New Direct Flame Monitoring Technology to Help Operators Comply with Increasingly Stringent Flaring Regulations

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ZEECO

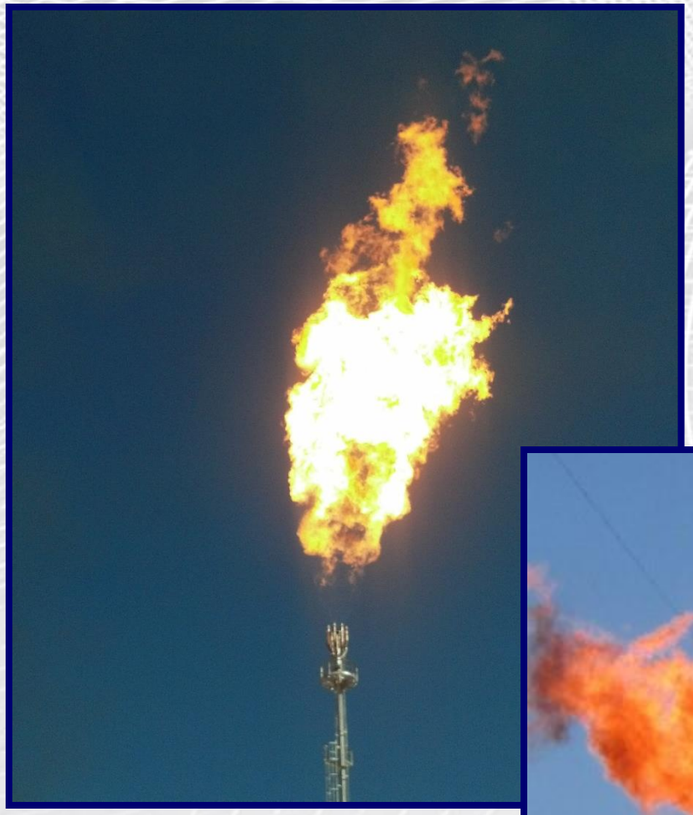
GPA MIDSTREAM ASSOCIATION

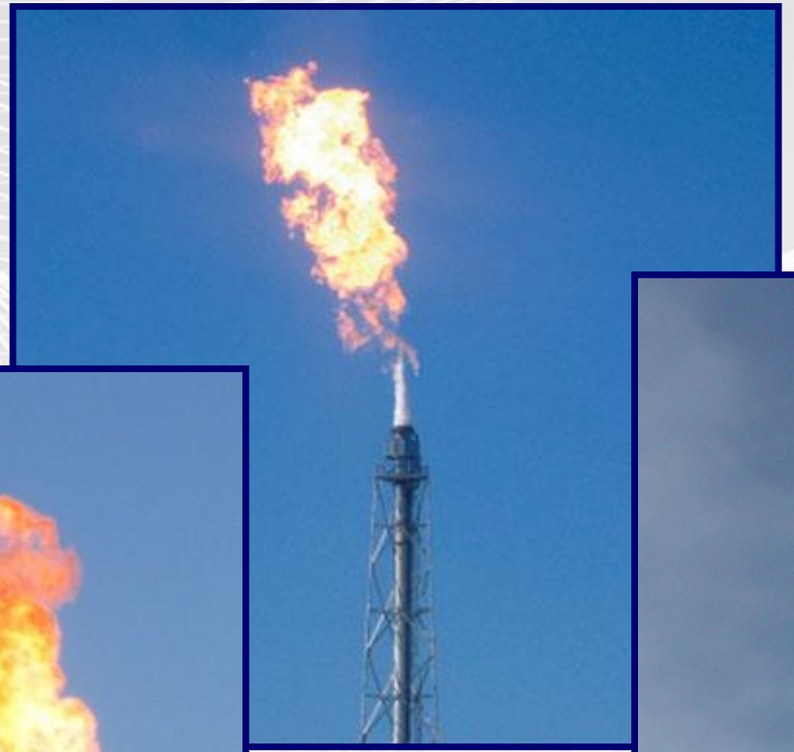

BURNERS


FLARES


INCINERATORS


PARTS & SERVICES





General Definition of Flare Systems

- Merriam-Webster Definition:
  - A fire or blaze of light used especially to signal, illuminate, or attract attention
- API-527/537 Definition:
  - A device or system used to safely dispose of relief gases from a process in an **environmentally compliant manner** through the use of combustion

Flare Use Advantages

- Used to eliminate an overpressure in a process using combustion
- Relatively inexpensive to operate and is always online
- Safe & reliable form of protection for plant personnel and surrounding community

Flare Perceived Disadvantages

- Customers often worry about producing one or any of the following:
  - Smoking
  - Noise
  - Visible Flame
  - Odors
- Aside from these, there is a growing concern for more regulation on "invisible pollutants", or in short…

EMISSIONS

Emissions Regulation Overview

- Historical Background:
  - US Environmental Protection Agency (EPA)

- 1986: EPA broadcast emission standard for flare under NSPS Subpart A (40CFR § 60.18), amended 1998 and 2000
  - No visible emissions – determined by EPA method 22
  - Presence of pilot flame
  - Vent gas NHV must meet specified criteria
  - Flare tip velocity must be less than 60 ft/s or as defined by formulas

