

Path to Compliance

Refinery Sector Rule 63.670 Compliance



imagination at work

GE Oil & Gas

Subsea Systems

- Subsea trees & wellheads
- Subsea power & processing
- Controls
- Manifolds
- Flexible risers
- Flow lines
- Specialty connectors & pipes



Digital Solutions

- Asset condition monitoring
- Vibration monitoring solutions
- Control sensing & inspection solutions
- Optimization & diagnostic software
- Pipeline inspection and integrity services
- Control & safety relief valves
- Natural Gas solutions

Drilling & Surface

- Drilling risers
- Blow-out preventers
- Electric submersible pumps
- Logging & wire line tools
- Surface wellheads & flow control
- Logging services
- Well Performance Services



~45,000
employees
~\$16.5B
revenues '15



Turbomachinery Solutions

- Gas turbines
- Axial & centrifugal compressors
- Electric motor driven compressors
- Turn-key industrial modular solutions
- Turboexpanders & heat exchangers
- Contractual & maintenance services
- Upgrades & industrial applications
- Monitoring & diagnostics

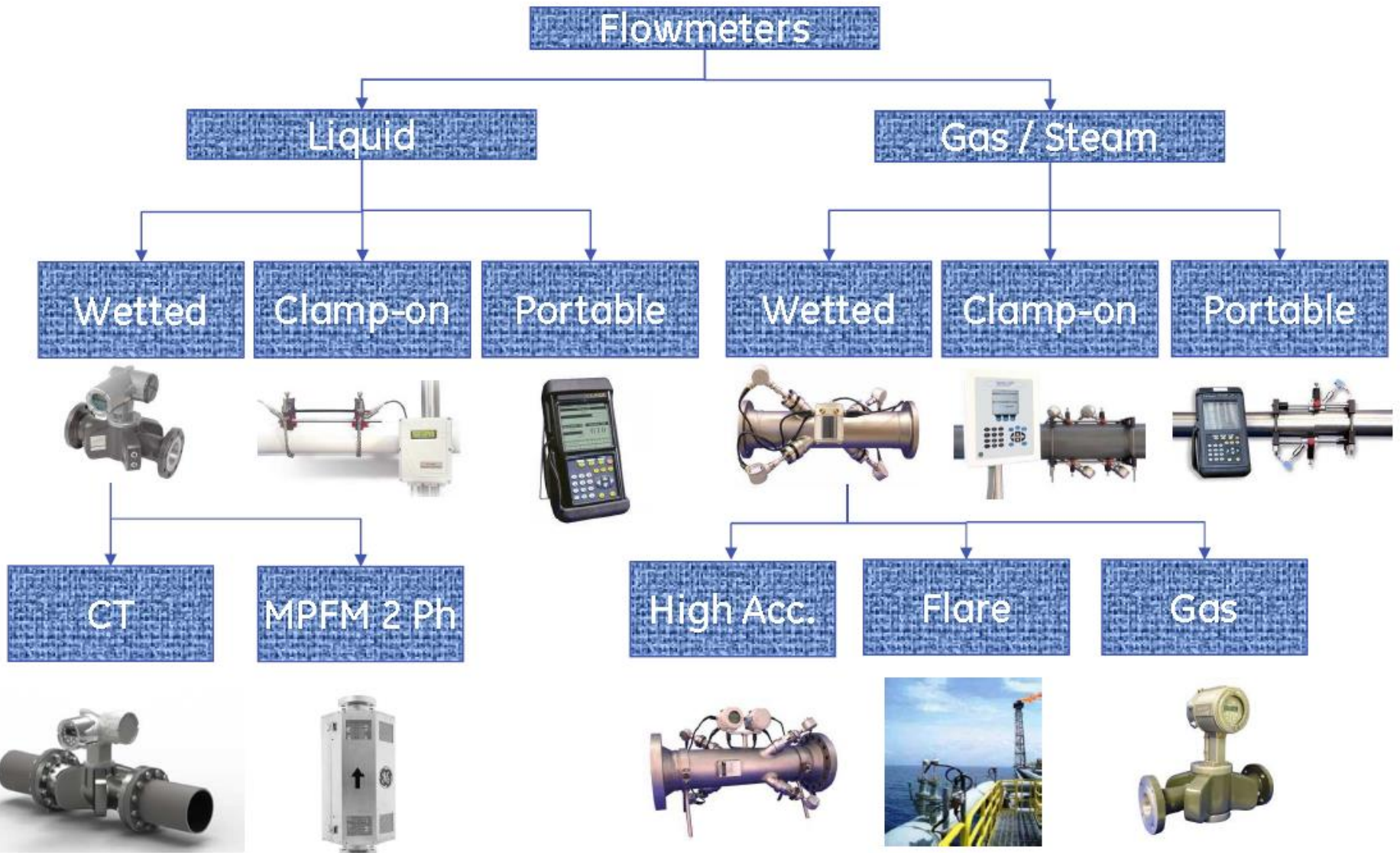


Downstream Technology Solutions

- Steam turbines
- Reciprocating compressors
- Distributed gas solutions – small LNG & CNG
- Pumps, valves & distribution systems
- Blowers & compressors
- Maintenance services & remote monitoring & diagnostics

Delivering customer solutions by applying systems-level engineering across the portfolio

Ultrasonic Flow



GE Digital Solutions



INDUSTRY
LEADER



EXPANSIVE PRODUCT
OFFERING



DEDICATED
SERVICE TEAM



