2011 AFRC Industrial Flares Colloquium
Houston, TX

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COMBUSTION AND ENVIRONMENTAL SOLUTIONS.
PURE AND SIMPLE.®


BURNERS


FLARES


INCINERATORS


PARTS & SERVICES

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Company Profile

- Incorporated in 1979
- 250-acre facility located in Broken Arrow, OK
- Specialists in the design and manufacturing of combustion equipment

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Zeeco Product Lines

Industrial Burners

Flare Systems

Incineration Systems

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Background

- Flare testing conducted by TCEQ and The University of Texas
  - Determined how air assisted and steam assisted flares perform at turndown rates
  - Suggested that incorrectly designed or operated flares may reduce the Destruction and Removal Efficiency (DRE) of flares
- Zeeco testing
  - Performed testing of steam assisted flares to compliment TCEQ tests
  - Zeeco focused on API recommended purge rates

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Testing Instrumentation & Setup

- Performed at Zeeco Combustion Research & Test Facility in Broken Arrow, OK

- Equipment
  - 36” Steam Assisted Flare Tip
    - QFSC Steam Assisted Tip
    - UFSC Steam Assisted Flare Tip
  - Temperature elements positioned on flare tip

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Testing Instrumentation & Setup

- Sample induction probe
  - Inductor
  - Flow conditioner
  - Thermocouples at probe inlet

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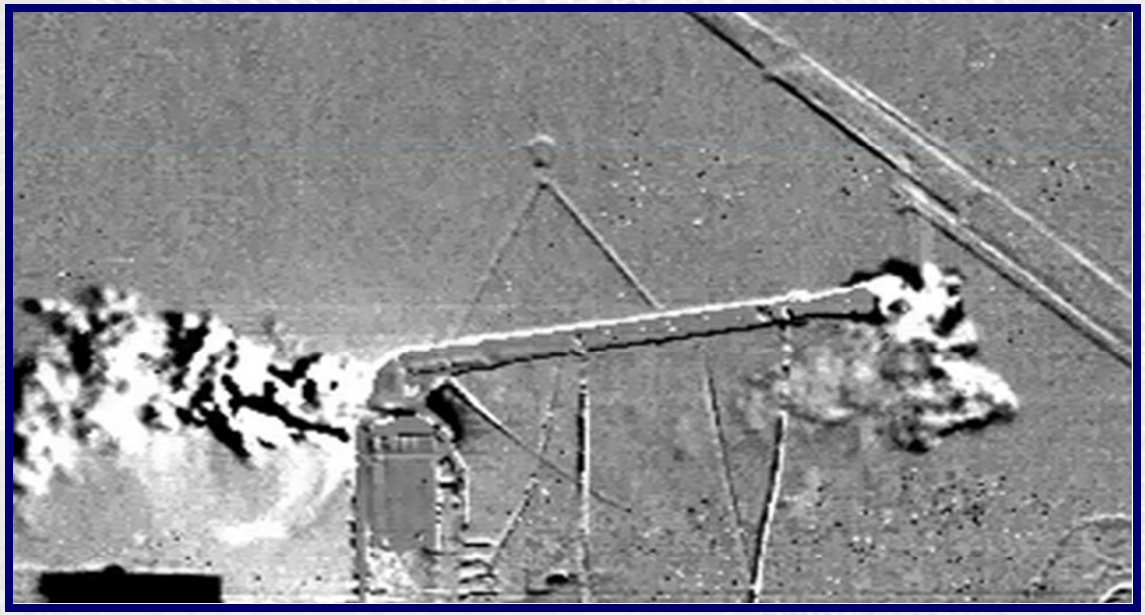
Testing Instrumentation & Setup

- LSI FLIR GasFindIR camera
- *Air Hygiene* emissions testing service
- Miscellaneous equipment
  - Video camera
  - Still camera



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Testing

- Phase 1- Test API recommended purge rates with steam operating at cooling rates
  - Three purge rates tested
    - Velocity Seal purge rates
    - Gas Seal purge rates
    - No Seal purge rates

	Velocity Seal	Gas Seal	No Seal
Purge Gas	NG	NG	NG
Purge Rate (SCFH)	990	250	1992

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Testing

- Three steam assist methods were tested for each purge rate
  - Center steam only
  - Upper steam only
  - Combined upper and center steam

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Testing

- Phase 2- Building a Hypothesis
  - Set steam rates and adjusted gas flow to achieve a high destruction efficiency
  - Set purge rates and adjusted center, upper, and combined steam flow rates to achieve a high destruction efficiency
    - The steam flow was turned down as low as reasonably possible without condensing
- A trend developed between the DRE and the LHV of the combined steam and gas stream