Future Emissions Regulation

- December 2015: EPA broadcast new emissions standards for flare under NESHAP Subpart CC (40CFR § 63.670)
  - Effective Date: 2/1/2016
  - Compliance Deadline: 1/30/2019
  - Most significant changes:
    - Continuous monitoring required
    - Change from vent gas NHV to CZNHV
    - Data point required every 15 minutes

Monitoring Flare Performance with Video Imaging Spectro-Radiometer (VISR)

VISR Presentation Outline

- Introduction to VISR
- Validation of the VISR method
- Capabilities
- Applications

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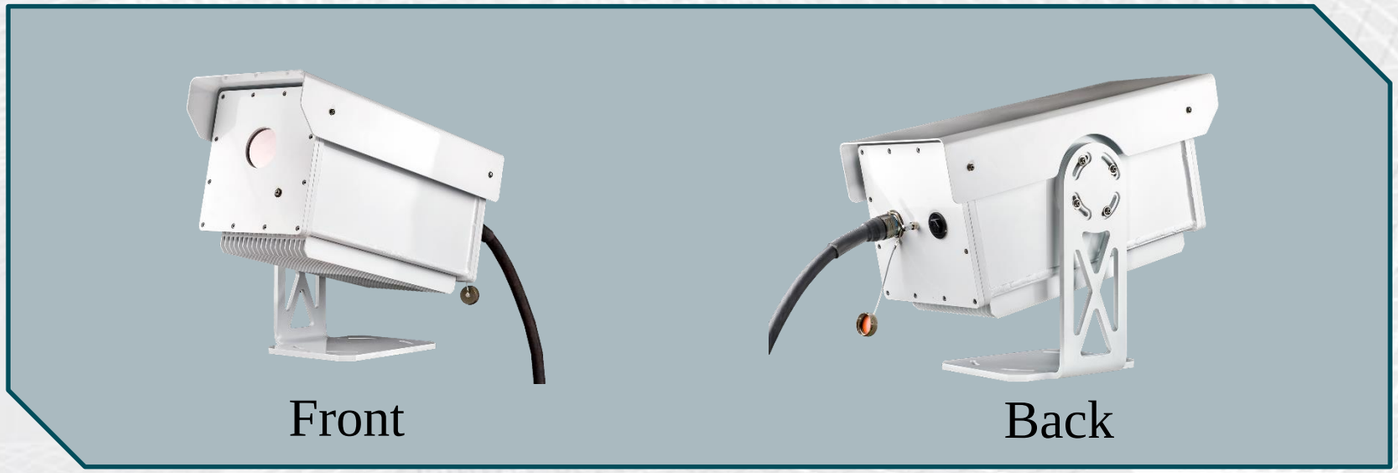
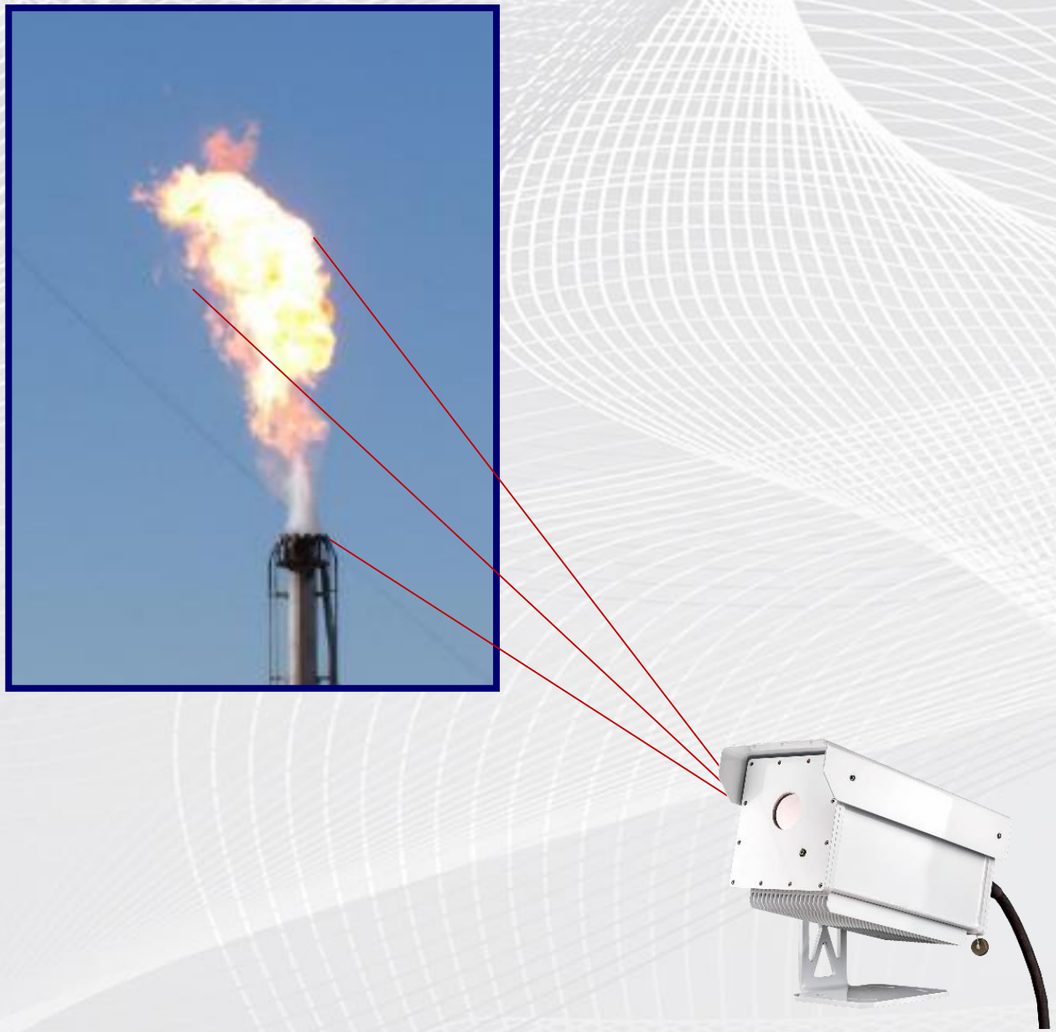
Introduction to VISR

