

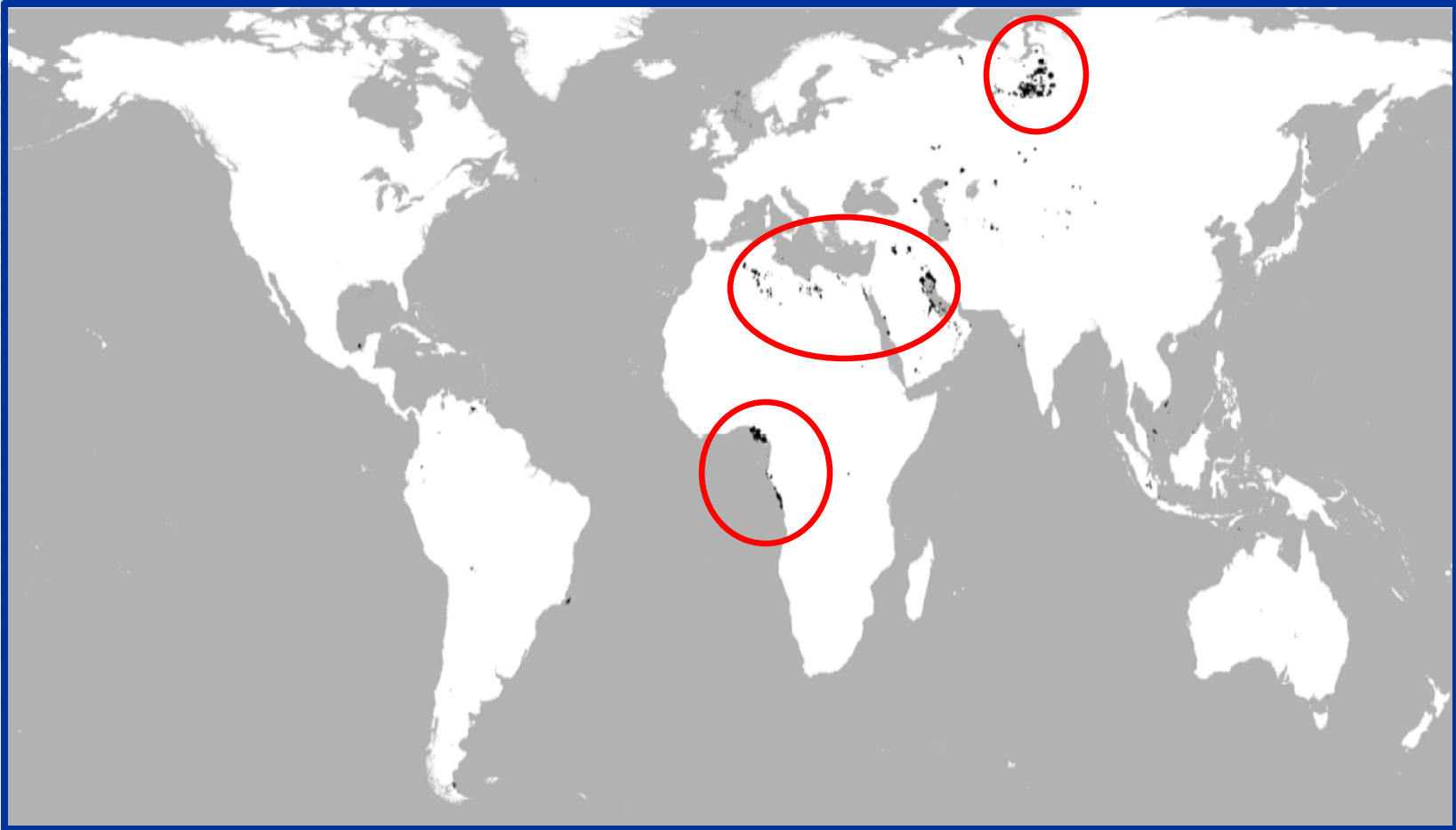


New Technology: Saudi Aramco High Pressure Air Assist System (HPAAS) for Upgrading Existing Flares to Smokeless Combustion

World Flaring



World Flaring



Source: A Twelve Year Record of National and Global Gas Flaring Volumes
Estimated Using Satellite Data Final Report to the World Bank - May 30, 2007

Utility Flares



Utility Flares - Drawbacks



- Low Exit Velocity leads to:
 - Smoke
 - Flame Pulldown → Shorter Tip Life
 - Higher Radiation Levels
 - ◆ Flame Lean
 - ◆ Higher Flame Emissive Value



