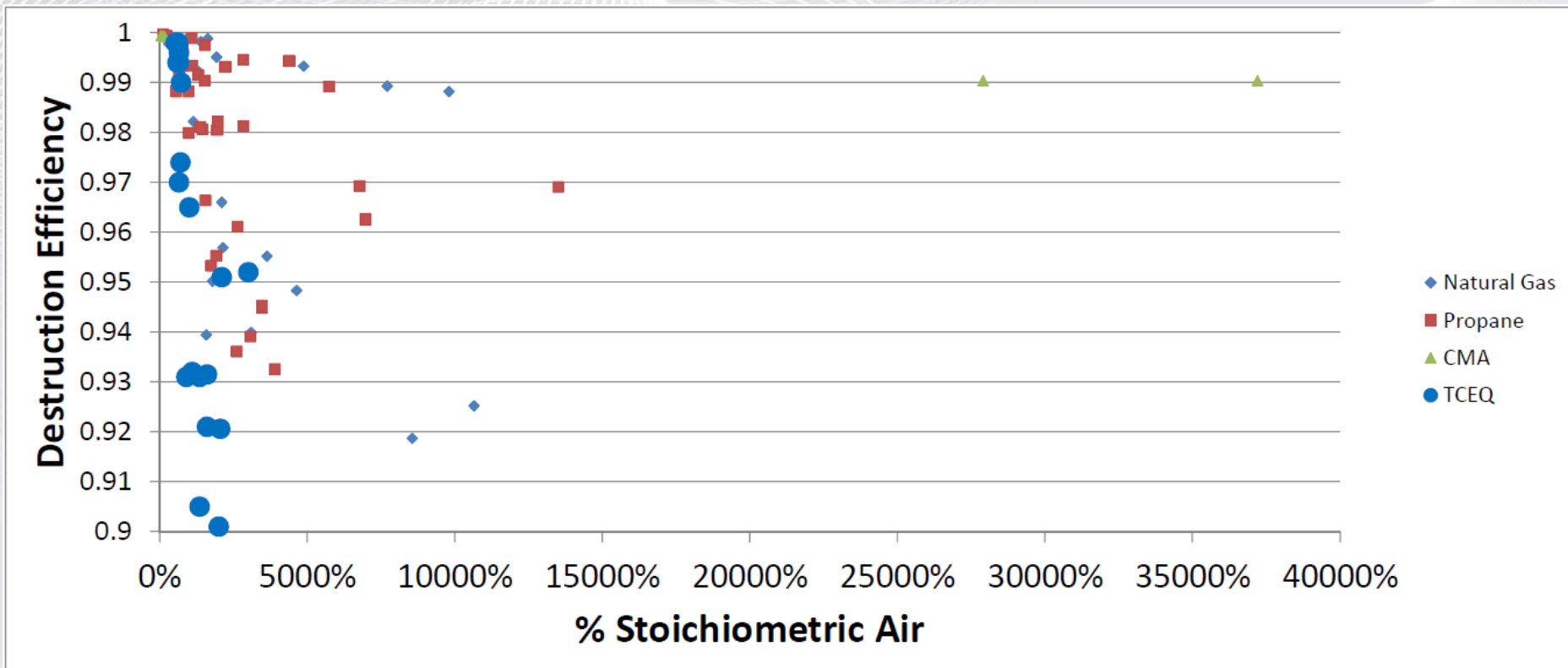
➤ *Zeeco Testing – Results*

- Can we reliably use % Stoichiometric Air?



