Flare Mitigation Strategies for Refinery

Lovraj Kumar Memorial Trust Workshop 2016

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Contents

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Introduction

Flare System

- The purpose of flare system is to conduct the relieved fluid to a location, where it may be safely discharged
- The primary function of a flare is to use combustion to convert flammable, toxic or corrosive vapours to less objectionable compounds (API 521 paragraph 6.4.1)
- Ultimate safety device in Refineries as well as related industries
- Safety during normal operating conditions, upsets as well as emergencies

Ultimate safety device – must be continuously available and reliable

Flare System

- Elevated Flares
  - Flare tip mounded at the top of stack
  - Ground level radiation less

- Ground Flares
  - Flare tip at the grade level
  - Enclosed Refractory lined CS shell or radiation shield
  - Expensive due to radiation shield and monitoring instrumentation

Typically refinery flares are elevated one and have both hydrocarbon and acid gas flares

Flare Load Mitigation

- Present Context
  - Refinery Capacity Revamp
  - Fuel Quality Upgradation Projects
- Constraints for new Flare
  - Space
  - Extended Refinery shutdown

Making existing flare system adequate with flare load mitigation strategies is the most preferred solution

Relief Load

Typical relief to Flare

- Emergency release
  - Flow from pressure relief valves
  - Emergency depressurization flow
- Occasional release
  - Start-up/ shutdown releases
  - Venting of regeneration gases
  - Venting for maintenance
- Continuous release
  - Purge gas of flare header/ sub-headers
  - Process venting like gas seals, on-line analyser outlet stream
  - Leakage from PSV and control valves connected to flare system

Typically Emergency release is the governing case for Refinery Flares

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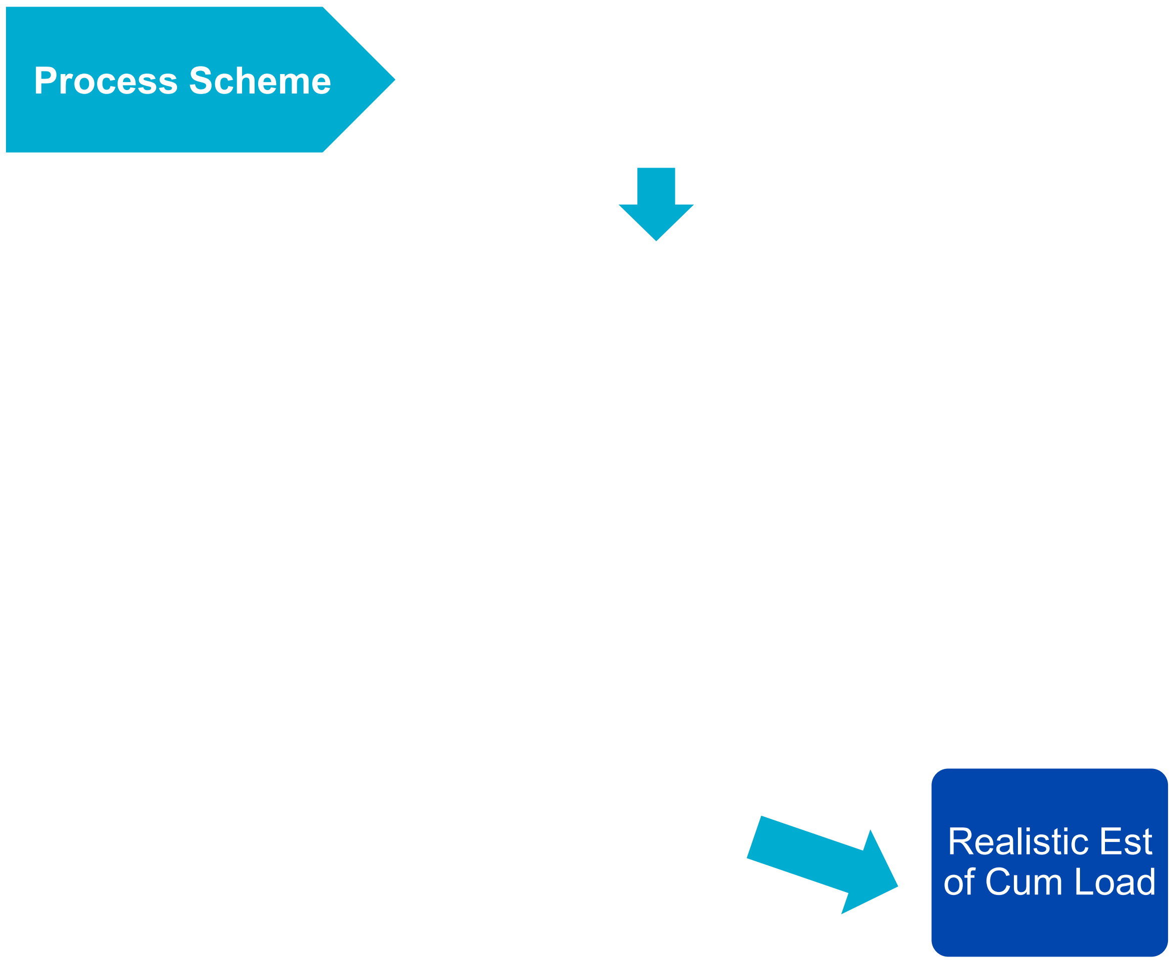
Relief Load – Concerns