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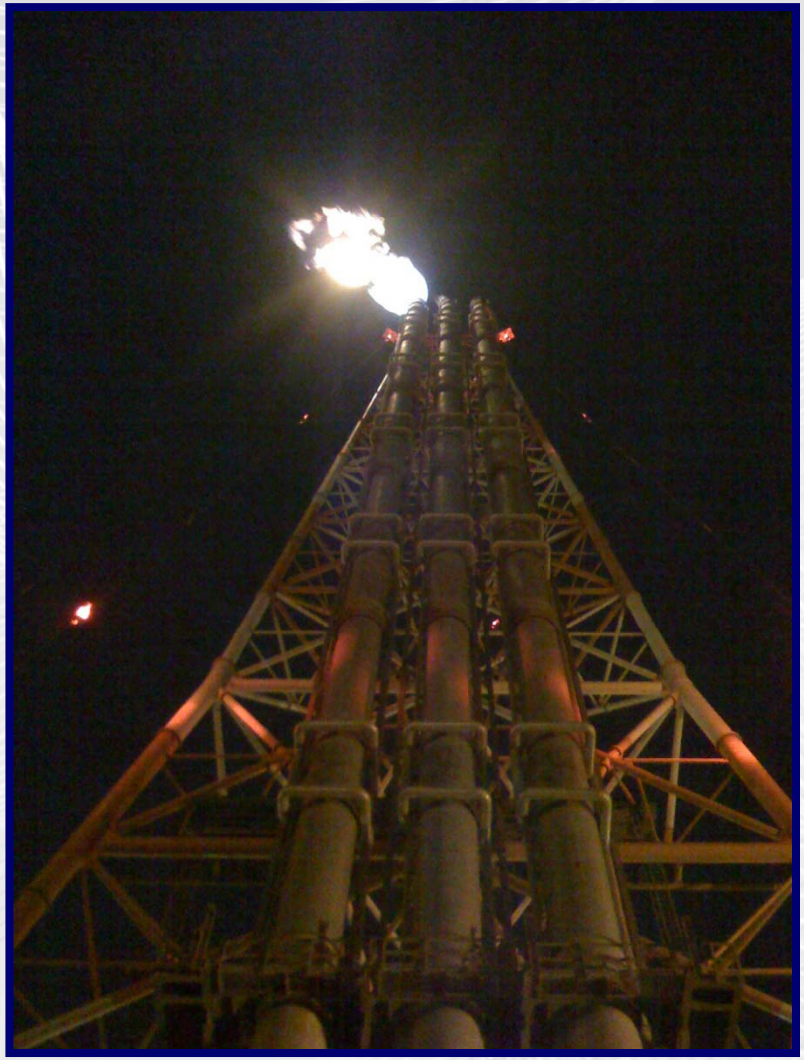
Testing

- Phase 3- Verify Hypothesis
  - Test points selected to produce a combined stream LHV, which achieved a 98% destruction efficiency



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Results

- Destruction Removal Efficiency (DRE) evaluation
  - CO, CO_2, NO_x, and total hydrocarbons were measured
  - The DRE calculations are based on the measured values and carbon balance accounts for the percentage of plume captured

$$DRE = 1 - \frac{total\ mol\ THC_{out}}{mol\ THC_{in}}$$

$$= 1 - \frac{mol\ \ THC_{out} measured}{(\%\ of\ C\ in\ plume) mol\ THC_{in}}$$

DRE = destruction and removal efficiency

mol THC_{out} measured = total mol hydrocarbons measured in the plume sample

mol THC_{in} measured = total mol hydrocarbons measured entering the flare

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Results

- Summary
  - Testing indicated that the DRE is impaired by cooling steam while operating at API recommended purge rates
  - Strong correlation between the DRE and the LHV of the combined gas and steam rates
  - The addition of center steam resulted in the largest reduction of DRE

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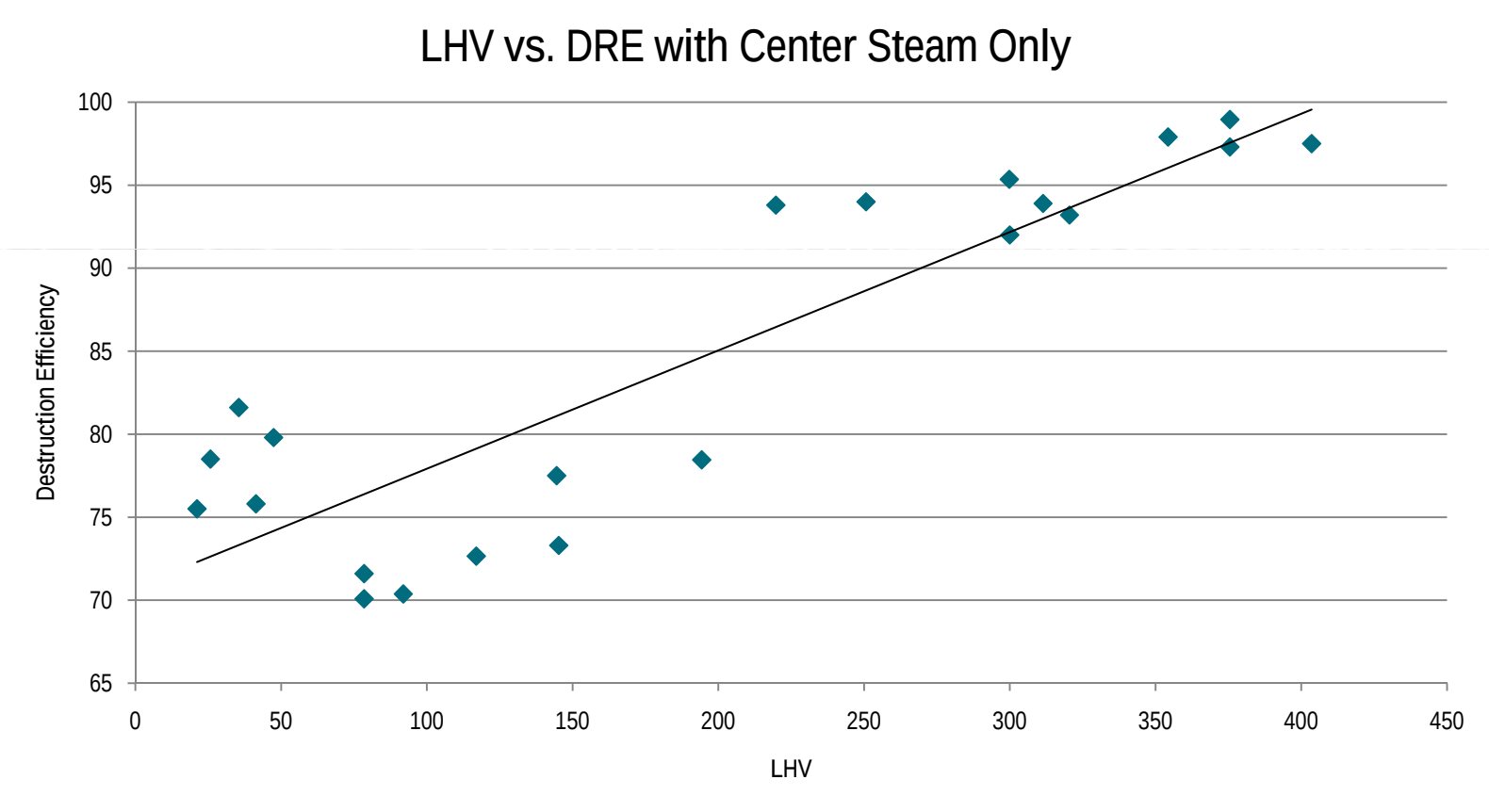
Results