Utility Flares – Smoke



Utility Flares – Smoke



Poor Public Perception



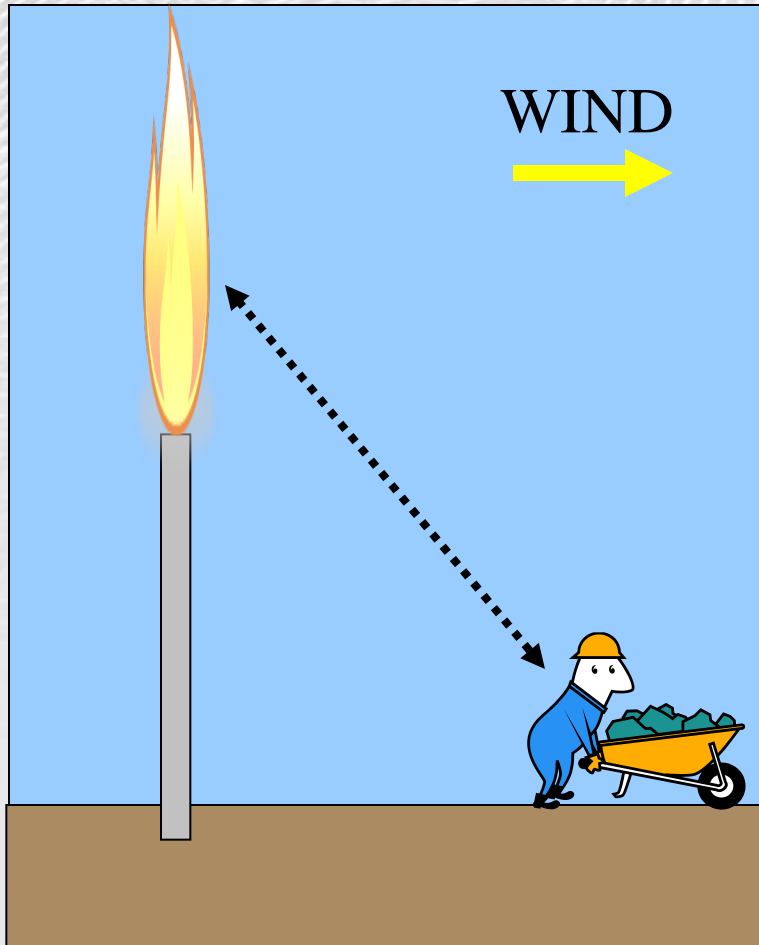
Utility Flares – Flame Pulldown



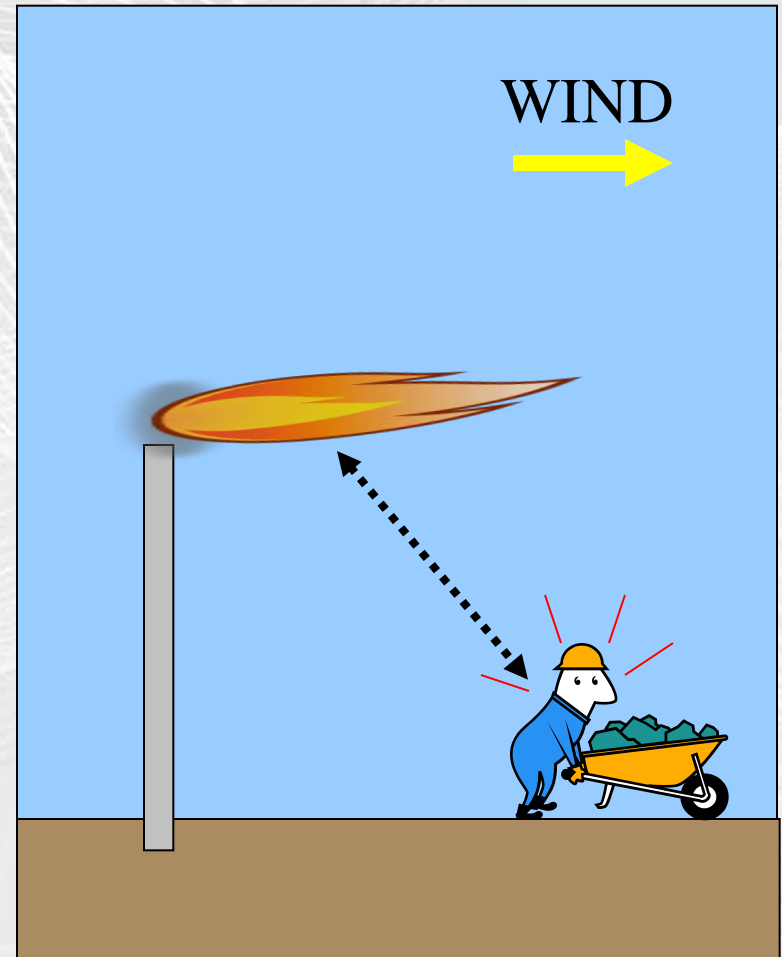
Utility Flares – Higher Radiation Levels



HIGH EXIT VELOCITY FLAME



LOW EXIT VELOCITY FLAME



Solution Needed for Saudi Aramco's Utility Flares



- Hundreds of flare systems in operation.
- Most Aramco systems are utility flares



Solution Needed for Saudi Aramco's Utility Flares



- Criteria for ideal solution:
 - Easy retrofit to existing flares with minimal installation time
 - Robust design
 - Low installation and capital cost
 - Low utility costs for operation

Solution Needed for Saudi Aramco's Utility Flares



- Analysis of Existing Technology
 - Steam-Assisted Flares
 - High-Pressure Sonic Flares
 - Low-Pressure Air Assisted Flares

Existing Technology: Steam Assist



Existing Technology: Steam Assist



- Inject steam into combustion zone
- Steam entrains surrounding air
- Smokeless Operation
- Minimal Flame Pulldown
- Low Radiation
- DRAWBACKS:
 - No Steam Available
 - Expensive Water



Existing Technology: HP Sonic Flare



Existing Technology: HP Sonic Flare



- Use the pressure in the flare gas to achieve a high exit velocity
- High velocity flare gas entrains surrounding air
- Smokeless Operation
- Minimal Flame Pulldown
- Low Radiation
- DRAWBACKS:
 - Most Saudi Aramco facilities were designed with low pressure relief systems