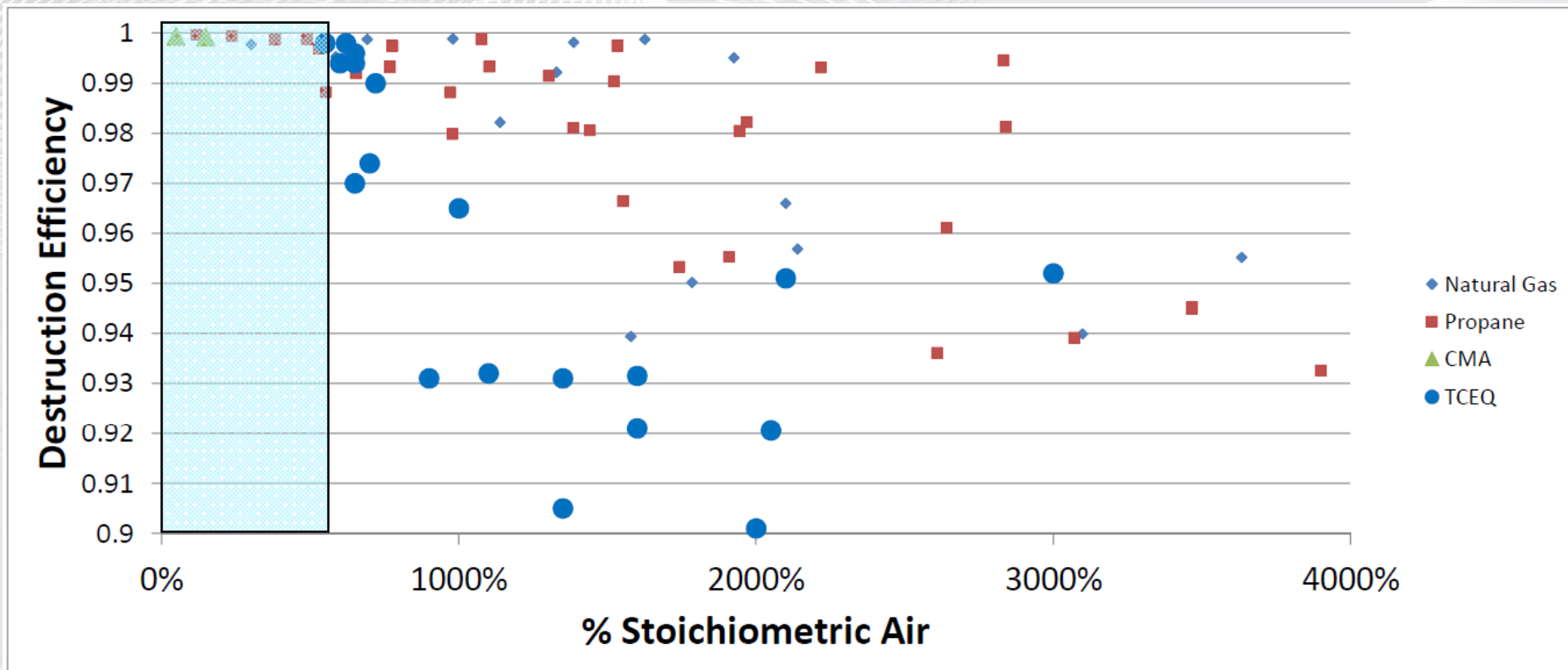
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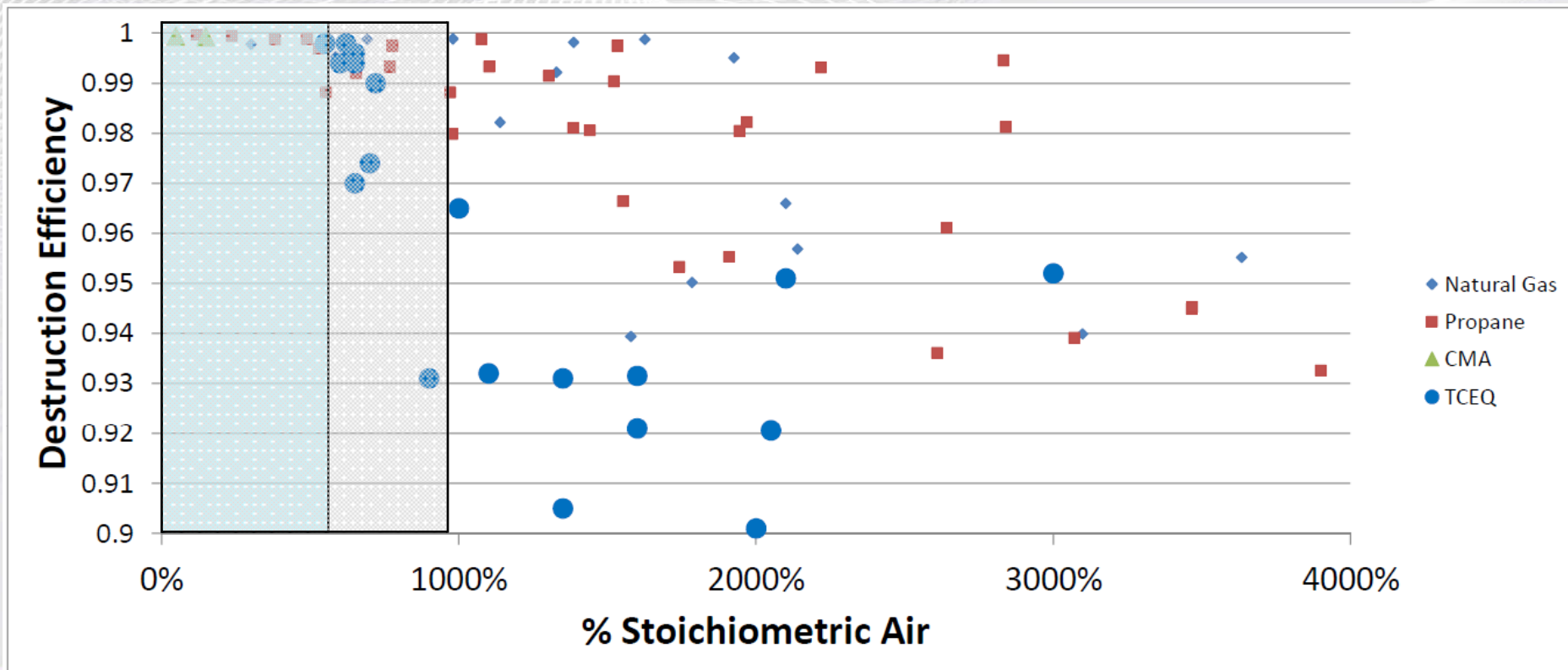
➤ *Zeeco Testing – Results*

