Texas Commission on Environmental Quality (TCEQ) 2010 Flare Study & Supplemental Flare Operations Training

Presented by Russ Nettles, Air Quality Division
Presented To: Association of Air Pollution Control Agencies (AAPCA)

September 12, 2014
Overview

- Previous TCEQ flare projects
- General industrial flare background information
- TCEQ flare test objectives
- TCEQ flare test results
- TCEQ flare training information
Air-Assisted Flare Infrared Video
TCEQ 2007 Differential Absorption Lidar (DIAL) Project

99+% destruction and removal efficiency (DRE)

<85% DRE
Flare Operations

- The TCEQ categorizes industrial flares by function.
- Three categories of flares:
  - Non-routine (emergency) operations flares
    Safety devices that combust waste gas during power outages, emergency conditions, or plant maintenance activities
  - Routine process flares
    Control and safety devices that combust waste gas from normal plant operations instead of releasing this gas to the atmosphere
  - Dual-service flares
    - Flares that are used to burn routine and non-routine (emergency) waste gas
    - Largest category of industrial flares
    - Focus of TCEQ 2010 Flare Study
Non-routine flare operations were **not** the focus of TCEQ flare study.

Photo courtesy of John Zink Institute
Dual-service flares in routine service were the focus of the TCEQ 2010 Flare Study.

Photo of flare tip used during TCEQ 2010 Flare Study.

The flare tip was designed to burn 1 million pounds of hydrocarbons per hour.
Current Flare Requirements

• Flares that meet federal requirements have:
  – a pilot (similar to a pilot on a natural gas oven, range, or water heater) that must always be lit;
  – waste gas that meets certain criteria; and
  – no visible emissions (e.g., smoke) for more than five minutes during a two-hour period.

• Assumes the flare destroys at least 98% of the waste gas stream if the requirements are met.
  – For example, using current assumptions, if 100 pounds of waste gas are routed to a flare:
    ▪ 98 pounds would be destroyed; and
    ▪ 2 pounds would be vented to the atmosphere
  – This is referred to as the flares destruction and removal efficiency (DRE). We will refer to it as flare efficiency.
Why Does A Flare Smoke?

- Smoke can form when the flame does not have enough oxygen to completely burn the waste gas into carbon dioxide and water resulting in carbon (smoke) being produced.
- Steam or air is mixed into the flame to reduce smoking.
  - Steam or air injection, known as assist, brings oxygen into the flame.
  - The assist helps shape the flame and mix the air and waste gas to reduce smoke.
  - TCEQ study focused on steam- and air-assisted dual-service flares.
Flare Without Steam Assist

Steam assist off

Photo courtesy of John Zink Institute
Flare With Steam Assist

Steam assist on

Photo courtesy of John Zink Institute
Flare Test Objectives

- Assess the impact of high turndown (low flow) rate of vent gas on flare DRE and combustion efficiency (CE)
- Assess if flares operating within 40 Code of Federal Regulations (CFR) §60.18 (CFR §60.18) can achieve the assumed hydrocarbon DRE of at least 98% at high turndown, varying assist ratios, and vent gas heat content
- Test air and steam-assisted dual-service flares
Extractive Sampler

Extractive sample inlet

Flue gas eductor

Pitot

GPS

Elevation chain

Sample lines

Positioning chains
Results: High and Low DRE Values Were Measured

- The flares tested were able to achieve greater than 99% DRE and combustion efficiency (CE) for vent gas streams with low heating value at low flow rate conditions.
- For the conditions tested, the highest DRE and CE was achieved at or near the incipient smoke point.
- As the air or steam-assist was added to the flare, DRE dropped significantly.
- The flares were easily over assisted.
Test Point S4.2

A visible flame is clearly seen. Steam cannot be seen.

<table>
<thead>
<tr>
<th>Vent Gas</th>
<th>Btu/scf</th>
<th>Steam to VG Ratio</th>
<th>DRE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,342 lb/hr</td>
<td>350 Btu</td>
<td>0.29</td>
<td>99.2</td>
</tr>
</tbody>
</table>
Test Point S4.7

<table>
<thead>
<tr>
<th>Vent Gas</th>
<th>Btu/scf</th>
<th>Steam to VG Ratio</th>
<th>DRE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,342 lb/hr</td>
<td>350 Btu</td>
<td>0.54</td>
<td>90.6</td>
</tr>
</tbody>
</table>

A visible flame is difficult to see. Excessive steam can be seen and is creating a loud “hissing” sound.
Test Point S4.3

<table>
<thead>
<tr>
<th>Vent Gas</th>
<th>Btu/scf</th>
<th>Steam to VG Ratio</th>
<th>DRE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,342 lb/hr</td>
<td>350 Btu</td>
<td>1.05</td>
<td>27.3</td>
</tr>
</tbody>
</table>

A visible flame can’t be seen. Excessive steam is highly visible and is causing a loud “hissing” sound.
Steam-Assisted Flare DRE

Constant Vent Gas Flow Rate of 2,342 lb/hr

Incipient smoke points

- Red diamonds: 2149 Btu/scf
- Blue squares: 600 Btu/scf
- Black triangles: 350 Btu/scf

Steam-to-Vent Gas Ratio lb/lb vs. DRE % Propylene

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Steam-Assisted Flare DRE

A flare can be operated according to CFR §60.18 requirements and not achieve 98% DRE. Flares were easily over-assisted.