- Typically flares are designed with unduly high safety margins leading to
  - Significant capital expenditure
  - More Plot Area requirement
  - Considerable operating cost – due to higher purging
  - Higher emission to atmosphere

Reduction in flare load to minimize Plot Area, Purging and Environmental Emission

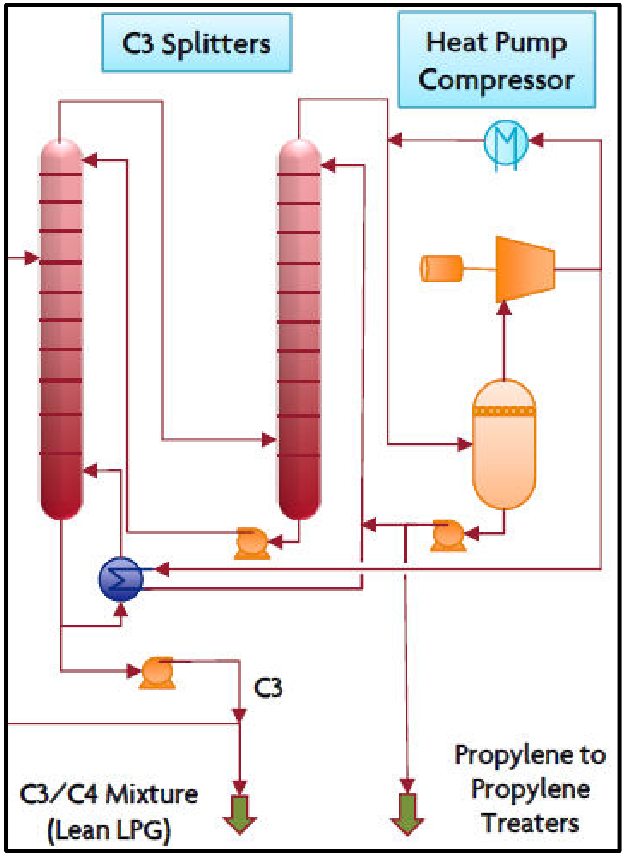
Flare Load Reduction Measures

Flare Load Mitigation – A Comprehensive Approach



Flare Load Reduction – Process Scheme

- Selection of suitable process scheme to eliminate the cause of relief
- Inherent design feature leading to less or no relief load in case of power failure
- May be an important consideration when a new unit is added as part of Refinery Revamp or Upgradation project
- C3 splitter with heat pump compressor – an example



Selection of suitable process scheme can play an important role in flare load mitigation

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Flare Load Reduction – Selection of Drive

- Typically most common governing relief load – General Electrical Power Failure (GEPF)
- Distillation Columns are major contributors for relief load
  - Steam turbine driven reflux pump will lead to significant reduction in relief load
  - Steam turbine driven cooling water pump supplying cooling water for condenser may result in no relief load scenario
- In some cases cutting the feed to the unit during power failure scenario may result in reduction of flare load, motor driven feed pumps will be most suitable option to mitigate flare load in such cases.