- Where do you draw the line? 600%



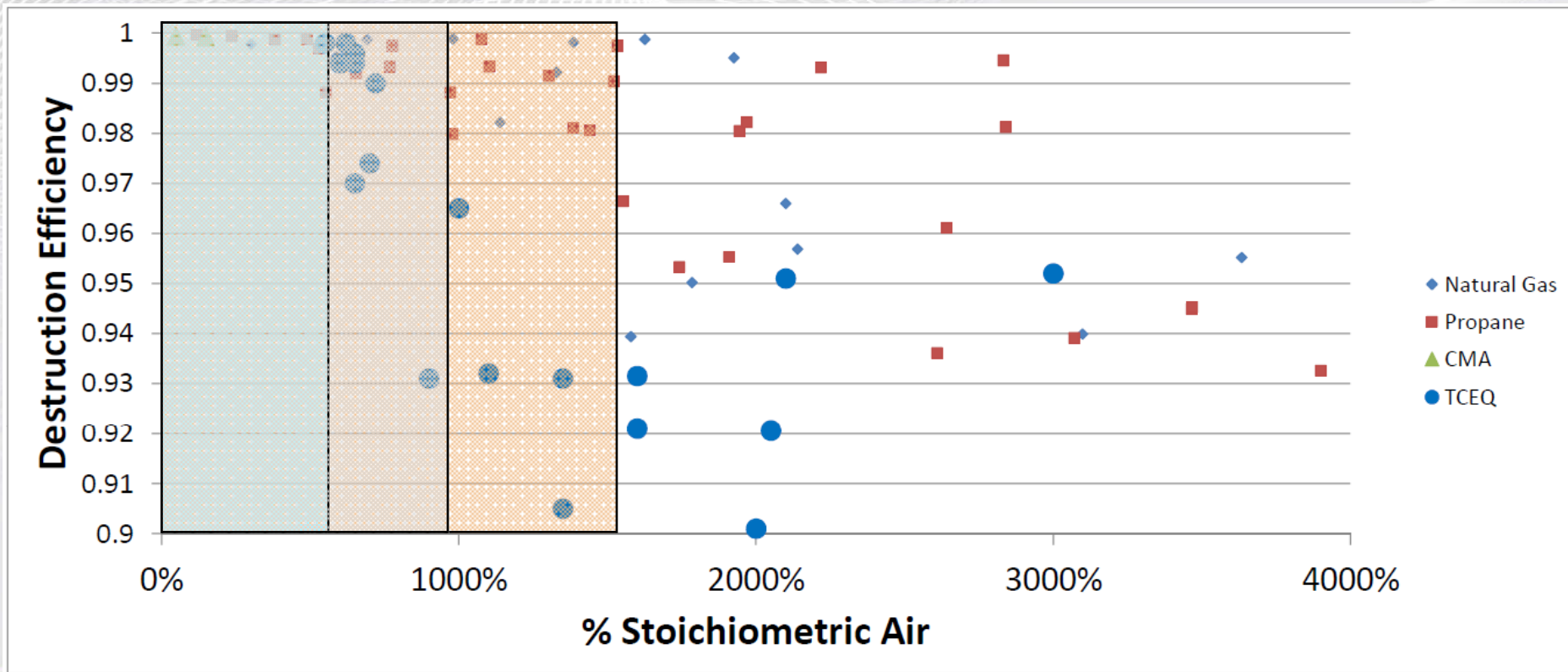
➤ *Zeeco Testing – Results*

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➤ Zeeco Testing – Results

- Where do you draw the line? 600%950%1500% ???



➤ *Zeeco Testing – Results*

- What about Combustion Zone Net Heating Value (CZNHV)?