Flare **DRE 99.2%** at steam-to-vent gas (SVG) ratio of 0.29.

As the SVG almost doubles to 0.54, the flare DRE decreases to **90.6%**. Note the flame is disappearing.

As the SVG almost doubles again to 1.05, the flare DRE drops to **27%**. Note the flame has disappeared.
Air-Assisted Flare DRE

Excess Air Factor of 10

Incipient smoke points

Excess Air Factor

DRE - Propylene (%)

A5: 80 lb/hr Hydrocarbon
A6: 131 lb/hr Hydrocarbon
A3: 200 lb/hr Hydrocarbon
A4: 330 lb/hr Hydrocarbon

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Results From Five Different Flare Tests

CE vs. NHVcz
All TCEQ Steam vs Base Loads

Combusion Efficiency (%)

Combustion Zone Gas Net Heating Value \((H_2=1212\ \text{BTU/scf})\) (BTU/scf)

- 250 Btu/scf

Information courtesy of Clean Air Engineering
Flare Training

- Historically, flare operations have been focused on compliance with CFR §60.18 with an emphasis on smoke prevention. Flare operators mostly concerned about smoke.
- Training to maximize flare DRE did not exist.
- TCEQ partnered with The University of Texas at Austin to develop the free Internet-based training.
  - $330,000 investment to develop the training.
  - The training heavily relies on flame appearance and sounds.
Flare Operations Training Objectives

• Provide tools to facilitate more efficient operation of dual-service flares during low flow, high turndown operation
  – Focus on elevated, assisted flares
  – Maximize dual-service flare efficiency using existing on-site resources

• Share knowledge and understanding of flare operations from the TCEQ 2010 Flare Research Project and other recent flare projects

• Clearly explain the impact of supplying too much steam- or air-assist during routine flaring operations
Technical Review Panel

• Diverse membership included:
  – Flare manufacturers
    Zeeco and John Zink
  – Industry representatives:
    • LyondellBasell, Dow, ExxonMobil, Phillips 66, Lubrizol, Shell, and Valero
    • Texas Chemical Council and Texas Oil and Gas Association
  – Flare experts
  – Environmental advocacy groups
    • Air Alliance Houston
    • Industrial Professionals for Clean Air
  – Consultants

• Open to other interested participants
Flare Training Development

- Traditional narrated video, charts, and graphs format
- Freely available to the general public
- Approximate two-hour investment in time
- Minimal registration requirements
- Consists of five independent concept modules

**The free training is located at:**
https://sfot.ceer.utexas.edu/
Flare Training Modules

• Module 1: Introduction
  Understand the purpose and importance of the training program

• Module 2: History of flares, applicable regulatory requirements, and flare types
  Understand the history and evolution of the design and operation of industrial flares

• Module 3: Optimizing flare performance
  Select the appropriate assist rates as well as understand operational considerations of flares to achieve optimal flare performance
Flare Training Modules (cont.)

- **Module 4: Flare performance parameters investigated in recent industrial flare studies**
  
  Apply lessons learned from recent industrial flare studies to improve flare performance

- **Module 5: Approaches to Monitoring Flare Performance**

  Effectively use practical available instrumentation and process control technology to monitor and improve flare performance
Flare Training Modules (cont.)

- Refresher training module
  - Approximately 15 minutes in length
  - Composed of key objectives from all learning modules

- Quiz at end of each module

- Optional final exam
  - Comprehensive test
  - Completion certificate available after passing final exam
Expected Outcomes

• Improve air quality:
  – Improve flare efficiencies
  – Reduced emissions

• Visible flames may be seen more often from industrial flares.

• Greater understanding by stakeholders of flaring operations.
Quiz: Is this Low or High DRE?
High DRE. The dark orange flame and lack of visible steam are excellent visual indicators of the flare being operated at high DRE.
Quiz: Is this Low or High DRE?
Low DRE. The lack of a visible flame and excessive steam at the flare tip are good visual indicators the flare is being operated at low DRE.
Contact Information

• Russell Nettles, Emissions Assessment Section
  Russell.Nettles@tceq.texas.gov, (512) 239-1493

• Study results are posted at:
  – TCEQ’s Flare Task Force Stakeholder Group Web site
  – Sign up for e-mail updates through TCEQ’s GovDelivery listserver. Select “SIP Hot Topics” under the “Air Quality” heading to receive Flare Task Force updates.

• The free training is located at this website:
  https://sfot.ceer.utexas.edu/