Existing Technology: Low Pressure Air Assist



GAS PLENUM

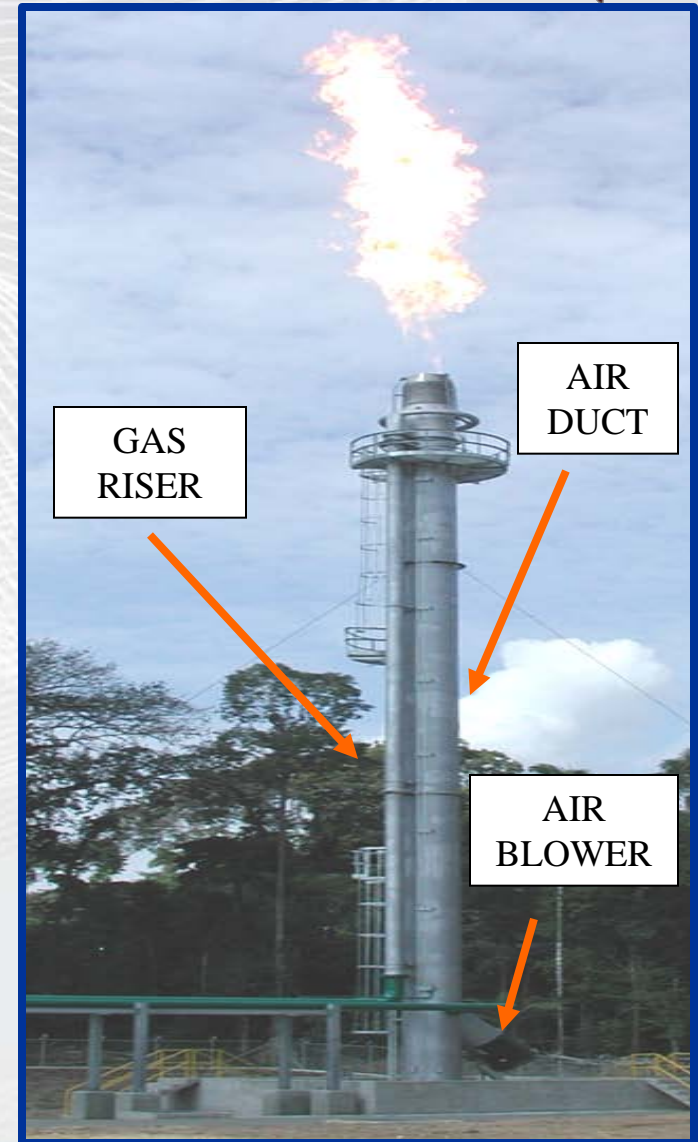
AIR PLENUM



Existing Technology: Low Pressure Air Assist



- Use a low-pressure blower to inject additional combustion air
- Assist air entrains some air from the surroundings
- Smokeless Operation
- Minimal Flame Pulldown
- Low Radiation
- DRAWBACKS:
 - Poor retrofit for existing flares because the air duct is so large.
 - Loss of cooling air exponentially reduces service life of flare tip.



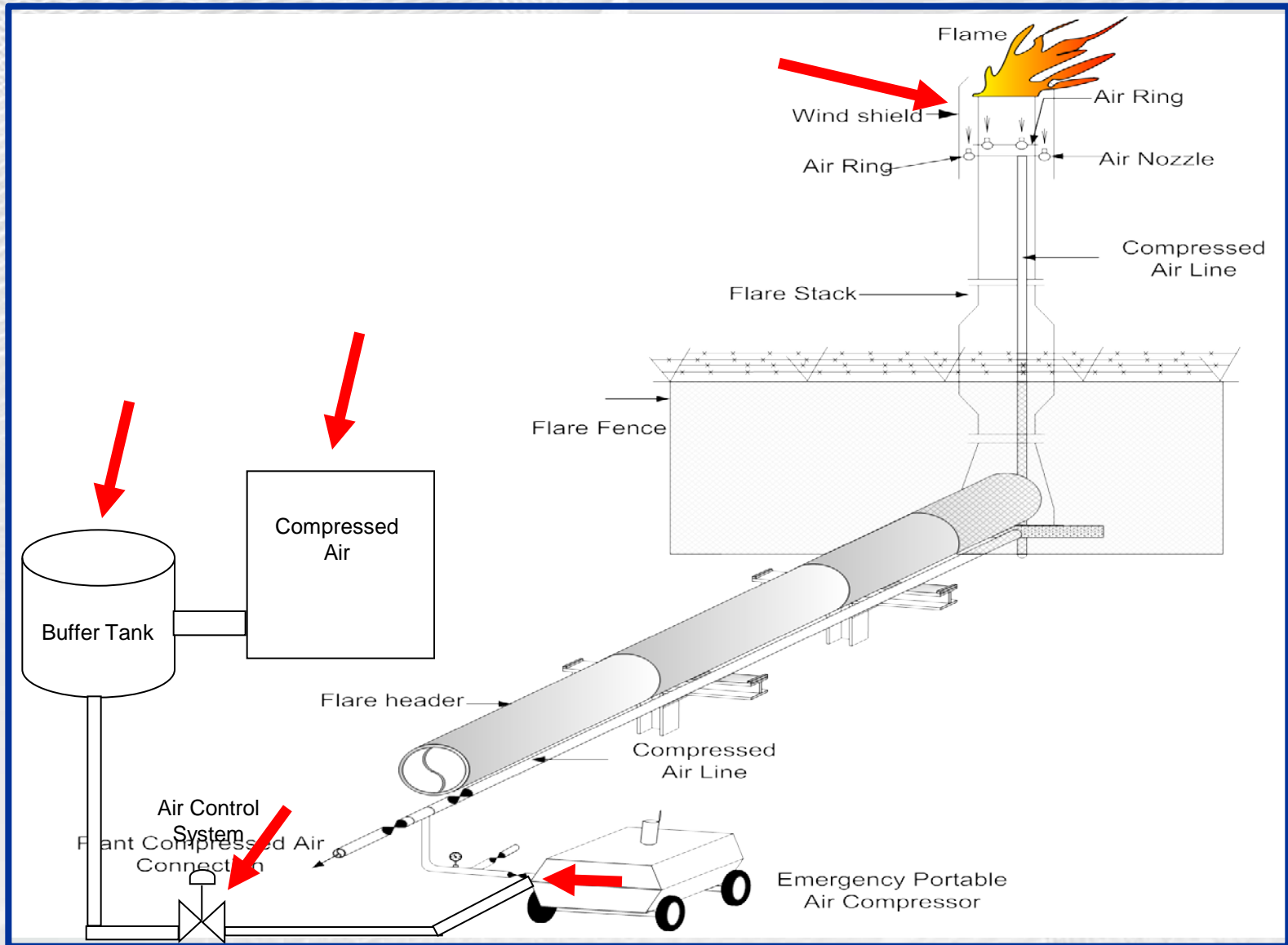
Saudi Aramco Solution: HPAAS



- High Pressure Air Assist System
- Developed and tested at Saudi Aramco's facilities
- Invented by Mazen Mashour of Saudi Aramco
- Patented Technology