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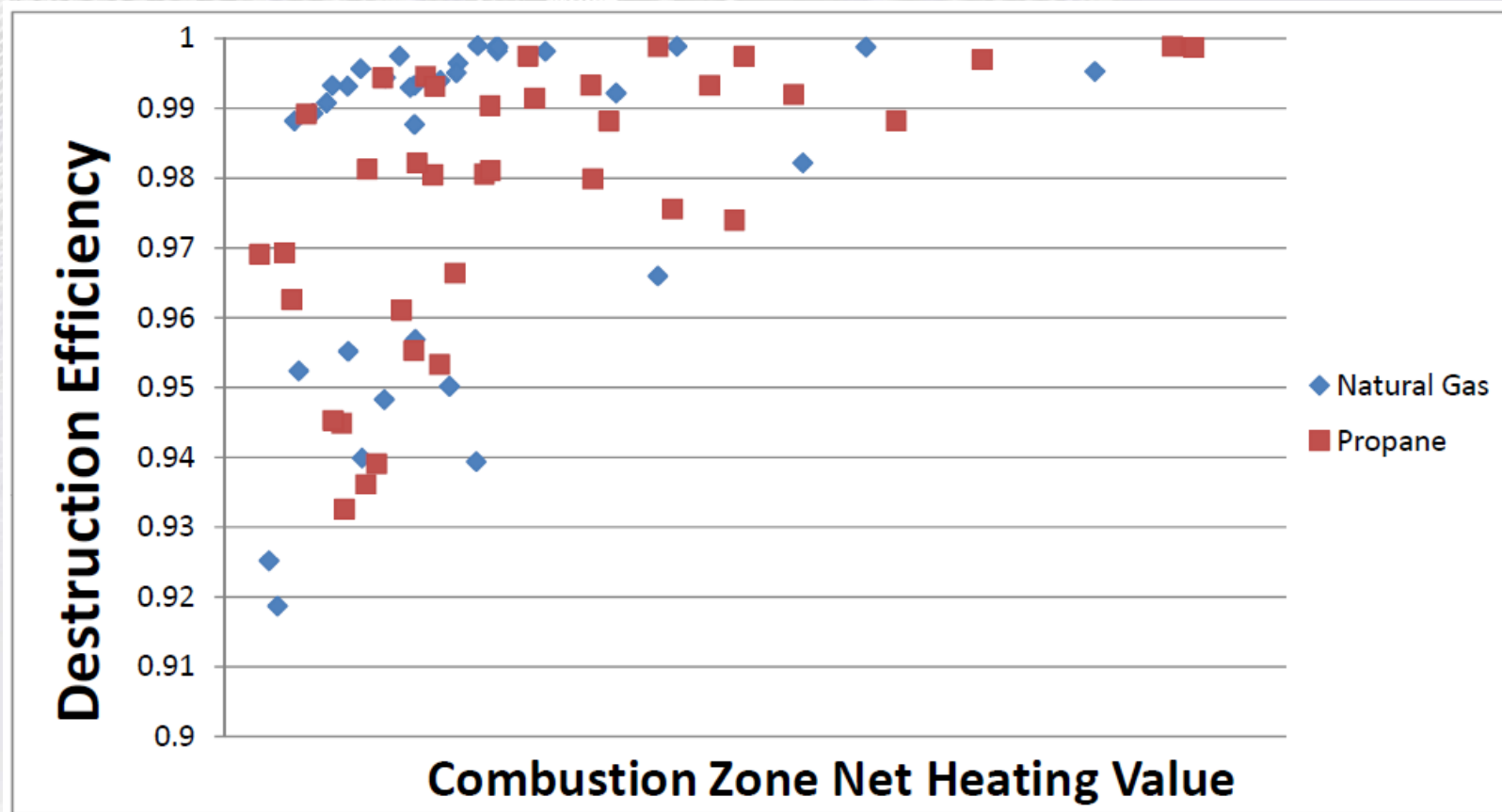
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