TECHNICAL
EXPERTISE



TOTAL SOLUTION
PROVIDER

Leader in Flare and Flow Measurement

- Total solutions provider and consultant
- Pioneers of flare metering
- Domain expert in process automation and condition monitoring
- CFD capabilities for difficult flow applications
- Scope and scale – Long-term partner

Service Capabilities

- 15 N.A. based field service experts with an average of 7+ years of GE field experience
- Extensive technical product and service training on an annual-basis
- Complete 40+ hours of EHS and safety courses each year
- Committed to integrity and professionalism

Agenda

- Overview of Regulations
 - NSPS, 40 CFR Part 60, Subpart Ja
 - Refinery Sector Rule 63.670
- GE RSR Solution
- Path to Compliance
 - Phase I
 - Phase II
 - Phase III



Refinery Sector Rule (RSR) 63.670



Implementation Timeline

- Publish Date: Dec. 2015
- Compliance Requirement Date: Jan. 2019

Overview of Regulation

- Includes ALL sources, not just new sources
- Flares must control, maintain and demonstrate a 96.5% combustion efficiency or a 98% destruction efficiency
- Flares must maintain a minimum combustion zone Net Heating Value of 270 BTU/scf and report values every 15 minutes
- Flares must operate with no visible emissions, except for periods not to exceed a total of 5 minutes during any 2 consecutive hours
- Flare tip pilot flame must be maintained and velocities may not exceed 400 ft/s
- Operators must measure and control all assist flows to assure that the combustion zone stays above the minimum Net Heating value