- The term “VISR” is used for both:
  - The Method – Video Imaging Spectro-Radiometry
  - The Device – Video Imaging Spectro-Radiometer

- FlareGuardian™ is a VISR based product produced by Zeeco, Inc. for flare monitoring



Introduction to VISR



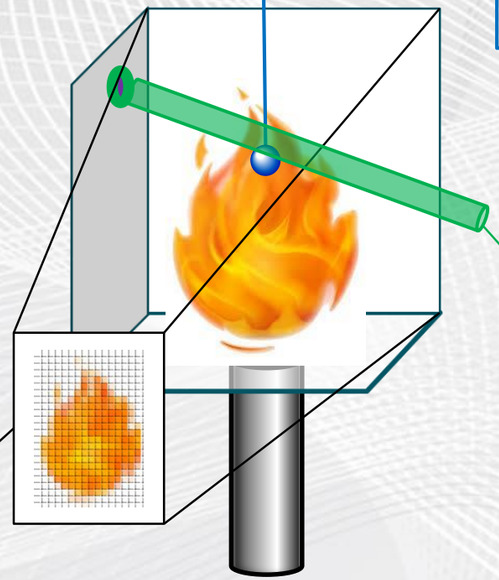
- Multi-spectral imager
- Directly measures relative concentrations of combustion products and unburned hydrocarbons (HC) in the flame
- Calculates flare combustion efficiency (CE) directly in real time
- Eliminates uncertainty in using surrogate parameters (CZNHV and tip velocity)