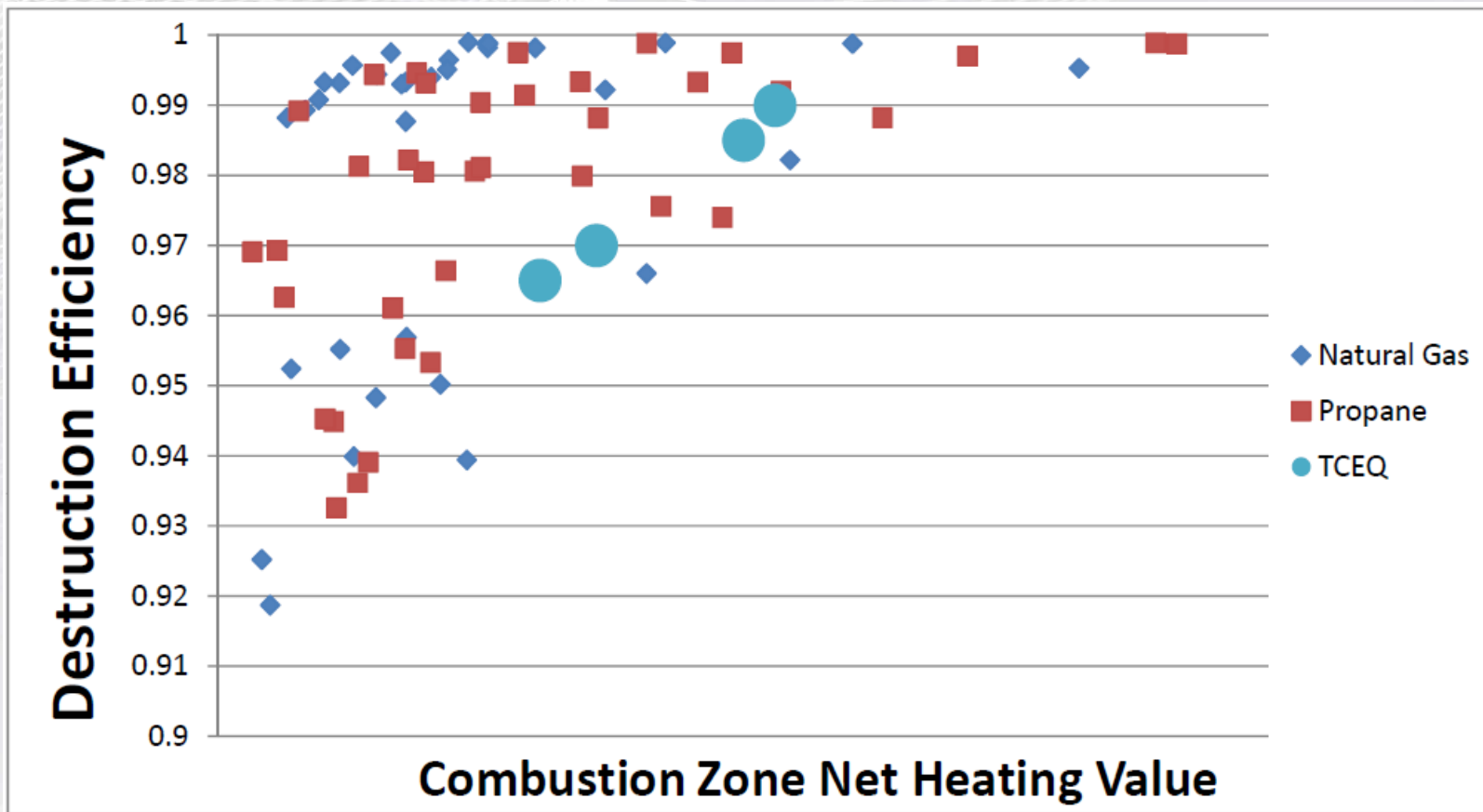
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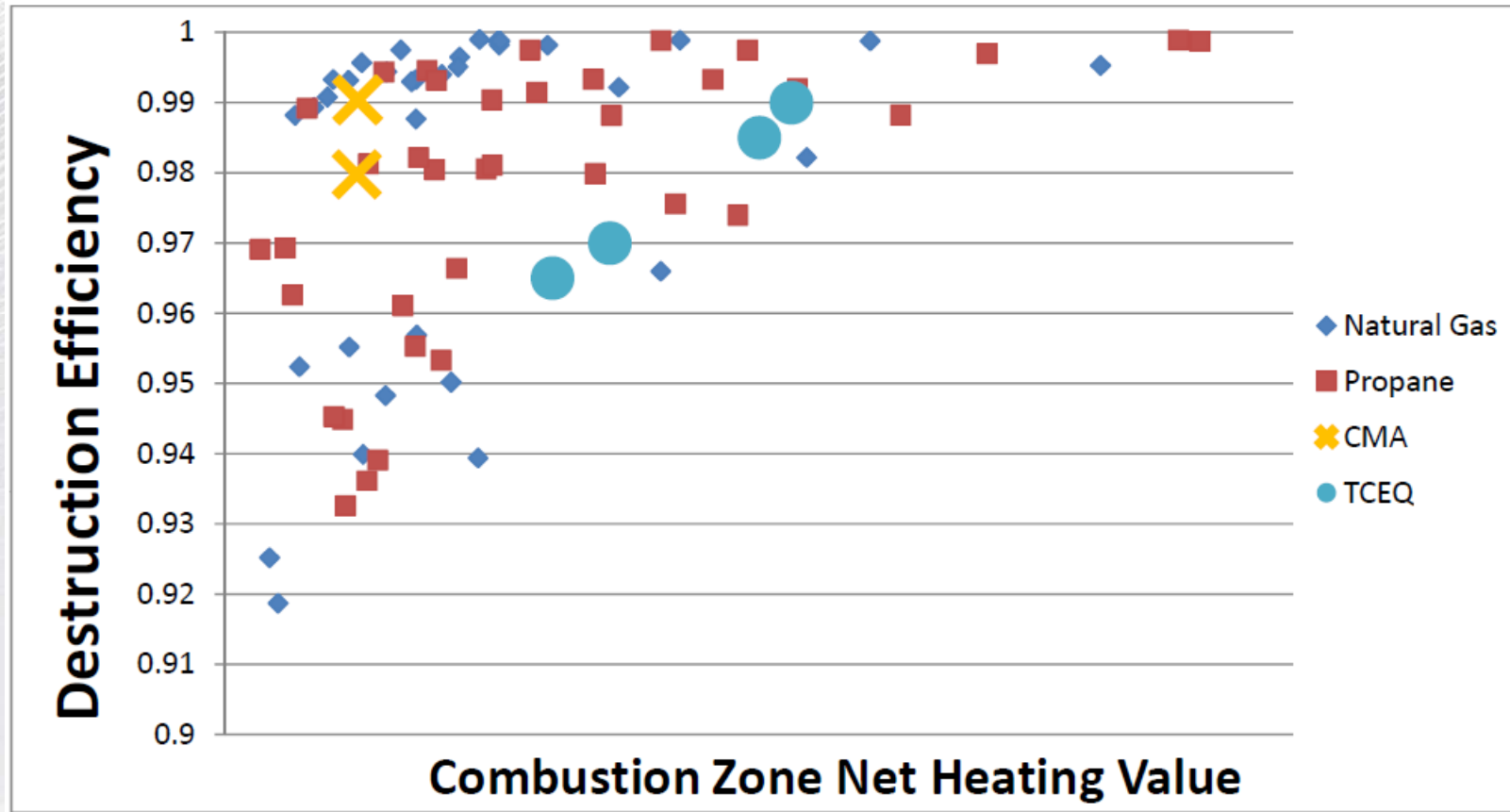
➤ Zeeco Testing – CZNHV Results