- Combined LHV vs. DRE with Center Steam Only



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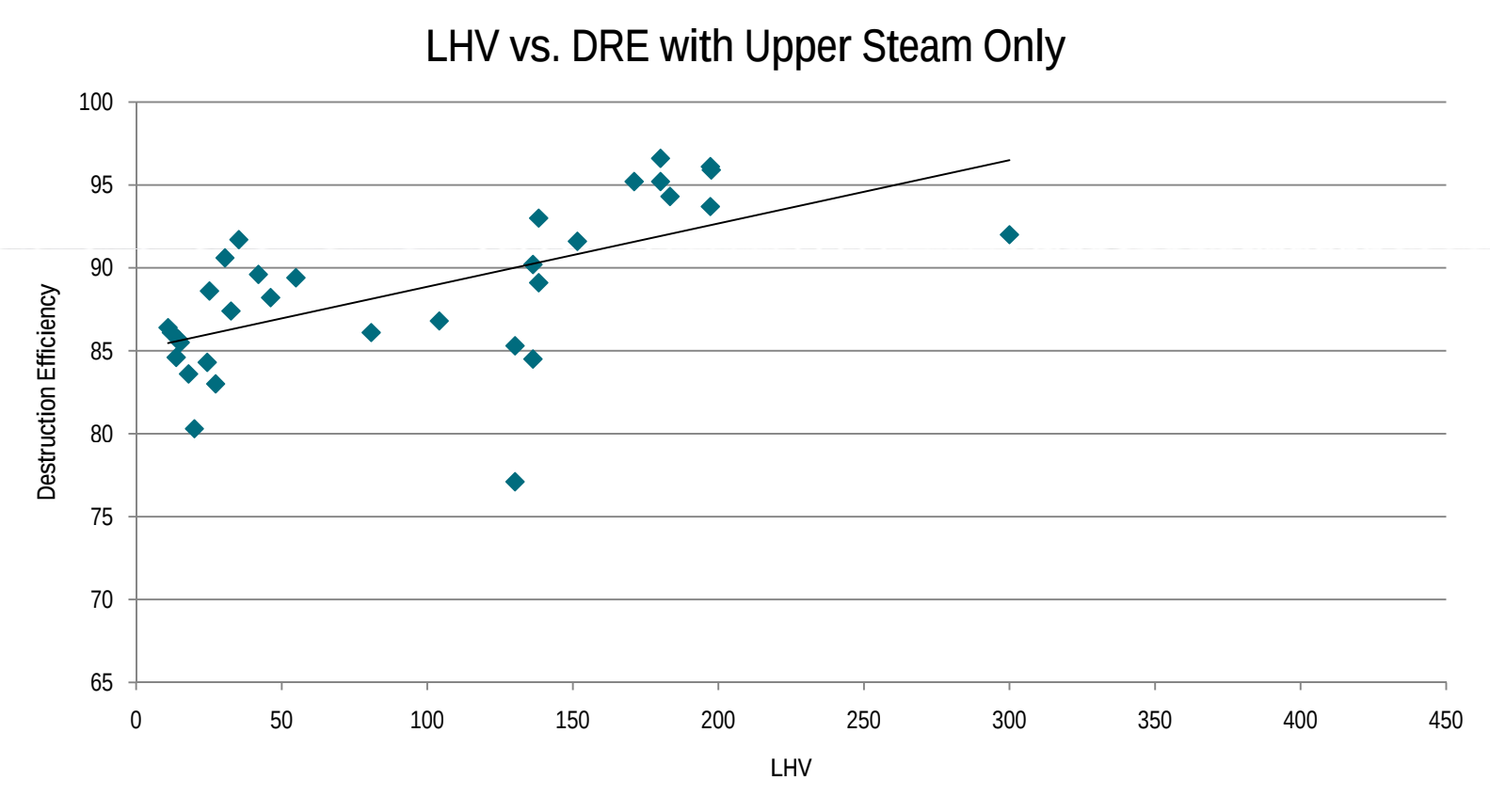
Results