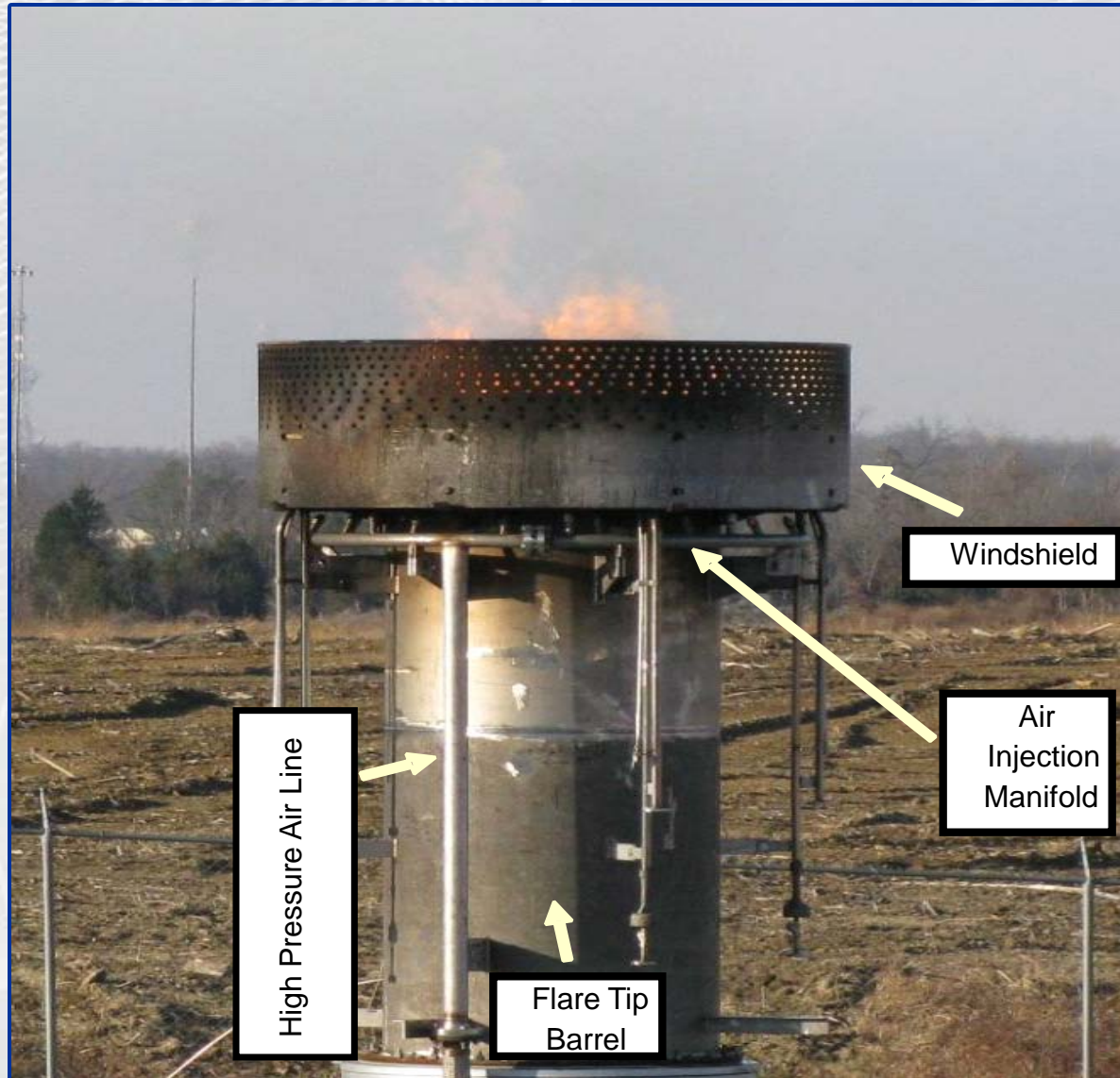
Saudi Aramco Solution: HPAAS



HPAAS Animation



HPAAS Flare Tip Components



HPAAS Advantages



- Quick and Easy Retrofit
- Robust Design
- Minor Impact to Existing Flare Structures





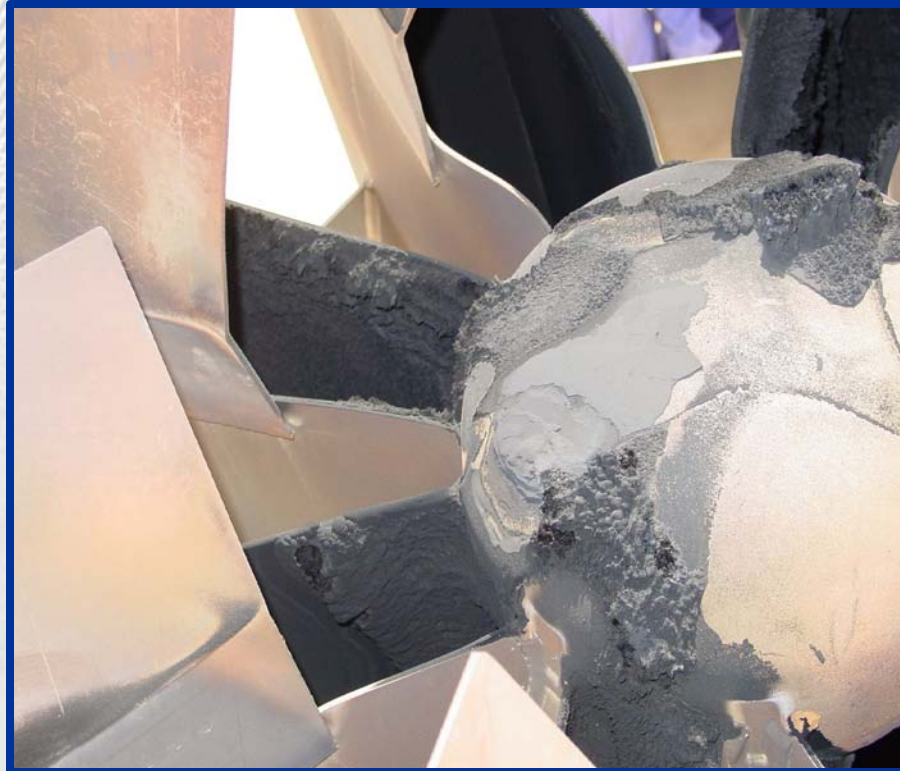
HPAAS Advantages: Quick and Easy Retrofit

- Flare tip bolts in place
- 3" or 4" air supply line added to flare stack
- Air compressor can ship as a modular unit
- Average installation time → **3 DAYS**