Selection of suitable drive is a key factor for mitigating flare load

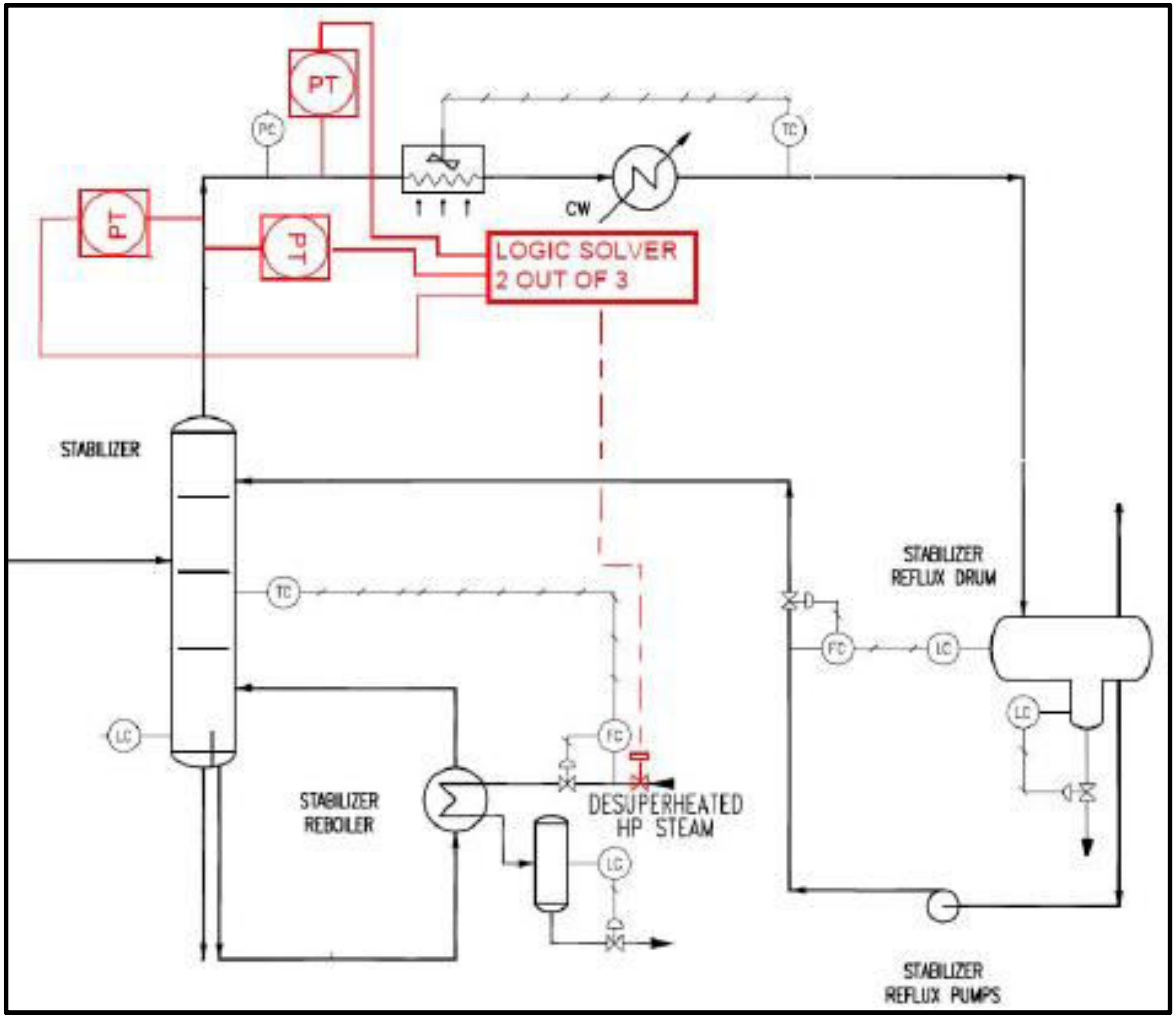
Flare Load Reduction by HIPS

- What is HIPS ?
  - *"High Integrity Protection System (HIPS) is an arrangement of instruments, final control elements (e.g. valves, switches etc.), and logic solvers configured in a manner designed to avoid overpressure incidents by removing the source of overpressure or by reducing the probability of an overpressure contingency to such a low level that it is no longer considered to be a credible case*"
- All Safety Instrumented Systems (SIS) are not necessarily HIPS
- A SIS can be qualified as HIPS only when
  - it achieves selected appropriate Safety Integrity Level (SIL) to ensure high degree of availability
  - it is subjected to specified testing intervals and procedures required to maintain the SIL

Significant reduction of flare load possible by applying HIPS

Flare Load Reduction by HIPS

A Typical SIS Configuration - Implementation of HIPS to stop heat input on High-High Pressure to reduce flare load