- Combined LHV vs. DRE with Upper Steam Only



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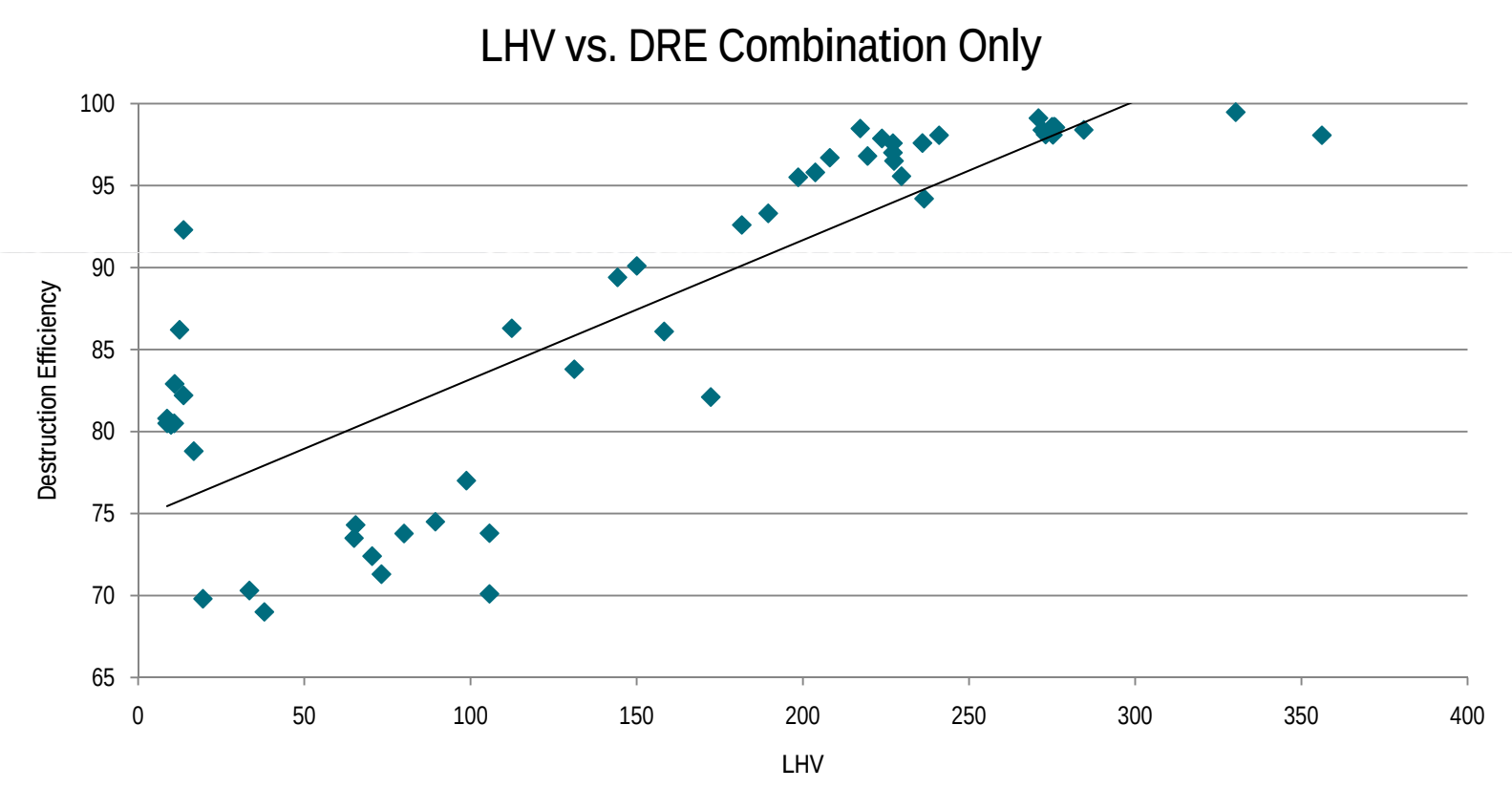
Results