Introduction to VISR

VISR is different from other direct flare measurement methods

- Extractive
- PFTIR
- VISR

Extractive Sampling
- Point measurement
- Not suitable for routine monitoring

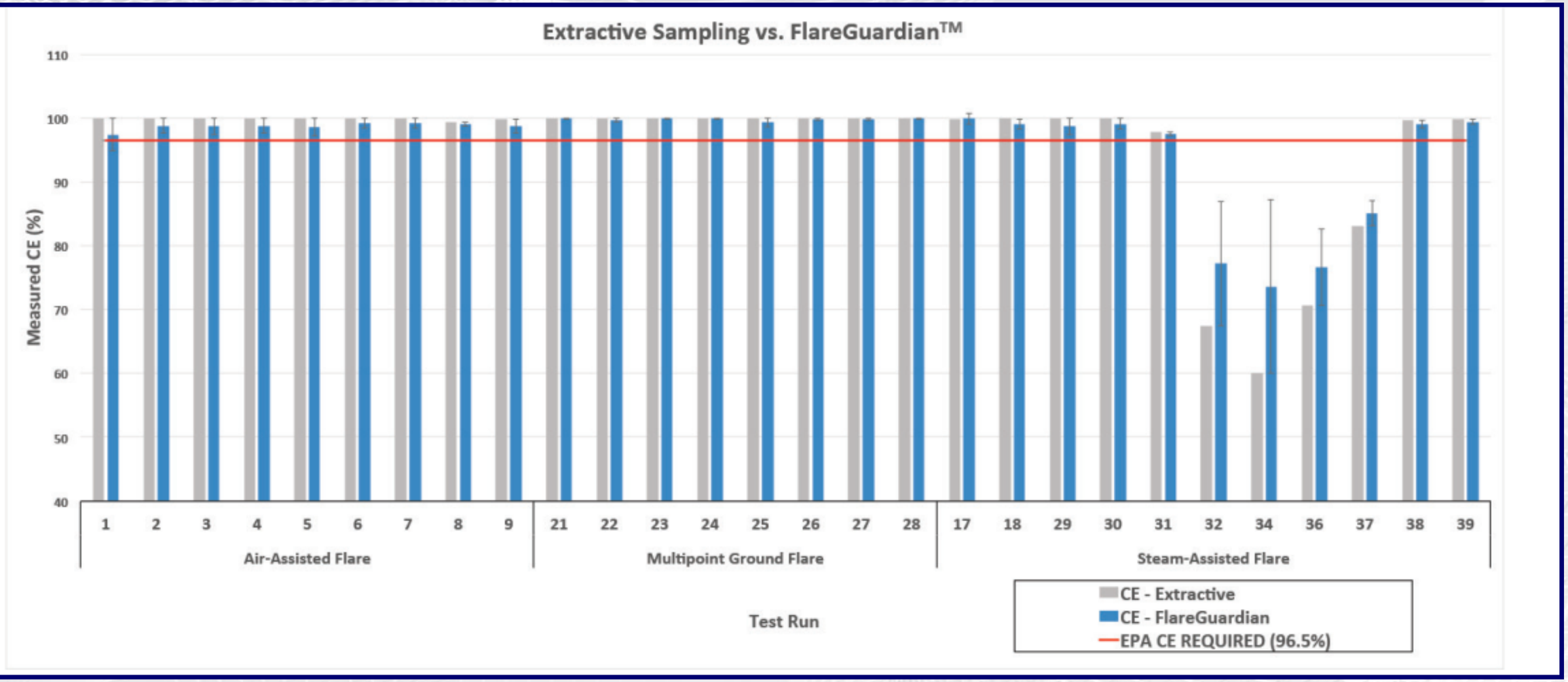


PFTIR
- Path measurement (the path is reduced to a point)
- Not suitable for routine monitoring

VISR
- 3-D measurement (3-D flame is reduced to a 2-D image)
- Suitable for autonomous monitoring or short-term study

Validation of the VISR Method

- Validated using extractive method
  - 28 test runs were compared
  - Average difference was 0.50% in CE
  - The difference was smaller (-0.30% in CE) when CE was > 80%


Extractive Sampling vs. FlareGuardian™
Measured CE (%)
110
100
90
80
70
60
50
40
1 2 3 4 5 6 7 8 9 21 22 23 24 25 26 27 28 17 18 29 30 31 32 34 36 37 38 39
Air-Assisted Flare
Multipoint Ground Flare
Steam-Assisted Flare
Test Run
CE - Extractive
CE - FlareGuardian
EPA CE REQUIRED (96.5%)

For More Details

- U.S. patent No. 9,258,495 issued on Feb. 9, 2016
- Validation test results can be found in *Journal of Air and Waste Management Association*, January issue of 2016, pp. 76-86
- The development of VISR was partially funded by U.S. EPA thru its SBIR Phase I and Phase II awards

VISR Capabilities

- Remotely, continuously, and autonomously monitor the following metrics:
  - **Combustion Efficiency (CE)**: 0-100%
  - **Smoke Index (SI)**: 0-10 for the level of smoke
  - **Flame Stability (FS)**: 0.1-1 (0.1=extremely unstable flame; 1=extremely stable flame)
  - **Flame Footprint (FF)**: flame cross section area ⊥ to VISR line of sight; shown as SQFT
  - **Heat Release (HR)**: Amount of heat released by flare in the mid-wave infrared (MWIR) region, expressed as Btu/min
- Default time resolution: 1-sec, 1-min, and 15-min average
- The data can be sent to DCS / PLC for display or closed-loop control of flare

What Can You See Through the Lens of VISR?