HPAAS Advantages: Robust Design



Low-Pressure Air
Assist Flare Design



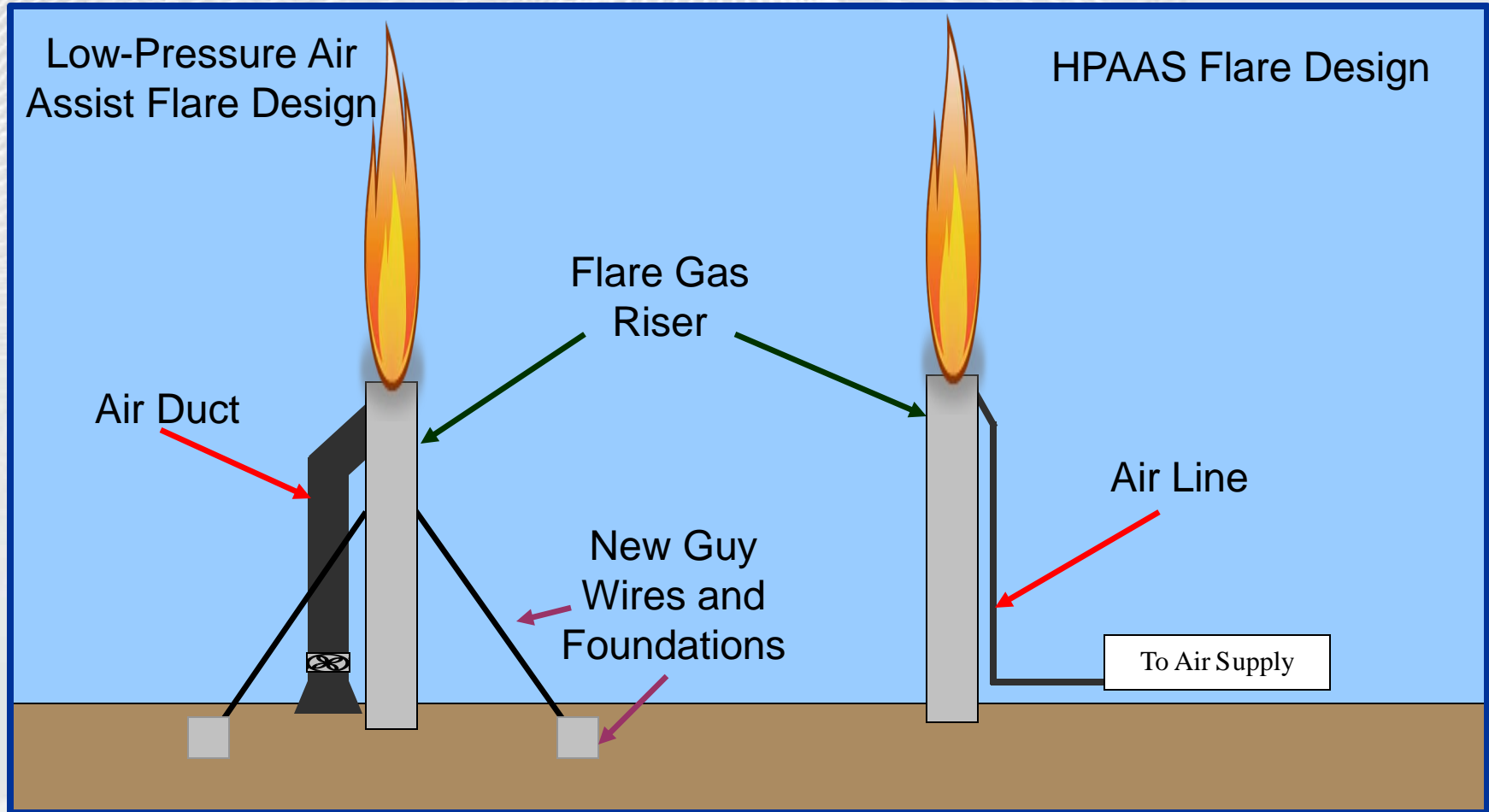
Flare tip damage due to loss of cooling air.

HPAAS Flare
Design



HPAAS tip can be operated for long periods
of time with NO cooling air.

HPAAS Advantages: Minor Impact to Existing Flare Structure



HPAAS Awards



- Gold Medal at 2006 Saudi Inventors Convention
- Excellent Achievement Award from the Malaysian Association of Research Scientists in 2006
- Gold Award and 2nd Place Overall at Geneva's 34th International Inventors' Conference in 2006
- Winner of 2007 Arab Thought Foundation's Innovation Award





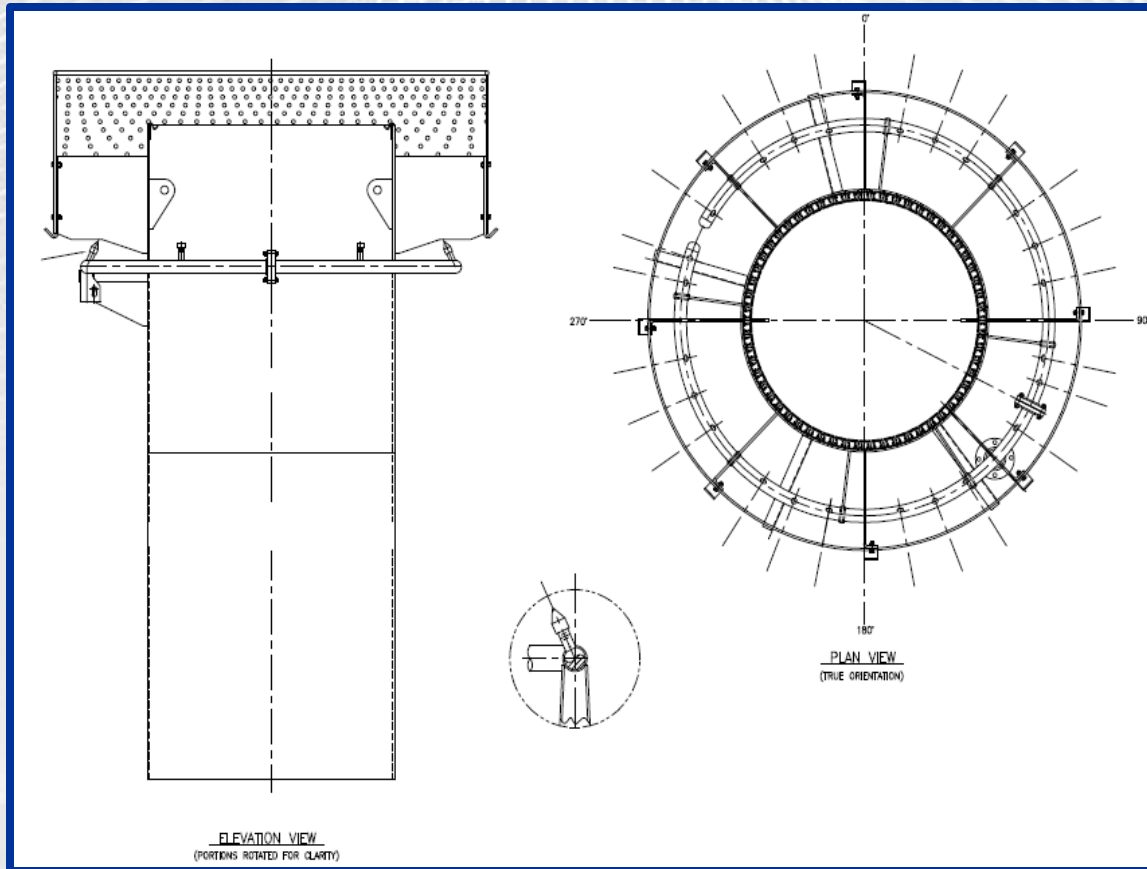
Zeeco Southern Area Smokeless Upgrade Project