- Combined LHV vs. DRE with Upper & Center Steam



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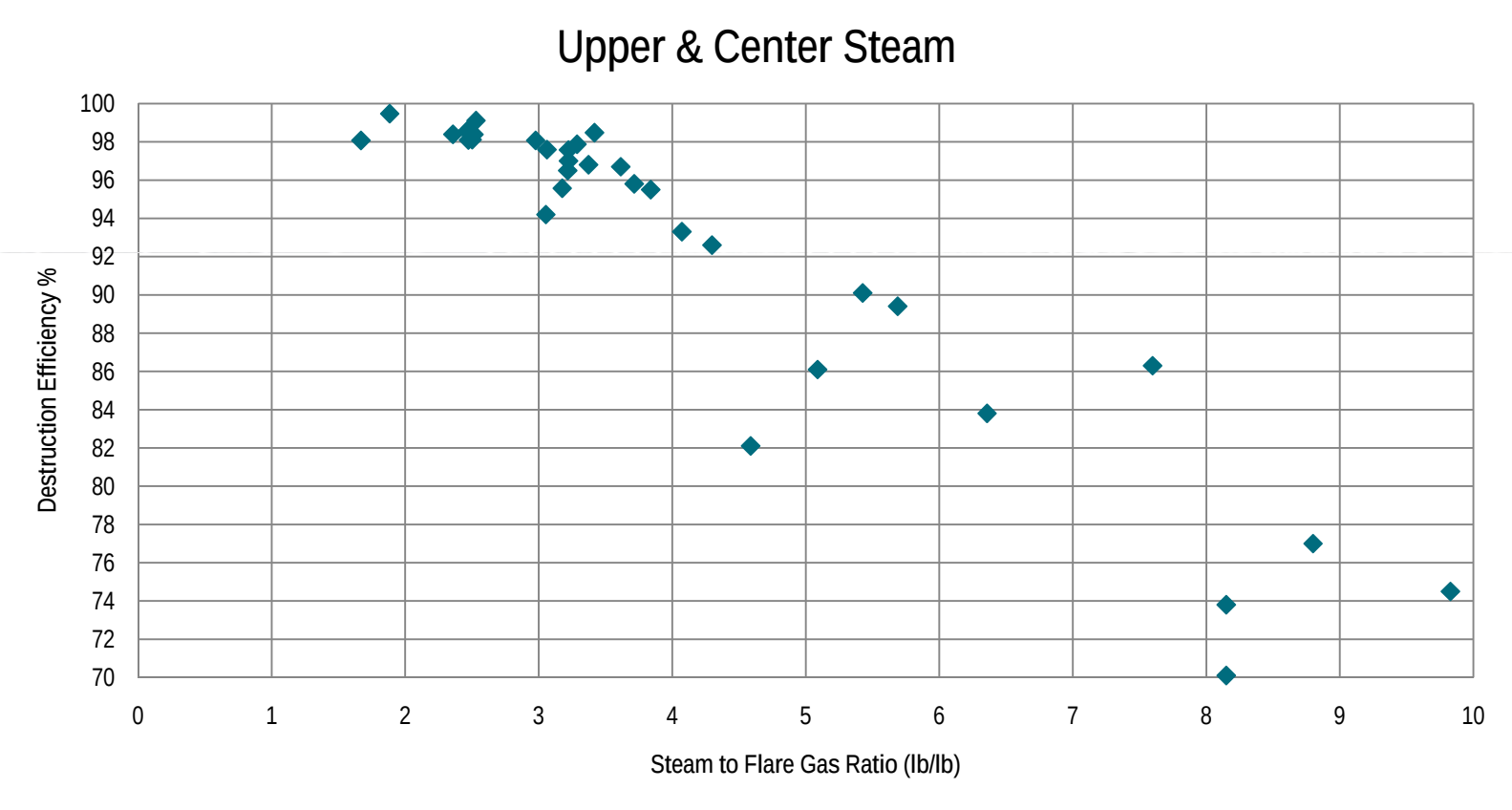
Results

- Steam to Gas Ratio vs. DRE with Upper & Center Steam



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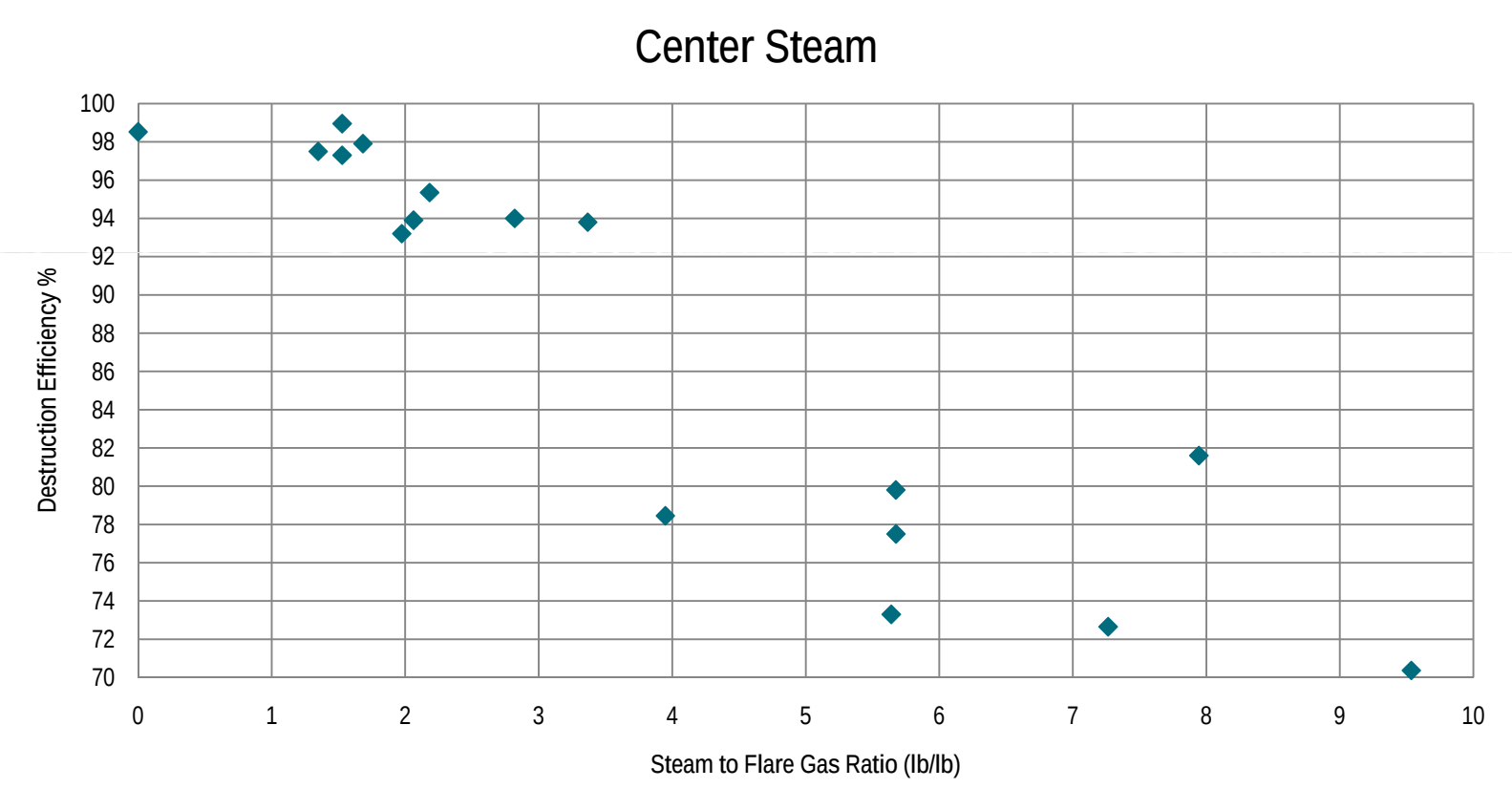
Results