Case 1: Higher CE, no visible emissions

Case 2: High CE, some visible emissions

Case 3: Low CE due to over-steaming

VISR vs. Visible Imagery

Green: Hydrocarbon
Red: CO2
Bluish/white: Carbon particles or hot solid objects

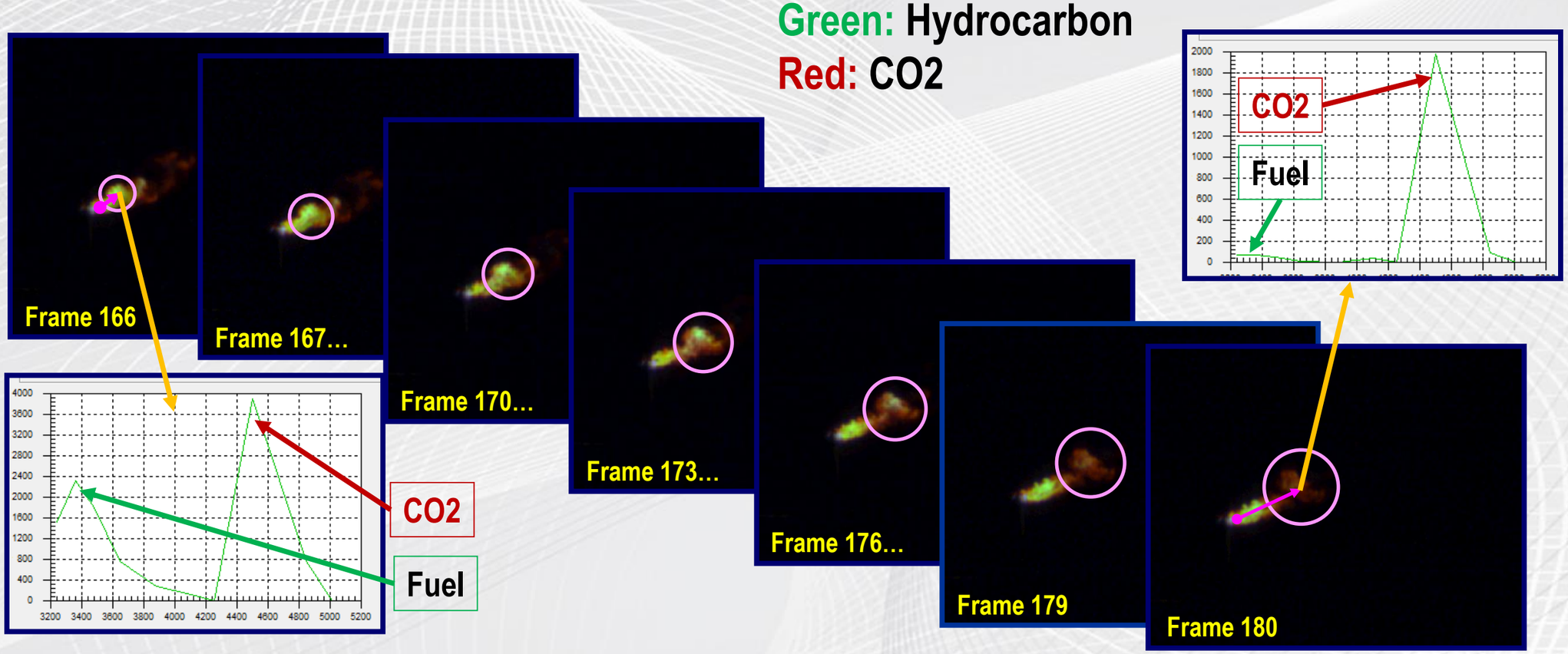
Case 1: High CE, No Visible Emission

CE measured by VISR: 99.8%

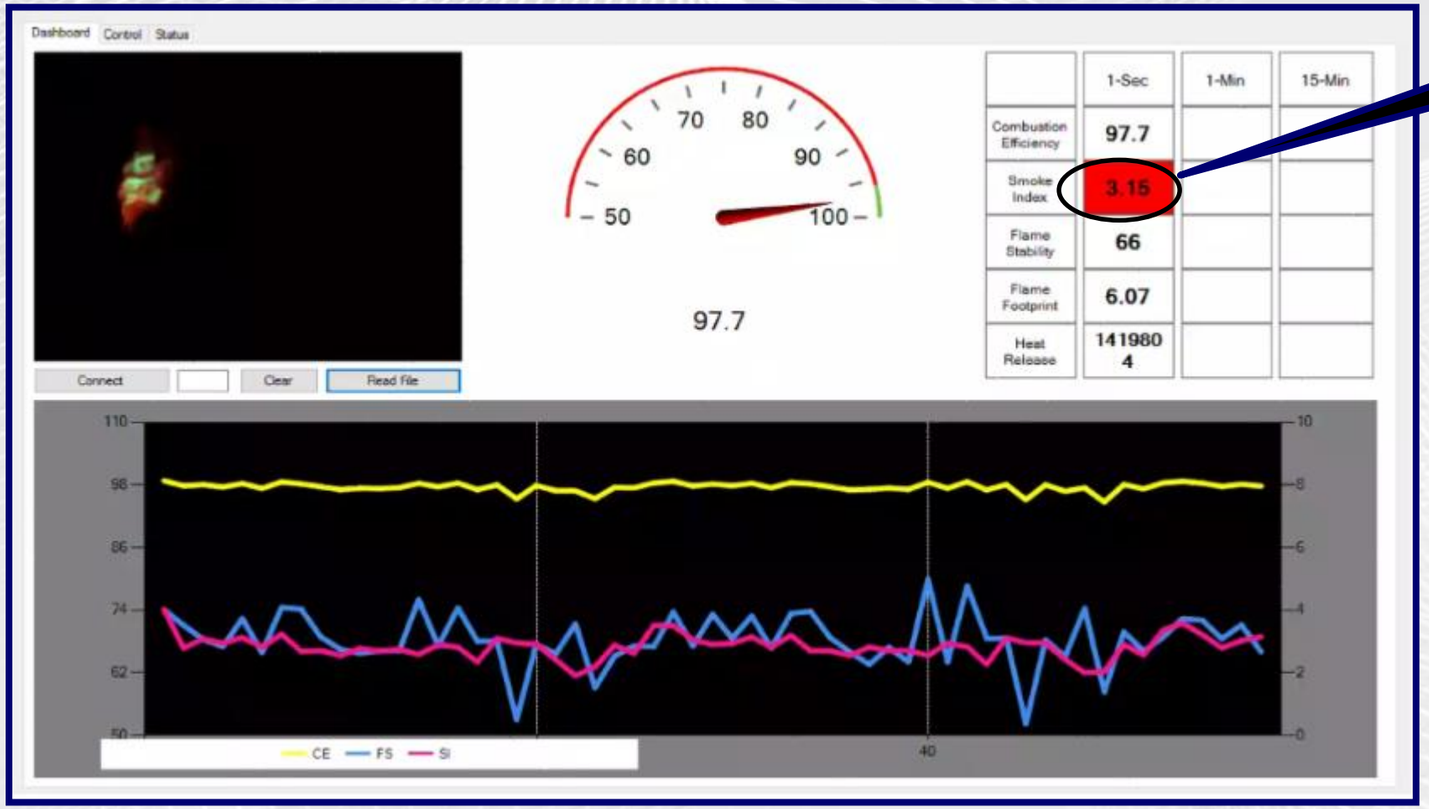
CE measured by extractive sampling: 99.9% w/ SD of 0.4%

Case 1: Progression of Good Combustion

Ex. A parcel of fuel gas is combusted in about 0.47 sec. (14 frames)