Flare Load Reduction by HIPS

Guidelines for Implementation of HIPS

- HIPS loops to have following attributes
  - Pressure Transmitter – normally 3 PTs required, PT to be SIL 3 certified
  - Programmable Electronic System (PES) – includes Logic Solvers, IO cards, power supplies, communication interfaces. Etc. to be SIL certified
  - Power Supply - Each HIPS cabinet shall be powered by two independent UPS 110 v, 50Hz
  - Shutdown Valves - Two quick SDVs shall be installed in series for SIL 2 certified SDVs. Alternately, one SIL 3 certified SDV can be considered
  - Solenoid Valves – Solenoids can be configured 1oo2 to maximize safety availability; or can be configured 2oo2 or 2oo3 to reduce spurious trips
  - Inspection and Testing - HIPS requires annual testing for pressure transmitters, monthly testing of solenoid valves, monthly partial stroke testing of shutdown valves and full stroke testing of shutdown valves during plant turnaround

Regular Inspection & Testing is MUST for taking credit of HIPS

Flare Load – Realistic Estimation

- Flare load estimated by conventional method is generally conservative and mostly leads to over designed relief system
- Dynamic simulation provides more realistic relief loads without sacrificing safety requirements
  - Dynamic model simulates the fluid inventory hold-up and predicts the time before relief-pressure is reached
  - Dynamic model accounts for the depletion of light components and estimates changes in heat of vaporization and temperature with time, which can lead to a partial loss of reboiler duty due to decreased LMTD or depletion of liquid inventory in the column sump

More realistic estimation by Dynamic Study

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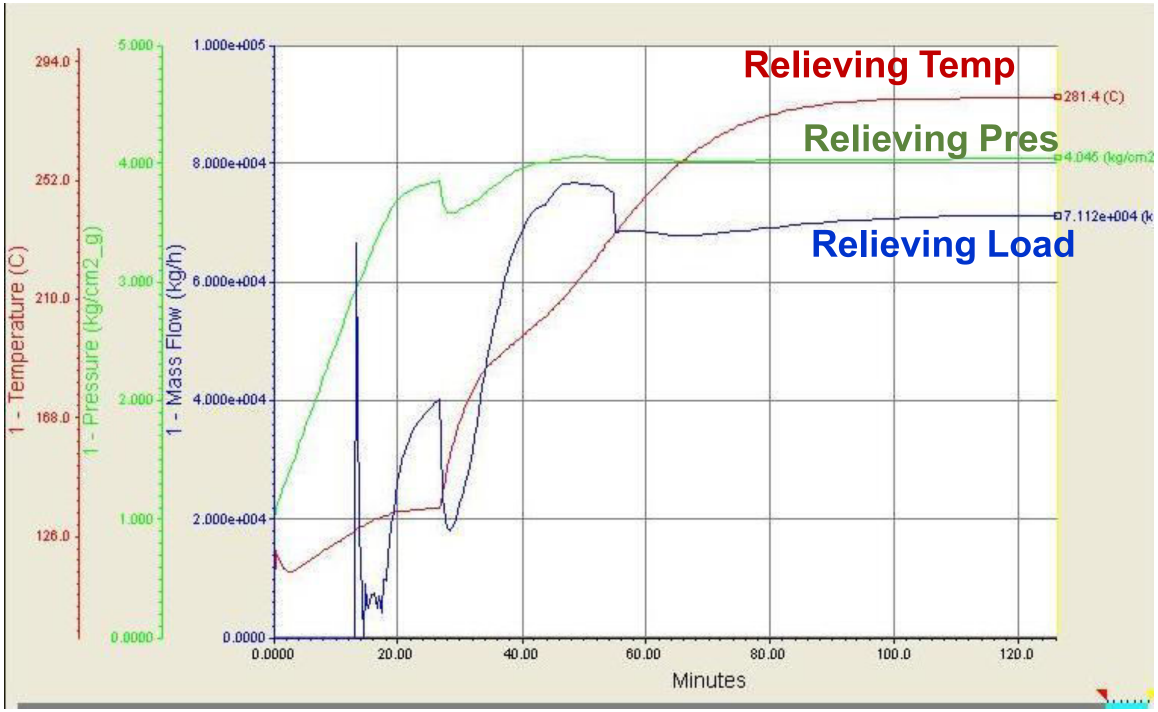
Realistic Estimation of Flare Load by Dynamic Study

Example: DHDT Main Fractionator (Recently executed by Technip India)



40% less relief load compared to conventional estimation

Conventional Method				Dynamic Simulation			
Relief Load (kg/hr)	Relieving Pres. Kg/cm^2g	Relieving Temp. Deg C	MW	**Relief Load (kg/hr)**	Relieving Pres. Kg/cm^2g	Relieving Temp. Deg C	MW
137,050	4.05	292	139.9	**77,000**	4.05	281.4	141.3