- Steam to Gas Ratio vs. DRE with Center Steam



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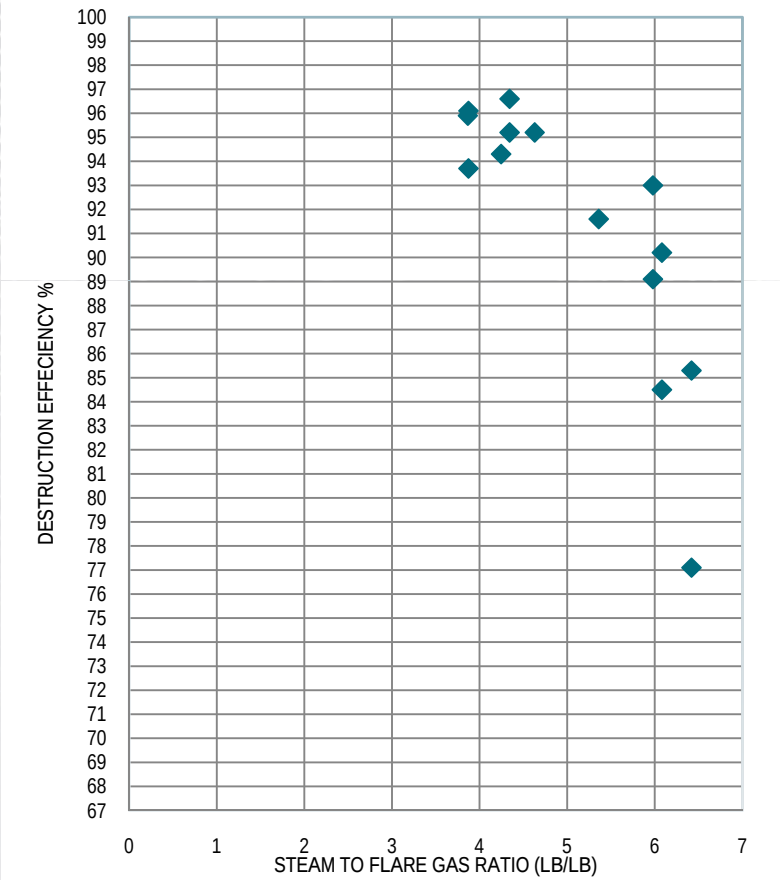
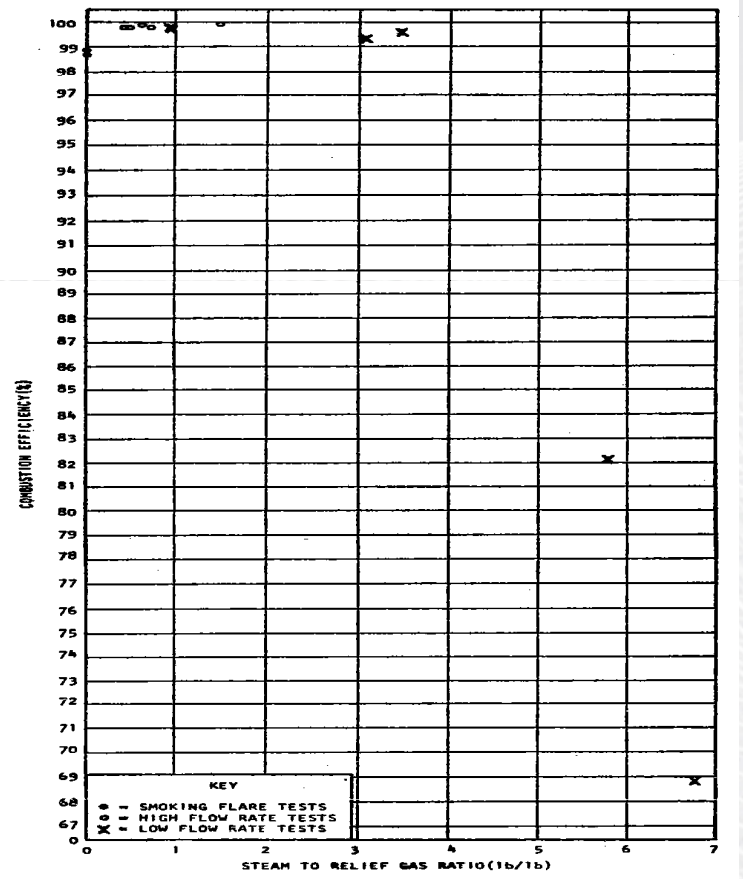
Results

- Steam to Gas Ratio vs. DRE with Upper Steam



Zeeco Testing with Natural Gas (914 TU/SCF)



CMA Testing with Propylene (2183 BTU/SCF)