Case 2: High CE, some visible emissions



SI = 3.15, indicating smoke

CE measured by extractive sampling: 99.9% w/ SD of 0.8%

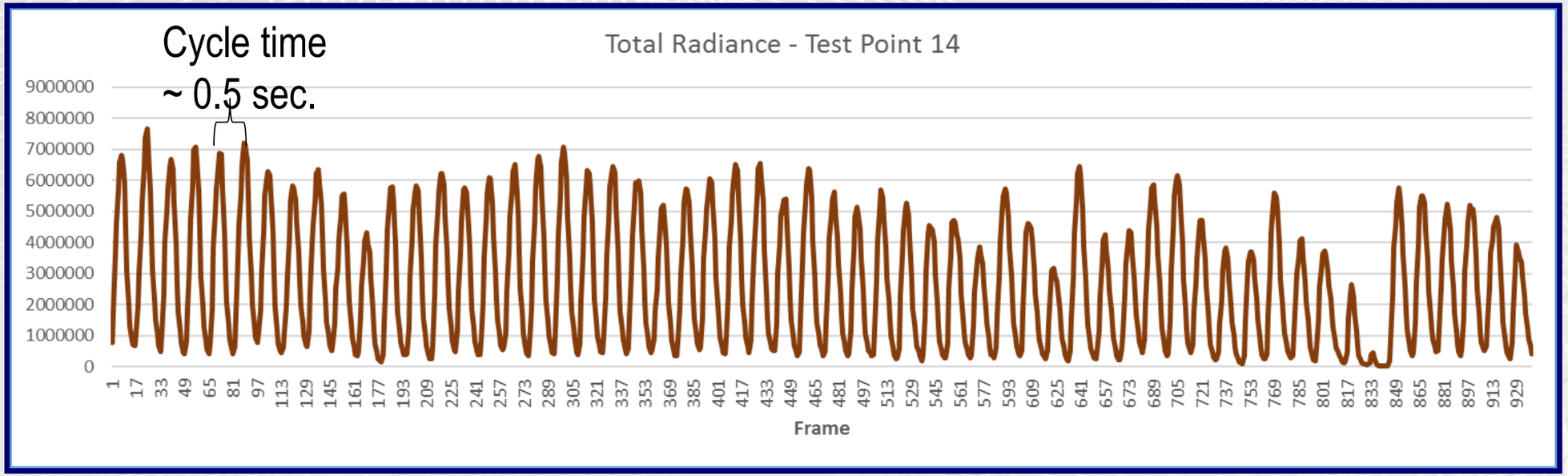
Case 3: Low CE due to over-steaming

CE measured by VISR: 56.6%

CE measured by extractive sampling: 62.0% w/ SD of 19.2%

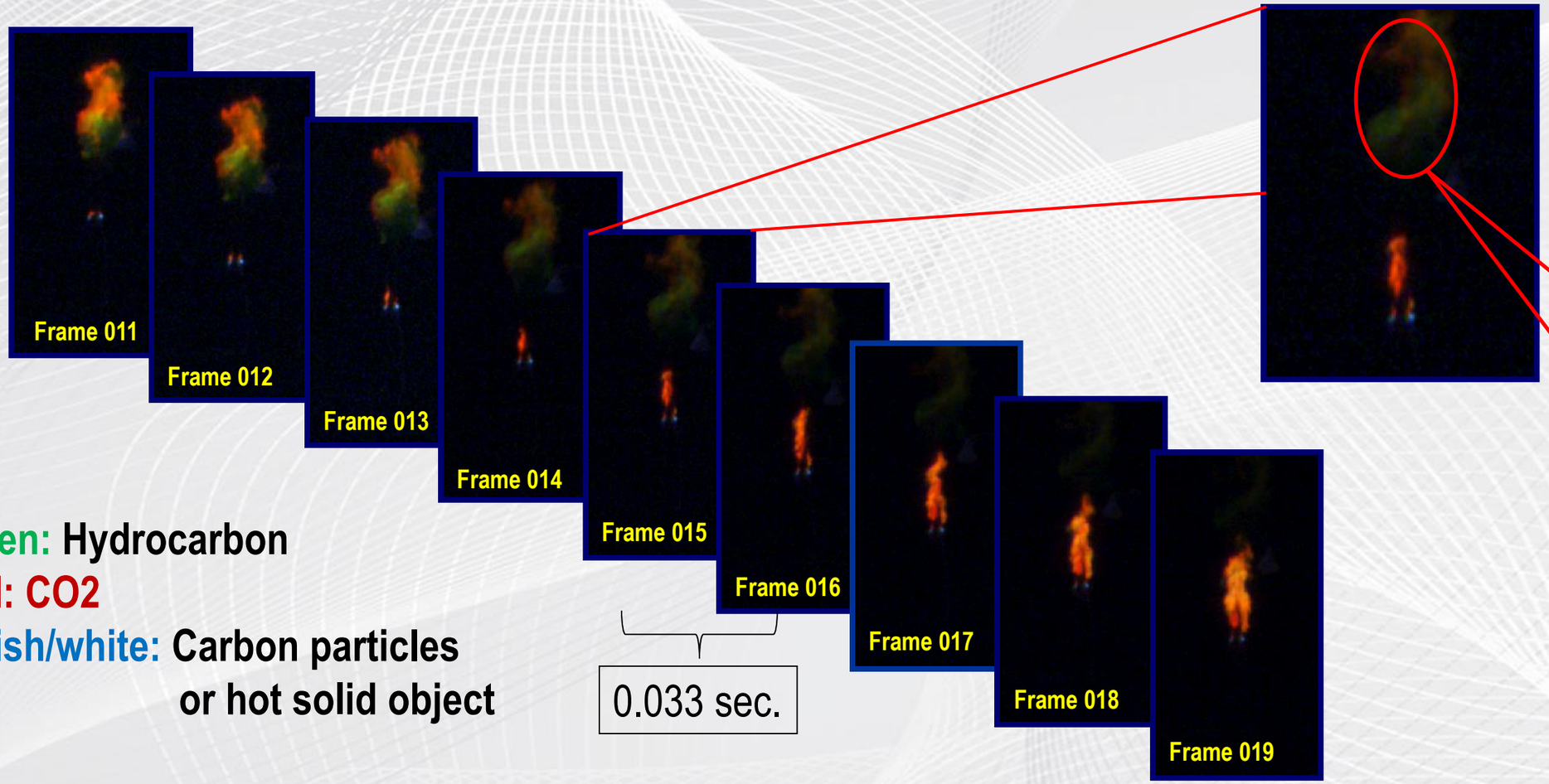
Case 3 (Cont'd): Low CE Condition

Very unstable flame; FS = 0.29; Flare is pulsing



Case 3 (Cont'd): Over-steaming Frame-by-frame