- Upgrade Twenty-nine (29) Flare Systems in the Saudi Aramco Southern Area Development
 - HPAAS Smokeless Flare System Upgrades
 - CFD Modeling
 - Combustion Testing
 - New Flare Pilots
 - New FFG Ignition Systems
 - Retractable Thermocouples

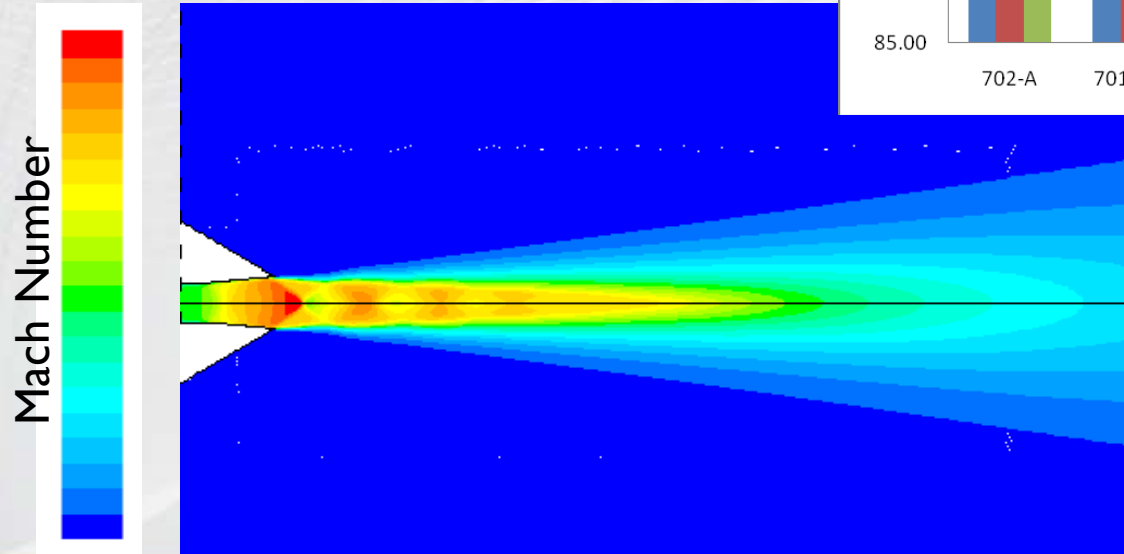
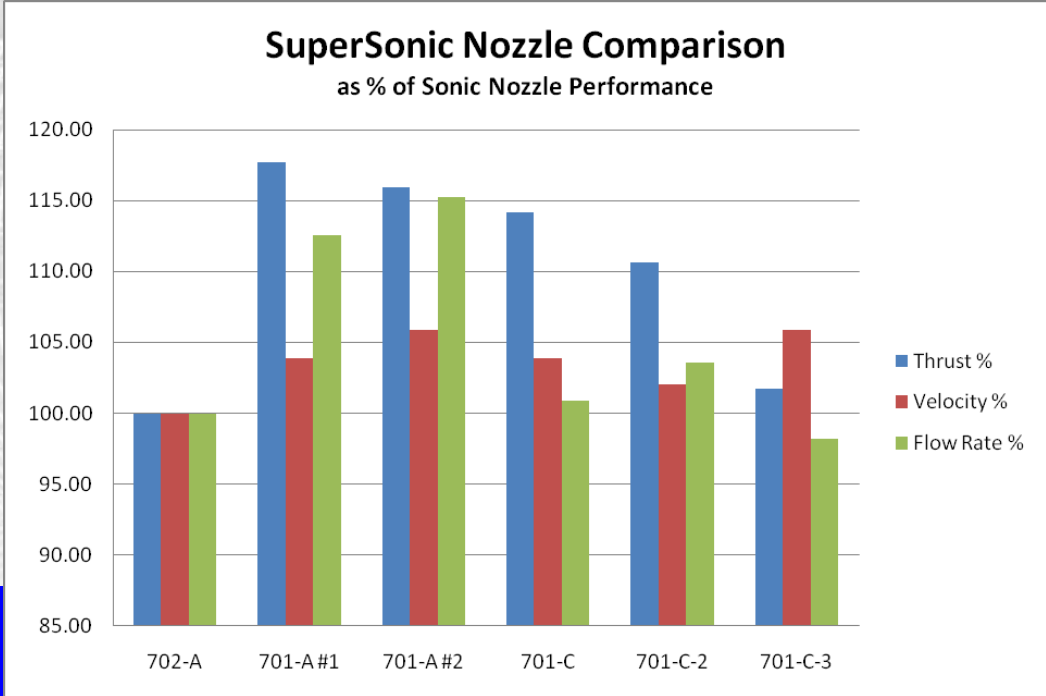
HPAAS Design Verification