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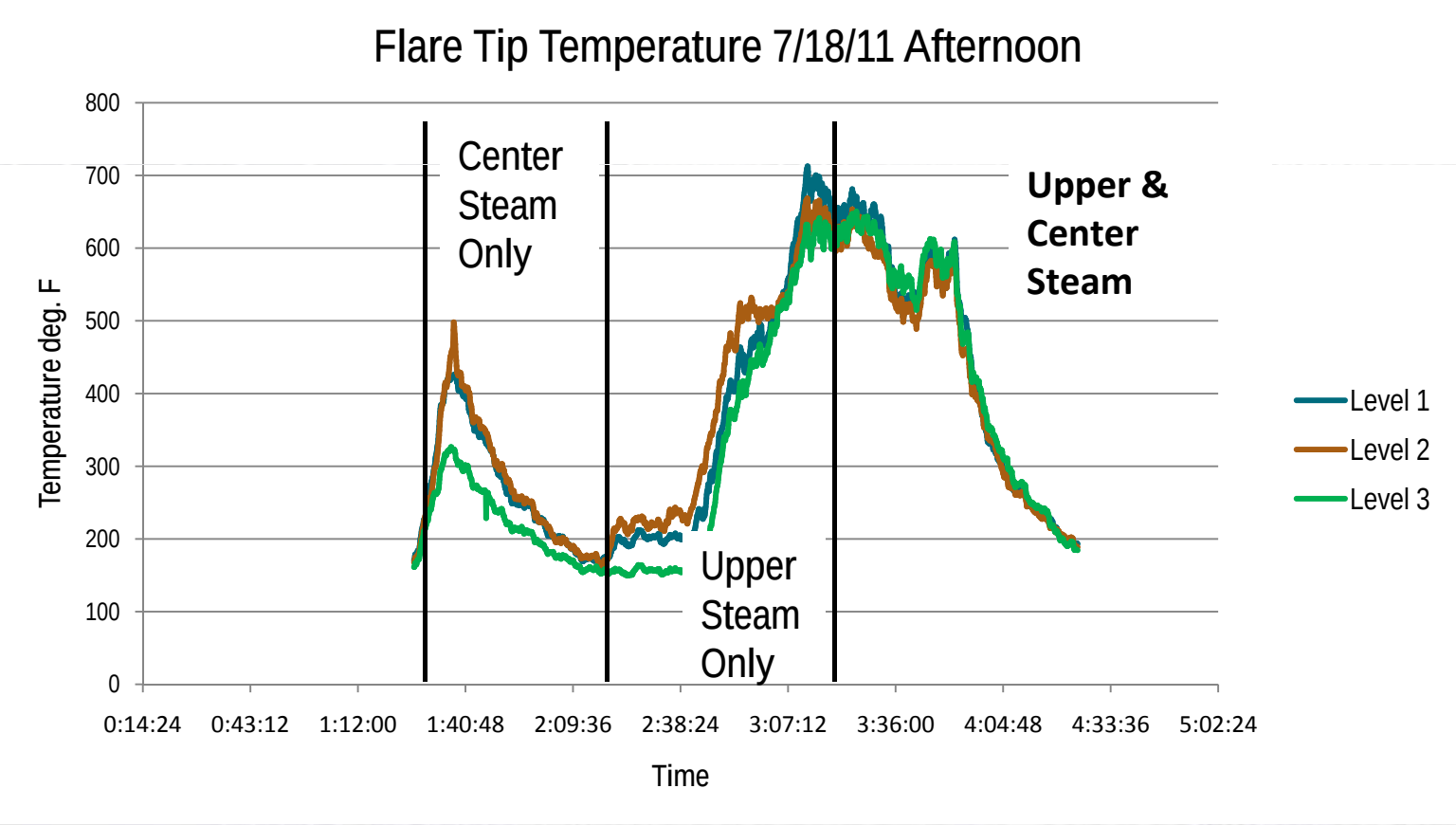
Results

- Thermocouple evaluation
  - Center Steam is used as an effective means for cooling the flare tip



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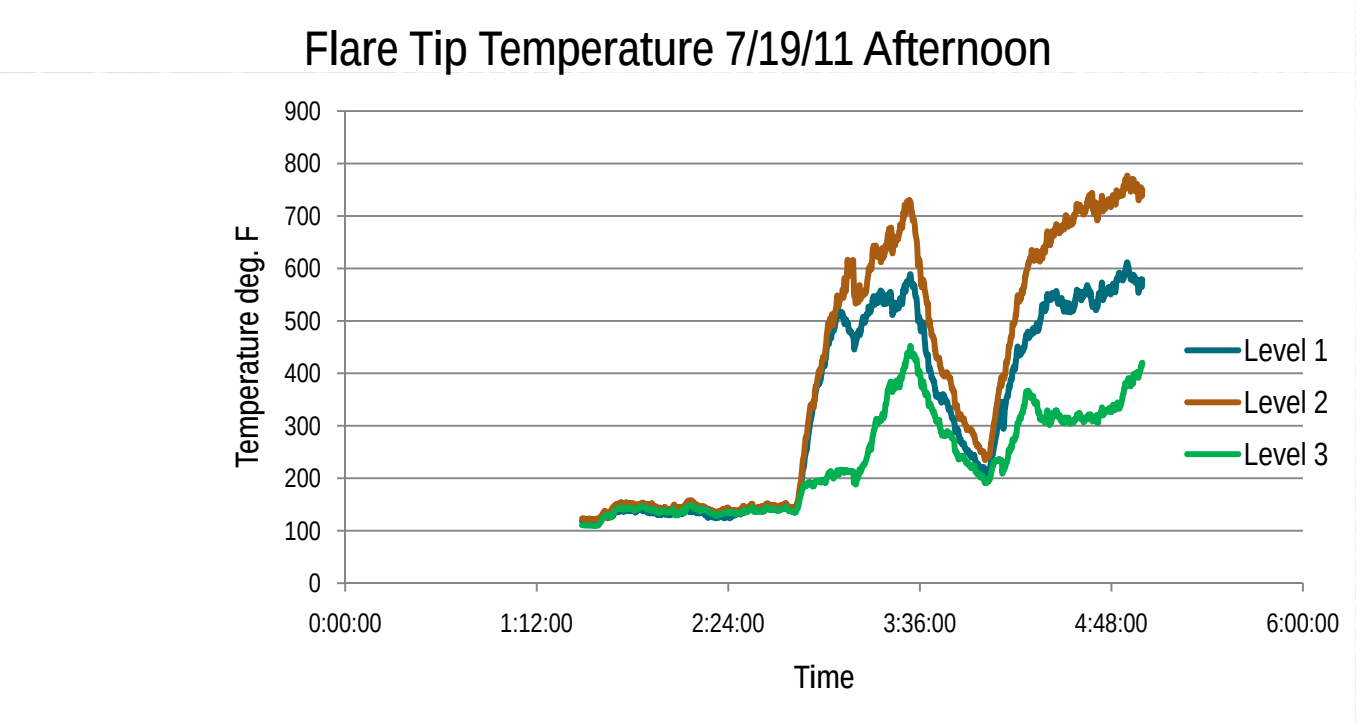
Results