Flare Load Mitigation – A Comprehensive Approach

Process Scheme

Realistic Est of Cum Load

Flare Load Mitigation – Segregation of Electrical System

- Typically most common governing relief load – General Electrical Power Failure (GEPF)
- Separate source of power supply connected with separate bus bars
  - Entire Refinery does not face power failure at a time
  - Major contributors are not on same bus bar
  - The philosophy can be employed for overall refinery as well as within units also
- To be conceptualised at the grass root design stage itself

Significant reduction of flare load possible with segregation of electrical system

Flare Load Mitigation – Segregation of Cooling Water System

- General Electrical Power Failure (GEPF) will lead to cooling water failure also if all cooling water pumps are motor driven
- Steam turbine driven cooling water pumps for secured supply of cooling water to major contributing units
- Cooling Water Failure – another major relief scenario
- Separate source of cooling water supply
  - Entire Refinery does not face cooling water failure at a time
  - Major contributors are not from same source
  - The philosophy can be employed for overall refinery as well as within units also
- To be conceptualised at the grass root design stage itself

Significant reduction of flare load possible with segregation of Cooling Water Network

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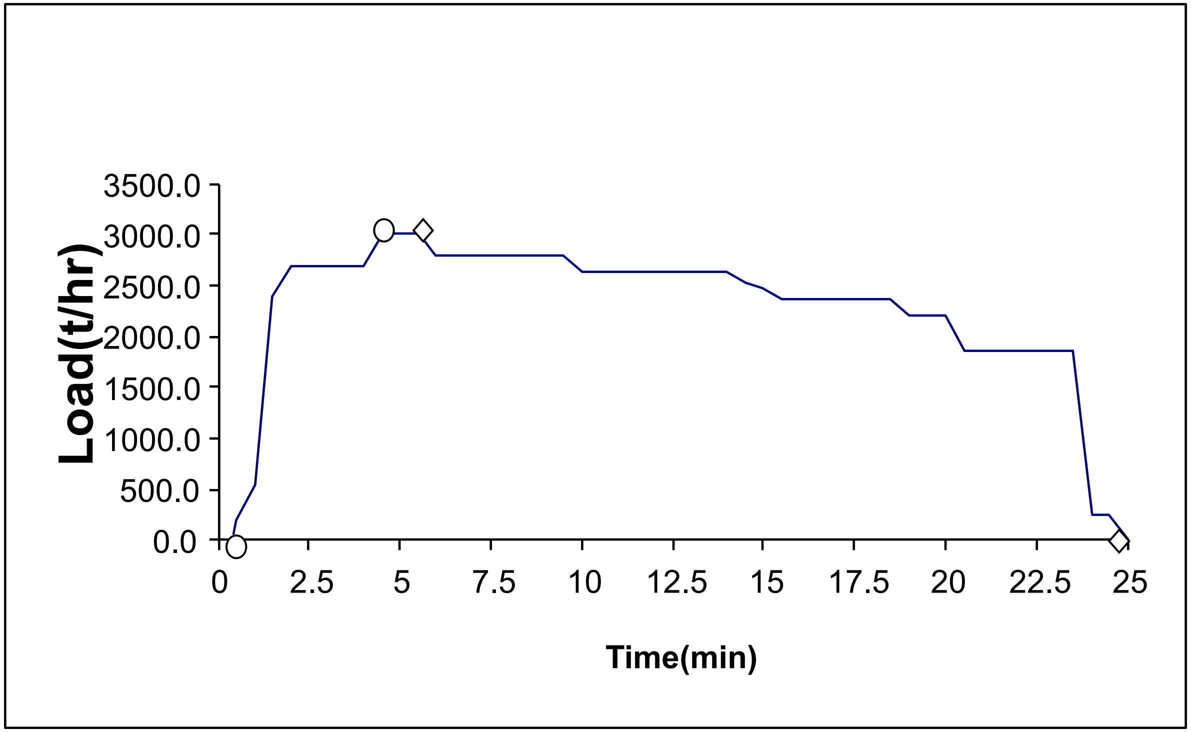
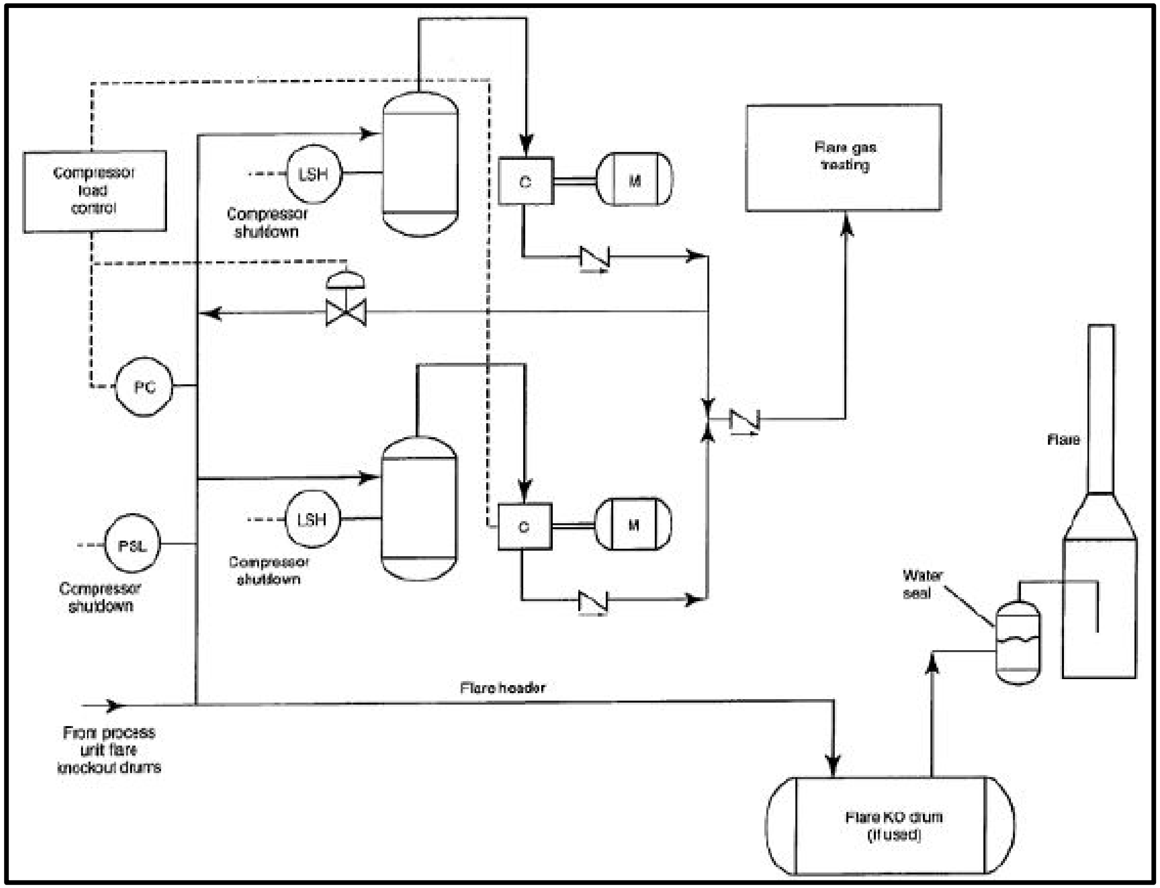
Cumulative Flare Load – Realistic Estimation