Flare pulsation behavior occurs in the following manner:

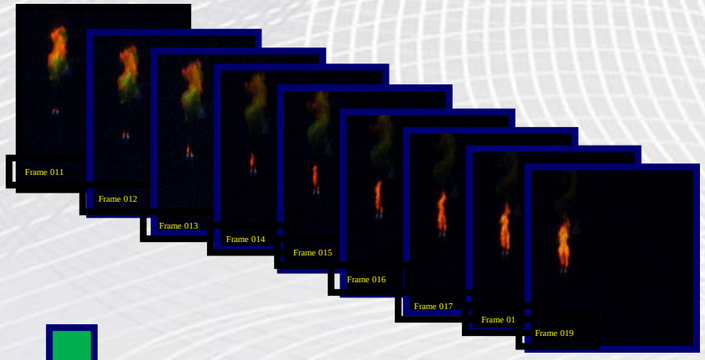


Green: Hydrocarbon
Red: CO2
Bluish/white: Carbon particles or hot solid object

Significant amount of unburned hydrocarbon (green color). Too cold to continue combustion

Detecting Pilot Flame

Pilot flames are readily identifiable



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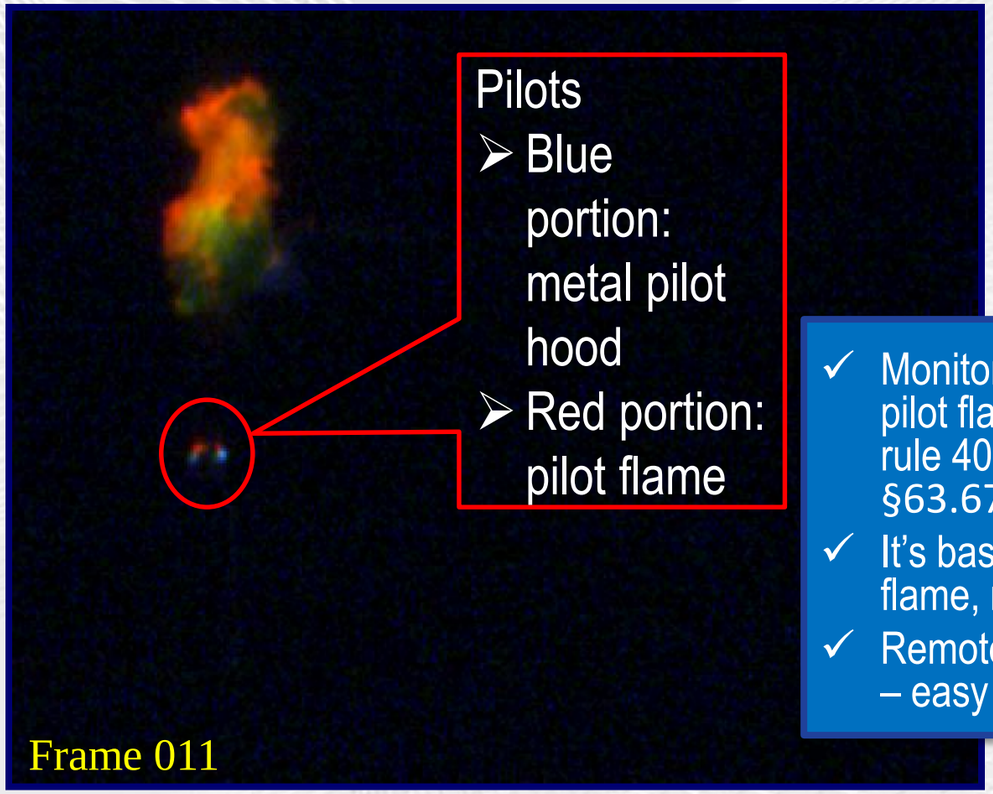