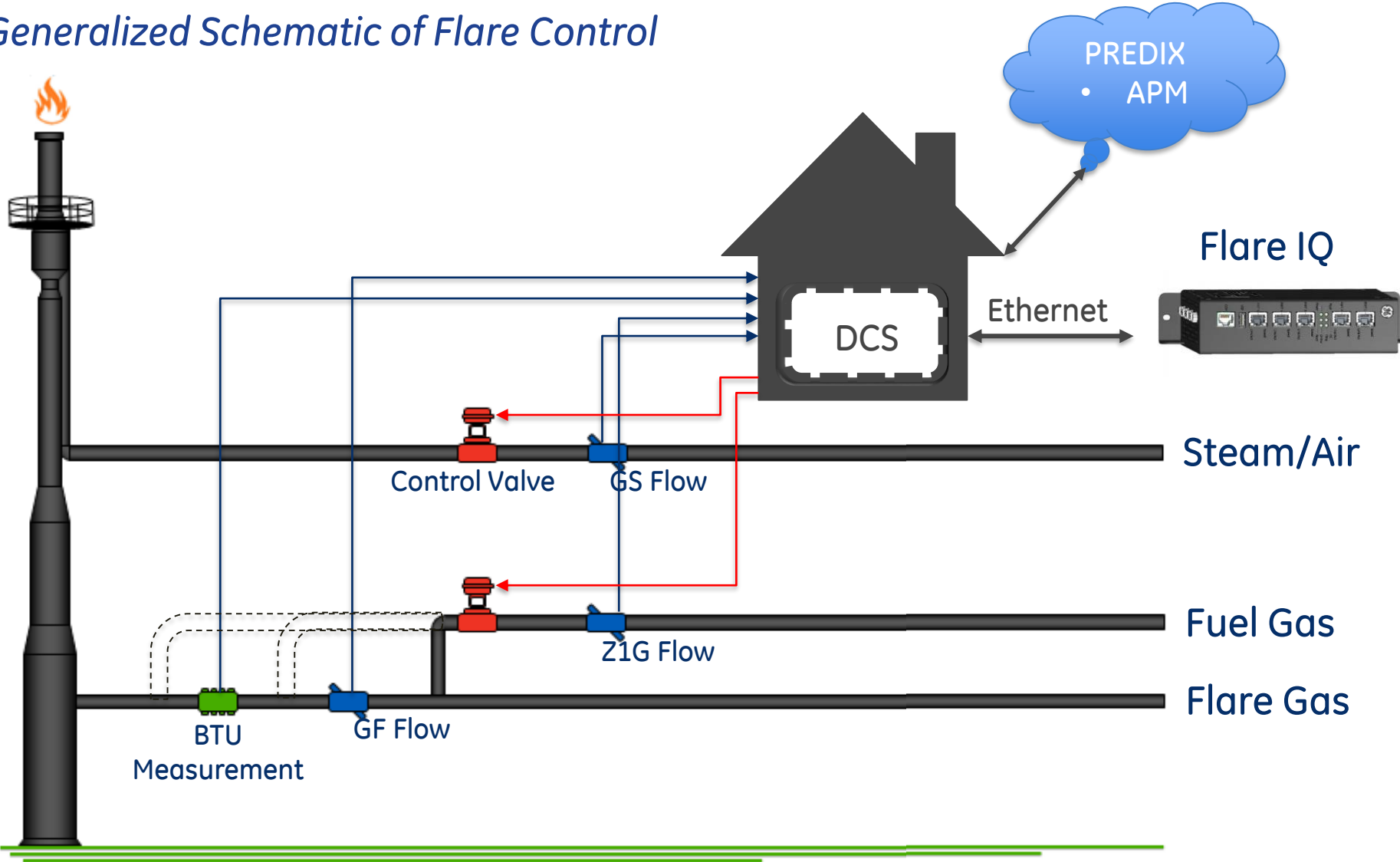
RSR - Continued

Table 13 - Calibration and Quality Control Requirements for CPMS

Parameter	Minimum Accuracy Requirements
Temperature	$\pm 1\%$ over normal measured range or 2.8 °C, whichever is greater
Flow Rate for All Flows Other Than Flare Vent Gas	$\pm 5\%$ over normal measured range or 0.5 GPM, whichever is greater for liquid flow $\pm 5\%$ over normal measured range or 10 CFM, whichever is greater for gas flow $\pm 5\%$ over normal measured range for mass flow
Flare Vent Gas Flow Rate	$\pm 20\%$ of flow rate at velocities ranging from 0.1 to 1 ft/s $\pm 5\%$ of flow rate at velocities greater than 1 ft/s
Pressure	$\pm 5\%$ over normal operating range or 0.12 kilopascals, whichever is greater
Net Heating Value by Calorimeter	$\pm 2\%$ of span
Net Heating Value by Gas Chromatograph	As specified in Performance Specification 9 of 40 CFR part 60, appendix B
Hydrogen Analyzer	$\pm 2\%$ over the concentration measured or 0.1 volume percent, whichever is greater

GE RSR Solution

Generalized Schematic of Flare Control



Path to RSR Compliance



Phase I
Flare system site
assessment



Phase II
Equipment Installation &
Start-Up



Phase III
flare.IQ installation &
Service Support

Phase I

Flare System Site Assessment

On-Site Review & Analysis:

- Assess applicable components of current flare system
- Perform diagnostic review of existing GE meters
- Evaluate pipe clearances for necessary meter upgrades
- Define performance requirements for flare gas monitoring
- Define performance requirements steam, air, and fuel gas flowmeters
- Evaluate control valves, temperature & pressure sensors, and any additional equipment as necessary



Deliverable - RSR Compliance Report:

- CPMS asset gap analysis
- System-level evaluation
- Solution road map
- Implementation timeline
- Report-out of Flare Compliance Flare system site assessment



FLARE REFINERY SECTOR RULE 63.670 SAMPLE COMPLIANCE REPORT

EPA RSR 63.670 REGULATION OVERVIEW

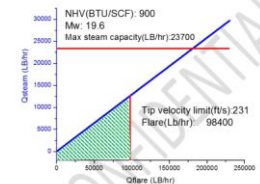
The new Refinery Sector Rule (RSR) passed by the EPA in October 2012, extends and strengthens the regulations governing stationary emission sources subject to the NSPS requirements. The existing NSPS JO regulations focus primarily on sulfur emissions and apply only to sources that were modified, installed or upgraded after 2012. The RSR now requires operators to achieve and maintain compliance for all sources, regardless of age, by January of 2018. The key provisions of the new rule as it applies to flow measurement and flare combustion efficiency:

Overview of Regulation

- Includes all stationary emission sources.
- Flares must control, monitor, and demonstrate destruction efficiency.
- Flares must operate to maximum combustor report status every 15 minutes.
- Flares must operate with no visible emission except during start-up, shutdown hours.
- Flare pilot flame must be maintained.
- Flare tip/speacles may not exceed 400 ft/s at heating value content.
- Operators must measure and control all of the above to minimum hot heating value.

NOMINAL CONDITIONS: FLARE PERFORMANCE OVERVIEW

- Minimum required steam 12,700 lb/hr
- Minimum allowable flare tip velocity is 98,400 lb/hr or 231 ft/s
- Maximum allowable flare tip velocity is limited by BTU content
- Adding more natural gas will not increase BTU content or allowable flare tip velocity



Under nominal case conditions, the sample flare system is constrained to a maximum tip velocity of 231 ft/s or 98,400 lb/hr. This constraint is a function of the BTU content of the gas as defined by the EPA rules governing tip velocity. Since the flare is operating at a net heating value of 900 BTU/cf, adding more natural gas will not increase the allowable flare tip velocity. In order to maintain smallest operator at the minimum tip velocity of 231 ft/s, the flare will require approximately 12,700 lb/hr of steam. The sample flare system is not limited by its maximum controllable steam capacity of 23,700 lb/hr. The area shaded in green on the chart defines the compliance operating map. The red line represents the boundaries imposed on the flare system by the stated capacity of the existing infrastructure.

Phase II

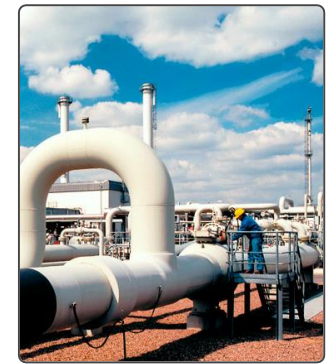
Equipment Installation & Start-Up

Equipment purchases for compliance may include the following:

- Steam meters
- Make-up / fuel gas meters
- Air meters
- Flare meters
- Control valves
- Any other equipment as identified

Additional Options:

- Extended warranty
- Spare parts
- Customer training
- Supporting Service Agreement



GF868 Flare Meter



Z1G / GM868 Gas Meter



Masoneilan Ctrl Valve



GS868 Steam Meter

Phase III

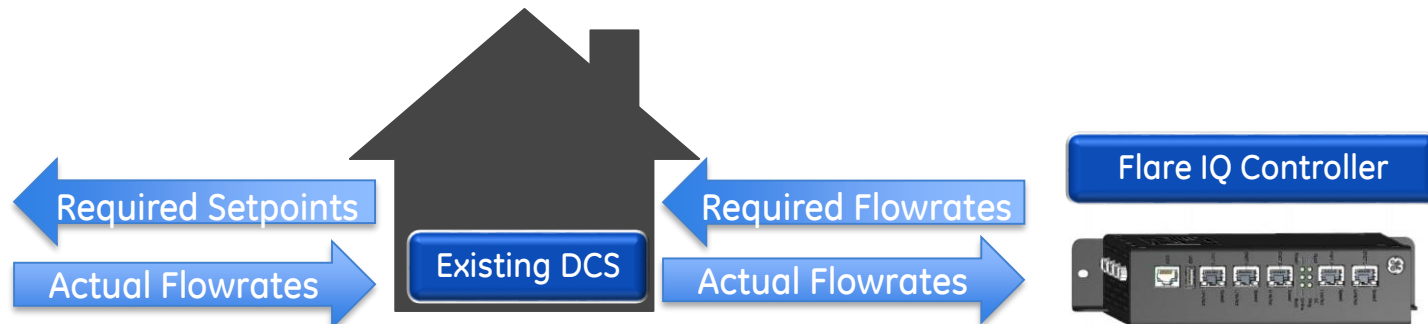
Flare IQ Installation and Service Support