- Thermocouple evaluation continued
  - At low center steam rates, burning was found within the flare tip



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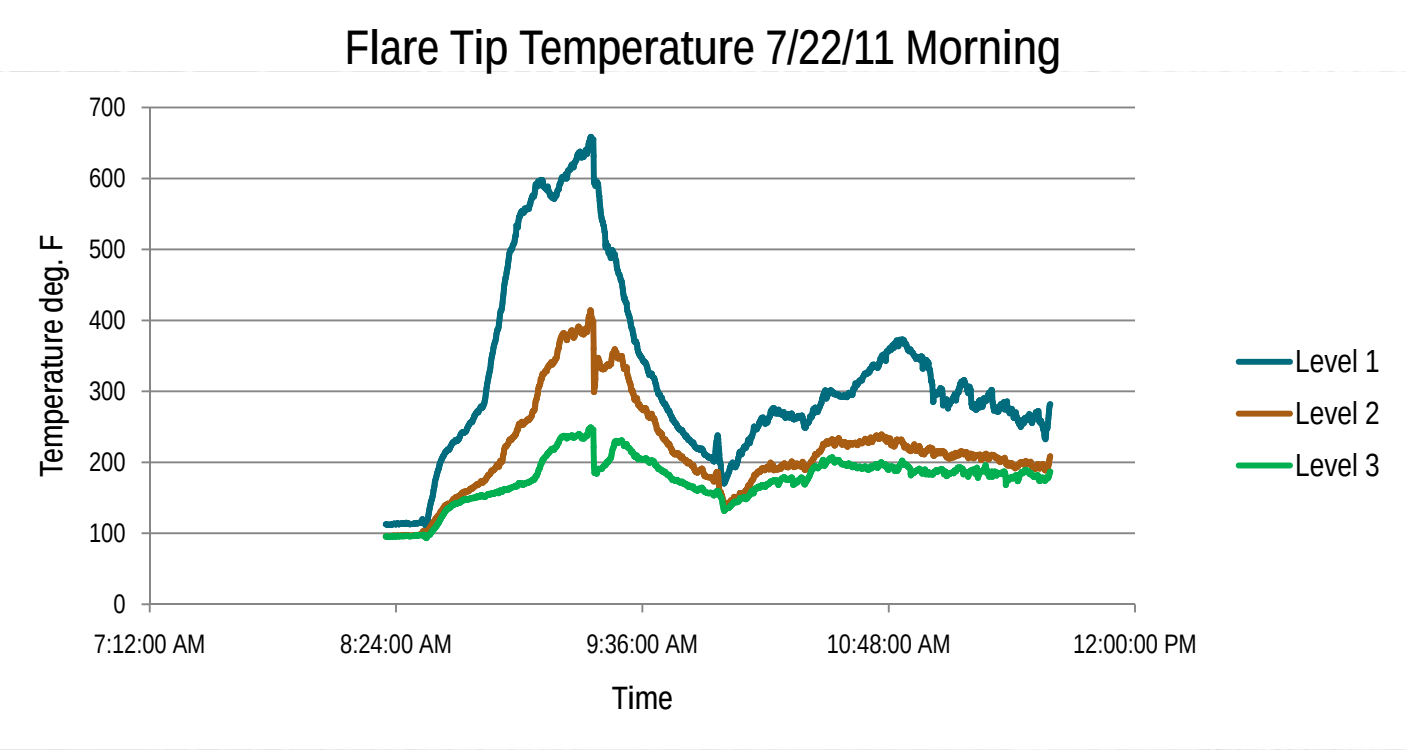
Results

- Thermocouple evaluation continued
  - When the flame was stable and located at the exit of the flare tip, a higher DRE was observed



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Conclusion

- Constant cooling steam is necessary for thermal protection of the flare tips and equipment
- Strong indication that cooling steam, while operating at API Purge Rates, does reduce destruction efficiency
- LHV for combined steam and gas is necessary for predicting the destruction efficiency of flares

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Recommendations

- Is this a real problem?
  - Many plants operate with sweep gases that are higher than API recommended rates
  - API rates are listed as the minimum recommended purge rate
- Increase LHV combustion zone
  - A minimum of 225 Btu/SCF is recommended
- Use nitrogen purge where available
- Use other means of flashback protection
  - Flame arrestor
  - Liquid seal base of flare stack and designed for flashback

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Questions

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