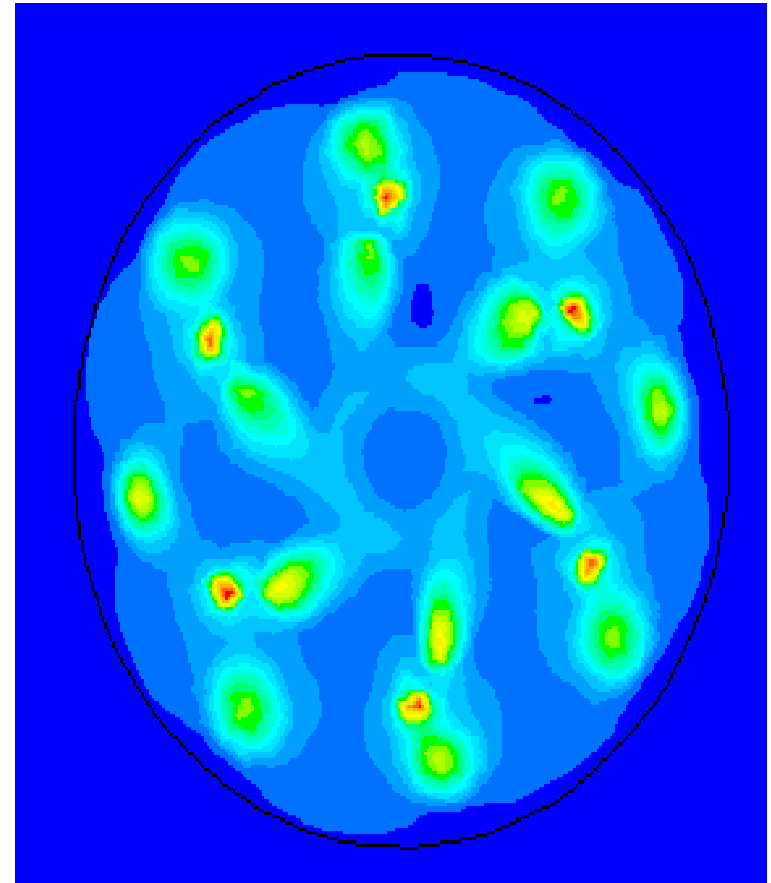
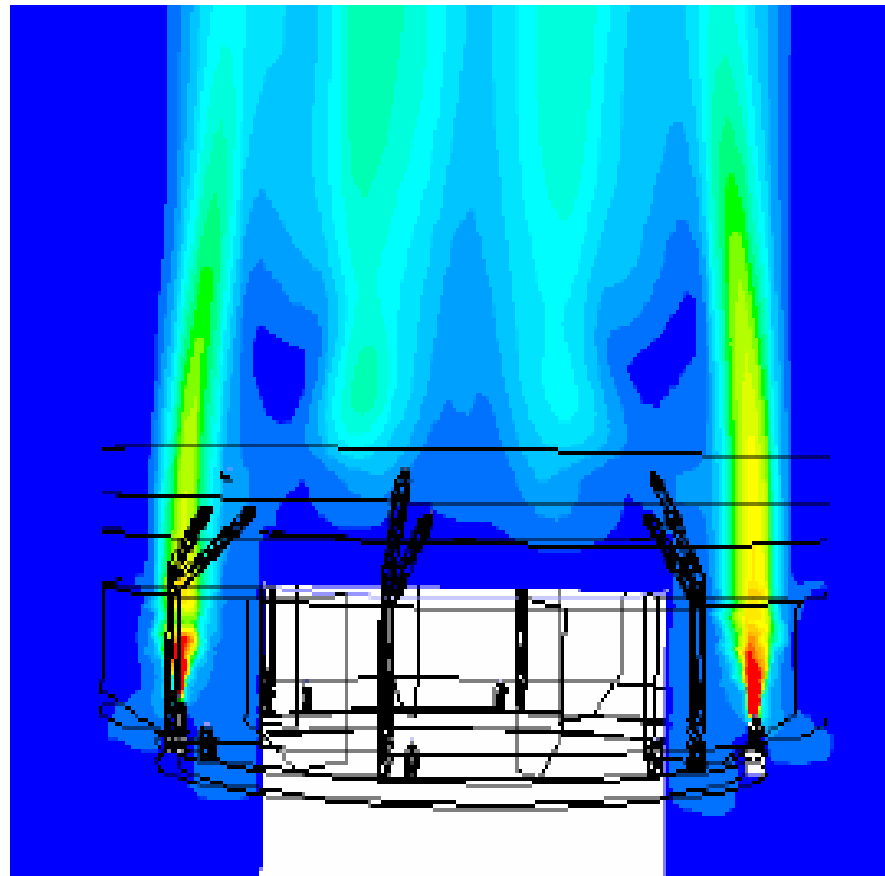
- Key Design Parameters Provided by Saudi Aramco



Testing & CFD Modeling – Supersonic Nozzles



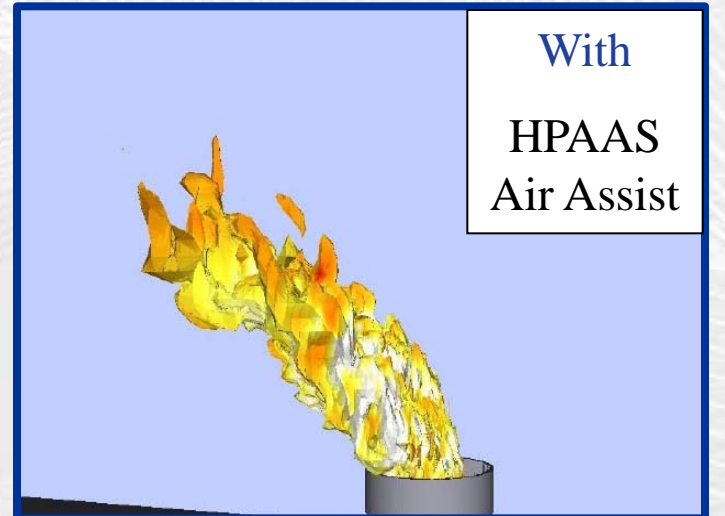
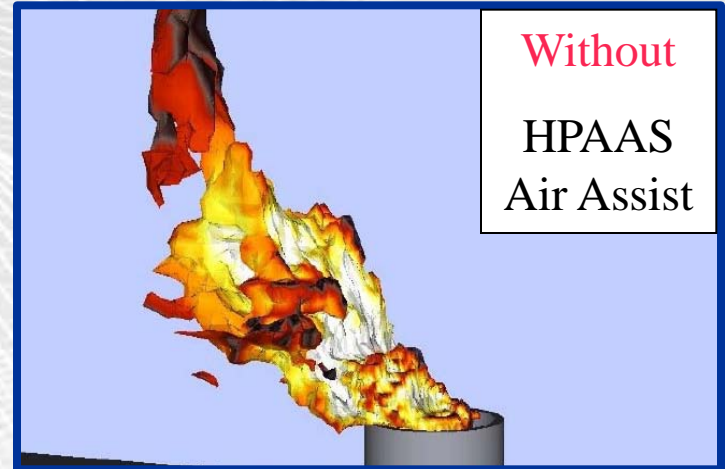
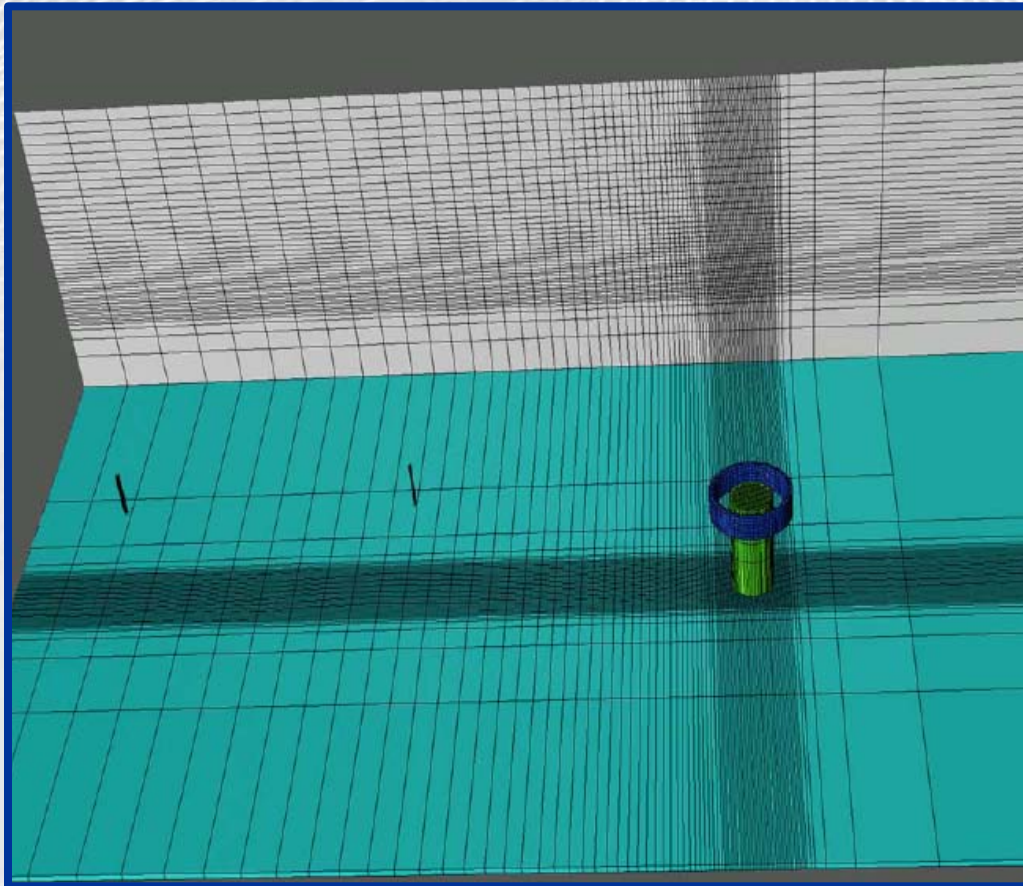
CFD Modeling – Cold Flow Modeling for System Layout