- ❖ Integration of all necessary fluid, thermal, and mechanical equipment required for an automated flare combustion control solution.

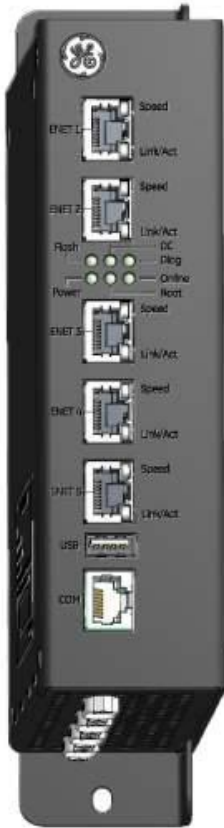


Included Products and Services:

- Flare IQ is a pre-programmed controller designed exclusively to comply with EPA RSR 63.670
- Flare IQ includes all calculations, and flowrates required to comply with RSR 63.670
- Flare IQ “learns” the specifics of your flaring and adjusts steam flows over time
- Services in Phase III Include:
 - On-site start up, commissioning
 - Supporting Service Agreement for GE assets
 - Introductory remote programming support

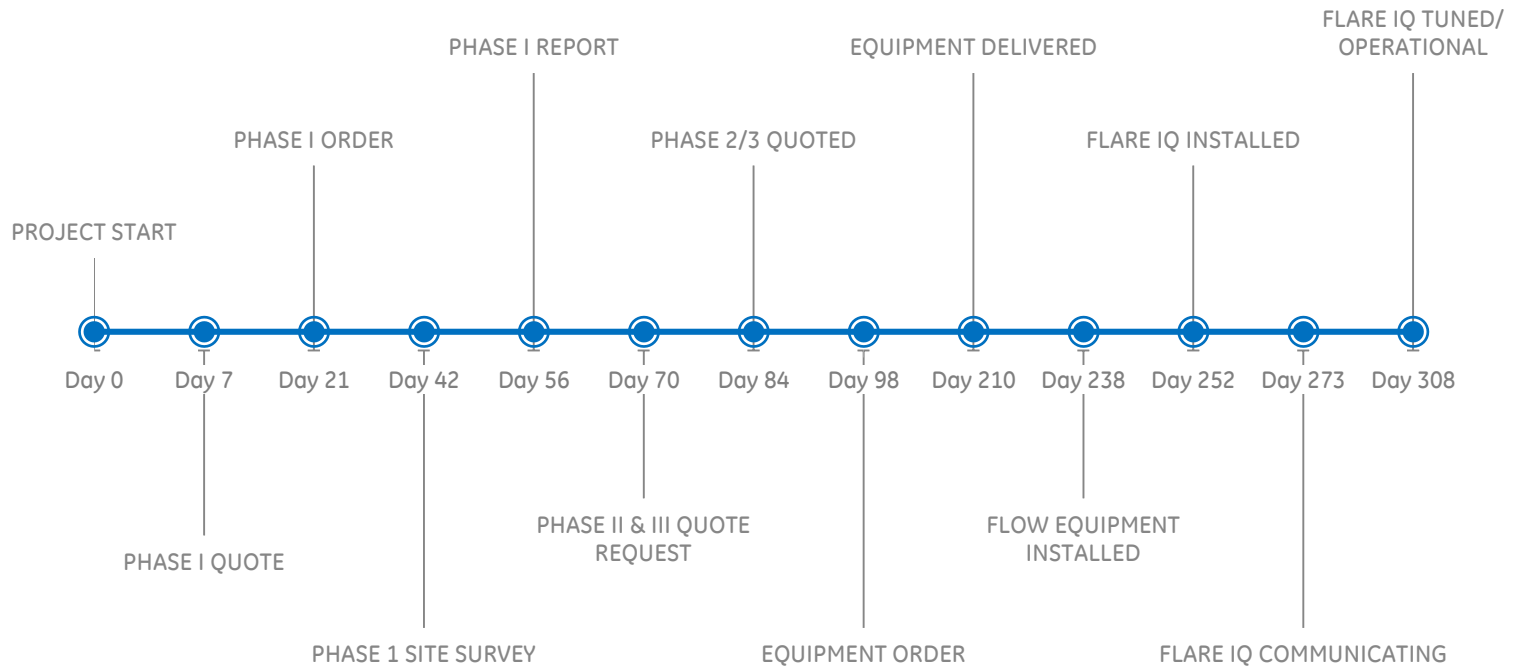


Controller Specification



- Redundant 24V dc input
- Intel® 1.66 GHz 64-bit embedded processor
- DDR2 667/800 MHz, 1GB memory; 2GB flash memory
- 1Gbps redundant UDH connections (Ethernet)
- 1Gbps redundant IOnet connections (Ethernet)
- 4 pairs of redundant high-speed intelligent serial link (1Mbps), Max. 12 Nexus IO modules for each redundant link
- 1Gbps dedicated tracking port for master/slave tracking
- I/O module connection capacity: Max. 48 pcs Nexus IO module
- QNX® real-time operation system
- Fast control loop, 40ms at fastest
- LED diagnostics display
- USB/COM port for controller setup
- NTP time synchronization, ± 1 ms, SOE accuracy 1ms
- Operation temperature: 0~60°C

RSR Compliance Timeline