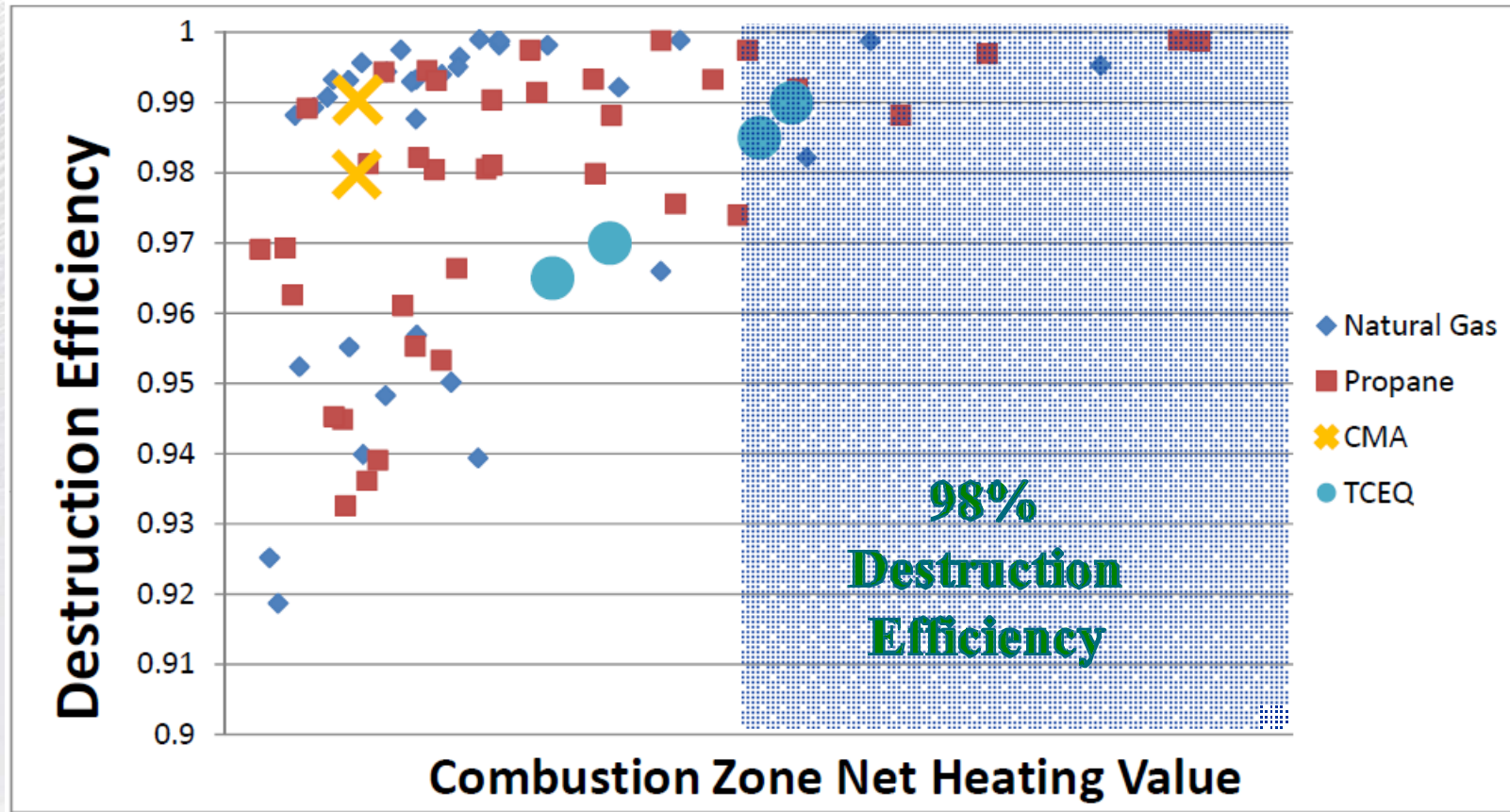
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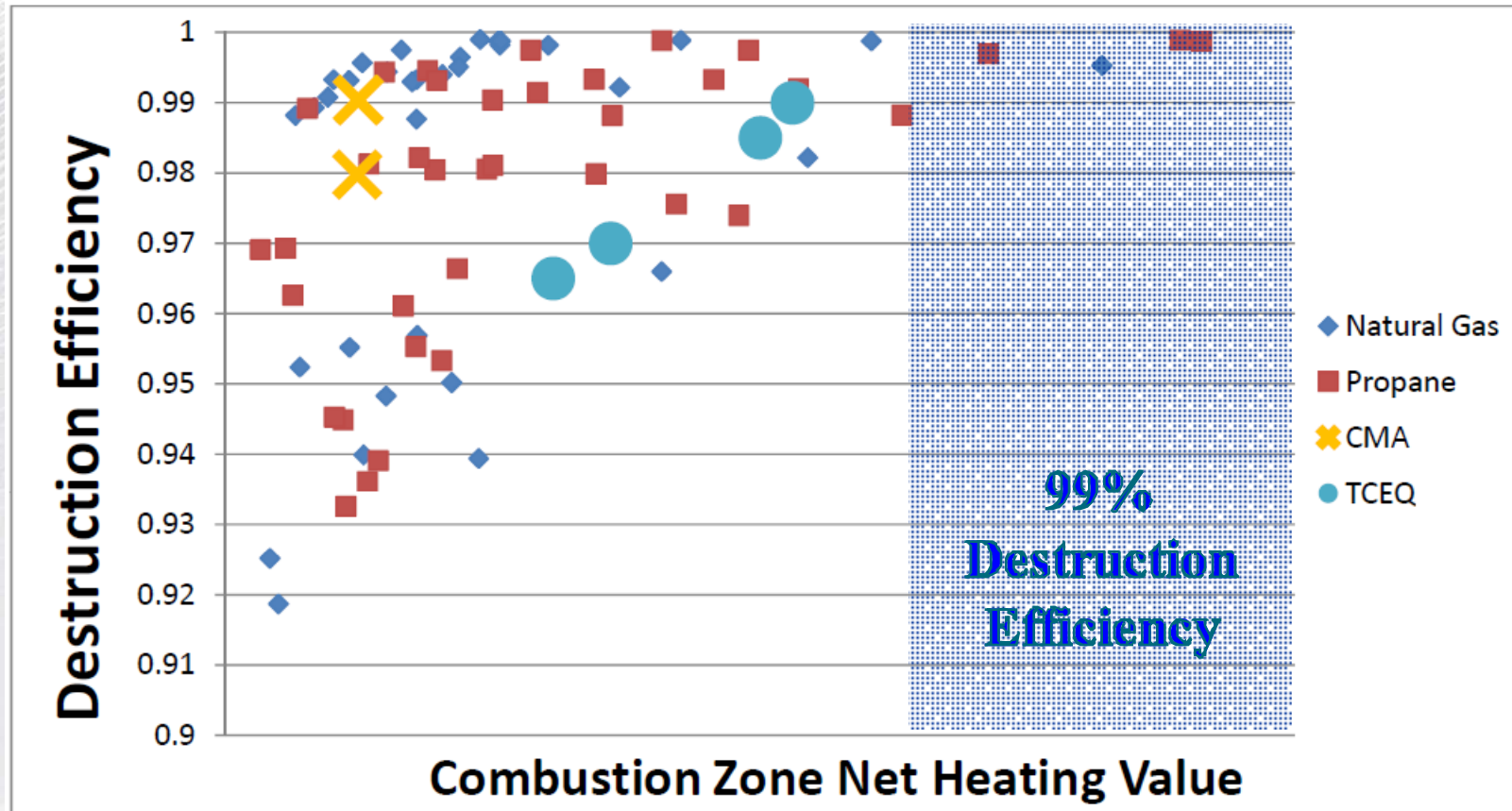