Velocity (ft/sec)



CFD Modeling – Combustion Model



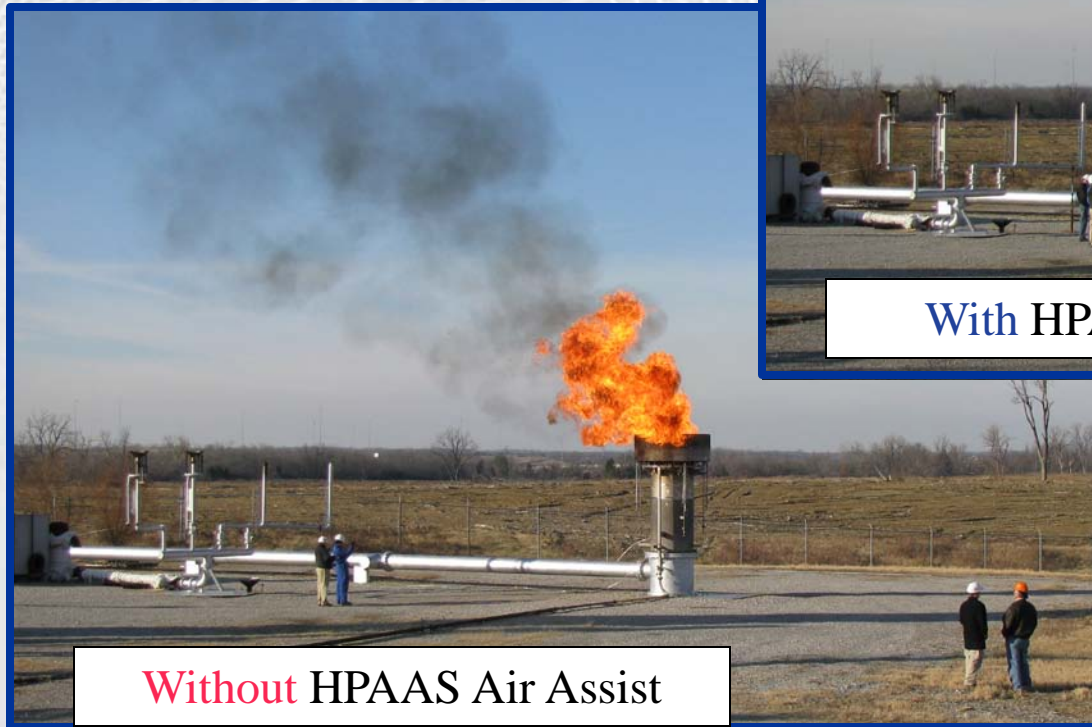
Full-Scale Combustion Testing



Full-Scale Combustion Testing



Full-Scale Combustion Testing



Without HPAAS Air Assist



With HPAAS Air Assist

Full-Scale Combustion Testing: Video



Field Success!!!



Without HPAAS Air Assist



With HPAAS Air Assist

Field Success!!!



Future of HPAAS: Saudi Aramco Licensee Agreement



Exclusive Licensee

HPAAS





Future of HPAAS: Zeeco Al-Rushaid Middle East Ltd.





Future of HPAAS: Advantages of HPAAS

- Easy retrofit to existing flares with short installation time
- Robust design
- Adaptable to range of conditions
- Minor impact to existing flare structures
- Low installation and capital costs
- Low operating costs

Future of HPAAS: Applications for HPAAS

- Retrofits to existing flare systems anywhere
- New Installations
 - Middle East
 - Russia
 - Africa
 - South America
 - Canada
- Offshore Platforms / FPSO





Contact Information

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Thank You IFRF!!!



- Questions???





ZEECO

COMBUSTION AND ENVIRONMENTAL SOLUTIONS.
PURE AND SIMPLE.



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FLARES



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PARTS & SERVICE