- ✓ Monitor presence of pilot flame - EPA rule 40 CFR §63.670 (b)
- ✓ It's based on pilot flame, not temp.
- ✓ Remote monitoring – easy to maintain

Summary of VISR Capabilities

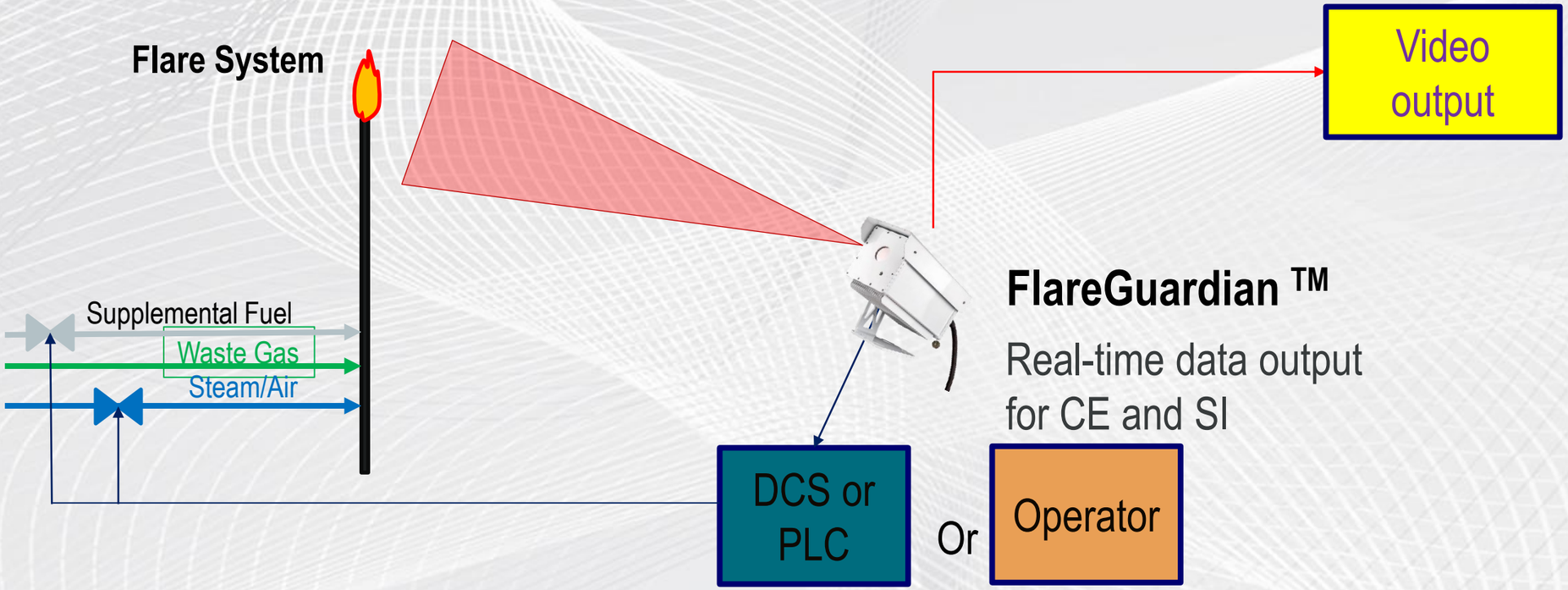
- For flare monitoring
  - CE (Combustion Efficiency)
  - SI (Smoke Index)
  - FS (Flame Stability)
  - FF (Flare Footprint) can provide flame length
  - HR (Heat Release)
    Potentially estimate mass rate
  - Monitor pilot flame

- For flare studies, same dashboard as above, plus:
  - Ability to look into flare with unprecedented spatial and temporal resolution
  - Tool for design/research (validating CFD modeling)
  - Troubleshooting of existing flare

Summary of VISR Capabilities

EPA Rule 40 CFR, Part 63	Compliance Requirements	Covered by FlareGuardian?
§ 63.670 (b)	Presence of Pilot Flame	✓
§ 63.670 (c)	No Visible Emissions	✓
§ 63.670 (d)	The three requirements are design to ensure sufficient CE through surrogate parameters	✓
§ 63.670 (e)		
§ 63.670 (f)		

Fixed Installation – Closed Loop Operations



Indirect/Surrogate Method vs. FlareGuardian

Conventional, indirect/surrogate method

Instruments require direct contact with streams

VS.

FlareGuardian™

Directly and remotely measure CE

- Remote sensing:
  - No contact with streams
  - Installation will be simple, no need for process interruption or waiting for turnaround
- Optimized coverage for flare system

Benefits of FlareGuardian

- Integral part of flare instrumentation and control
- Flare dashboard – Real time continuous performance data changes the way you operate flares
- Direct CE monitoring – avoid over- or under-regulating with the surrogate based indirect method
- Closed-Loop Control of Flare

Benefits of FlareGuardian (Con'd)

- Less expensive than GC & Calorimeter based regulatory methods
- Fast response (one second data resolution vs. 8-12 minute data resolution for GC), minimizing deviations in the15-min regulatory compliance period
- Supplemental fuel savings
- Remote sensing
  - Installation / maintenance can be scheduled independent of processes
  - No need to interrupt process for installation or maintenance
  - No contact with potentially corrosive process streams – low maintenance

Questions?