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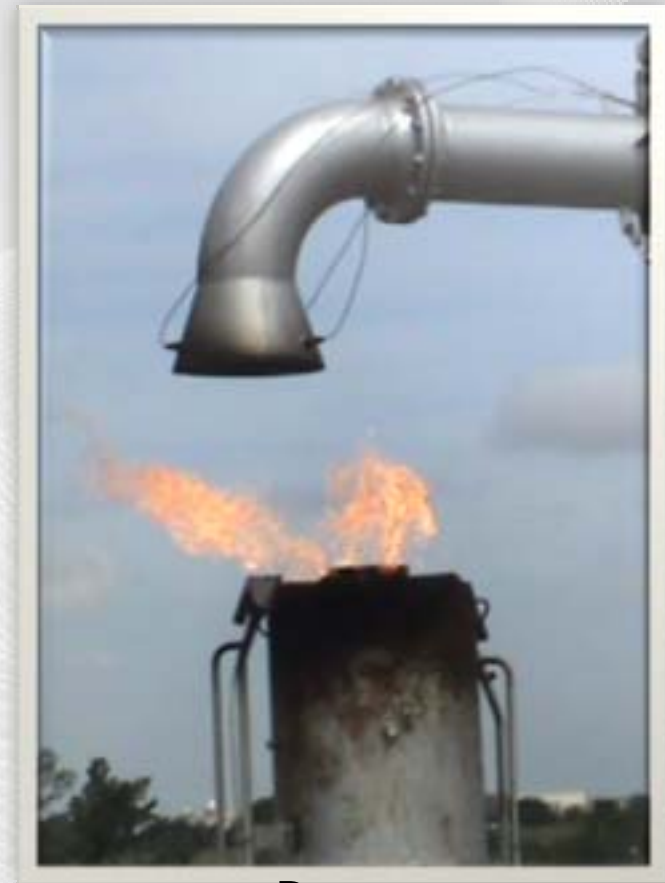