Plan on at least one year from start to finish!

Proper Execution requires proficiency, commitment and, importantly TIME

GE Robotics Inspection as a Service | Automated Flare stacks

Pairing UAVs & Data Analytics to perform automated inspections

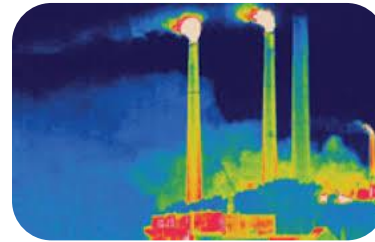
UAV autonomously inspects oil rig/flare stack



Data is sent to ground Mission Control



Automated defect recognition with Machine Vision AI



Data is displayed in a custom portal highlighting corrosion, cracks, and burn back spots



Benefits

Safety

- Transform the inspection space from human-centric to automation-centric
- Use UAVs to perform dangerous activities in a fraction of the time and a fraction of the cost

Cost reduction & business growth

- UAV inspections can reduce costs by 50% +
- Decrease rig down-time and increase safety of inspection operations
- On-demand, resident UAV



Technology

Data analytics

- Advanced analytics & visual inspection algorithms provide automated defect recognition
- Big data AI and video analytics provide change detection to highlight risk areas

Digital twin

- 360 degree view of flare stack highlights current and predictive risk areas
- Ability to view flare stacks from drone's perspective, to inspect issues

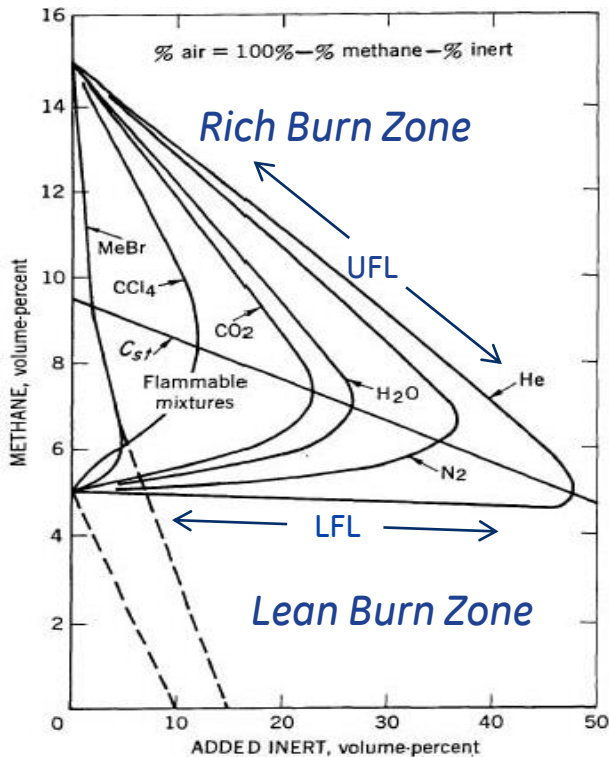
Discussion – Next Steps

Back-up

RSR - Continued

Combustion Control

Zabetakis Plot



Obtaining a Clean Burn:

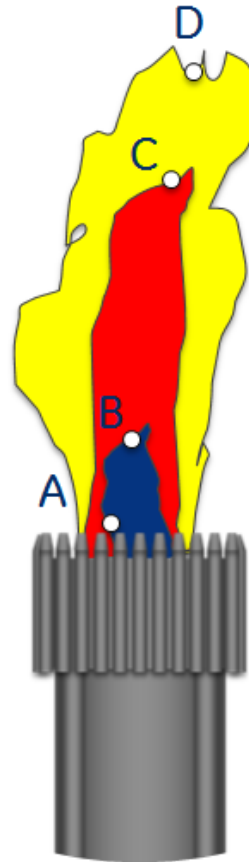
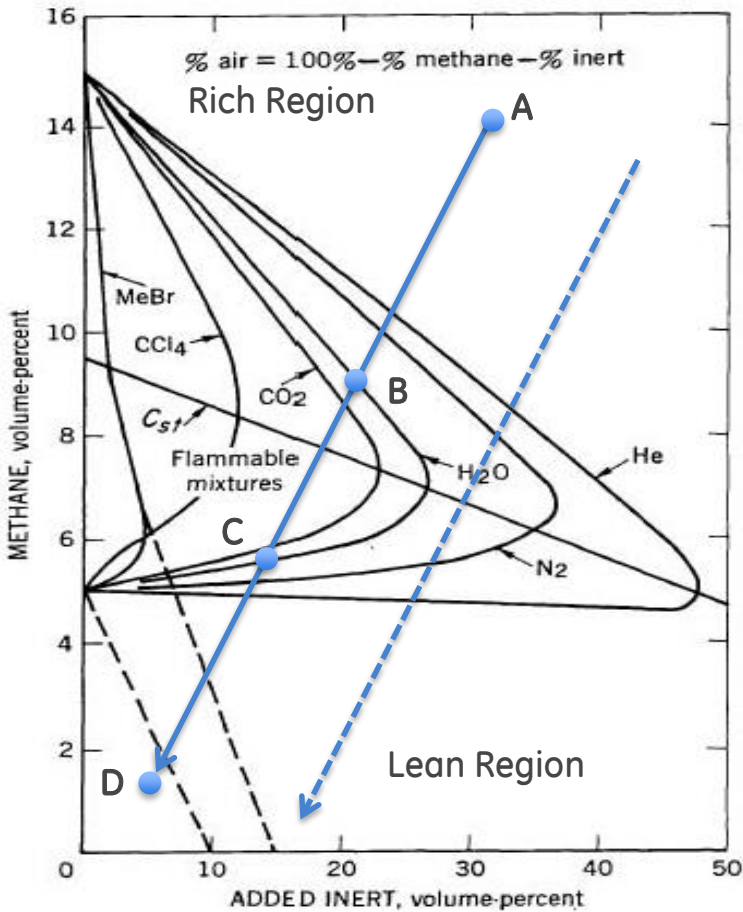
- The Zabetakis plot is the basis for defining the combustion zone (CZ) in a flare.
- Combustion Zone = all vent gas, pilot gas, and steam just outside the flare tip.
- Above Cst and below UFL = rich burn (oxygen starved) resulting in smoke.
- Below Cst and above LFL = lean burn (excess oxygen) resulting in extinguished flame.

Cst = Stoichiometric optimum of reaction

LFL = Lower Flammability Limit

UFL = Upper Flammability Limit

Flare Control – Why it is needed



- At Point "A" just after the flare tip, burn is rich and oxygen starved
- At Point "B", the flare is entering the combustion zone as air mixes with the gas
- At Point "C", Combustion is nearly complete as the flame progresses through the combustion zone
- At Point "D" the burn is complete as air mix is so high, combustion cannot occur
- The dotted line represents excess steam and combustion may not occur at all