► *Why CZNHV Instead of %SA?????*

- Gas Stability
- Pilot Impact



Natural Gas



Propane



Air Flare Operating Recommendations

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➤ *Recommendations*

■ Design Recommendations:

- Design Blower Arrangement to Allow Adequate Turndown
- Check to ensure that the combination of the purge rate, pilot quantity / heat release, and blower turndown flowrate will stay above the minimum recommended CZNHV

➤ *Recommendations*

- Operating Recommendations:
 - Try to maintain visible flame



Too Much Air



Questionable



Ideal

➤ *Recommendations*

- Operating Recommendations:
 - Try to stay just beyond incipient smoking point
 - Avoid unsteady rumbling.





➤ *Recommendations*

- Modifications for Existing Flares Operating Below Recommended CZNHV:
 - Increase purge gas rate, or use purge gas with a higher heating value
 - Use a VFD
 - Add a variable inlet damper
 - Systems with very large air blowers → add a small dedicated blower for purge rates



➤ Conclusion

- Properly designed/operated air-assisted flares can achieve hydrocarbon destruction efficiencies exceeding 99%.
- Combustion Zone Net Heating Value (CZNHV) is likely the most accurate parameter for ensuring high flare destruction efficiency of air-assisted flares.
- Zeeco testing affirms that properly designed air-assisted flares can be used to reduce hydrocarbon and VOC emissions at facilities by achieving high destruction efficiency.
- Smoking flares can have equal or higher destruction efficiency than non-smoking flares, achieving destruction efficiencies of 99% or higher.



► Contact Information

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Questions???



Thank You!!!

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