- All PSVs may not relieve at same time
- Not necessary to add all loads for a particular relieving scenario
- Dynamic or semi-dynamic analysis to establish cumulative flare load against time



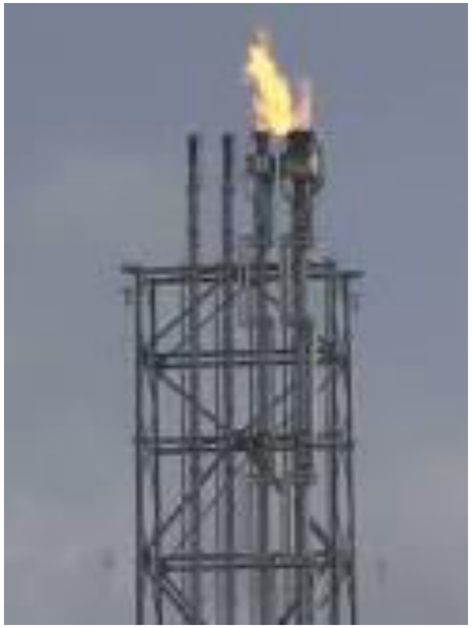
Flare Load Reduction – Other Options

- Flare Gas Recovery
  - Recovery of gas by compressing and routing to process unit having proper treatment facilities

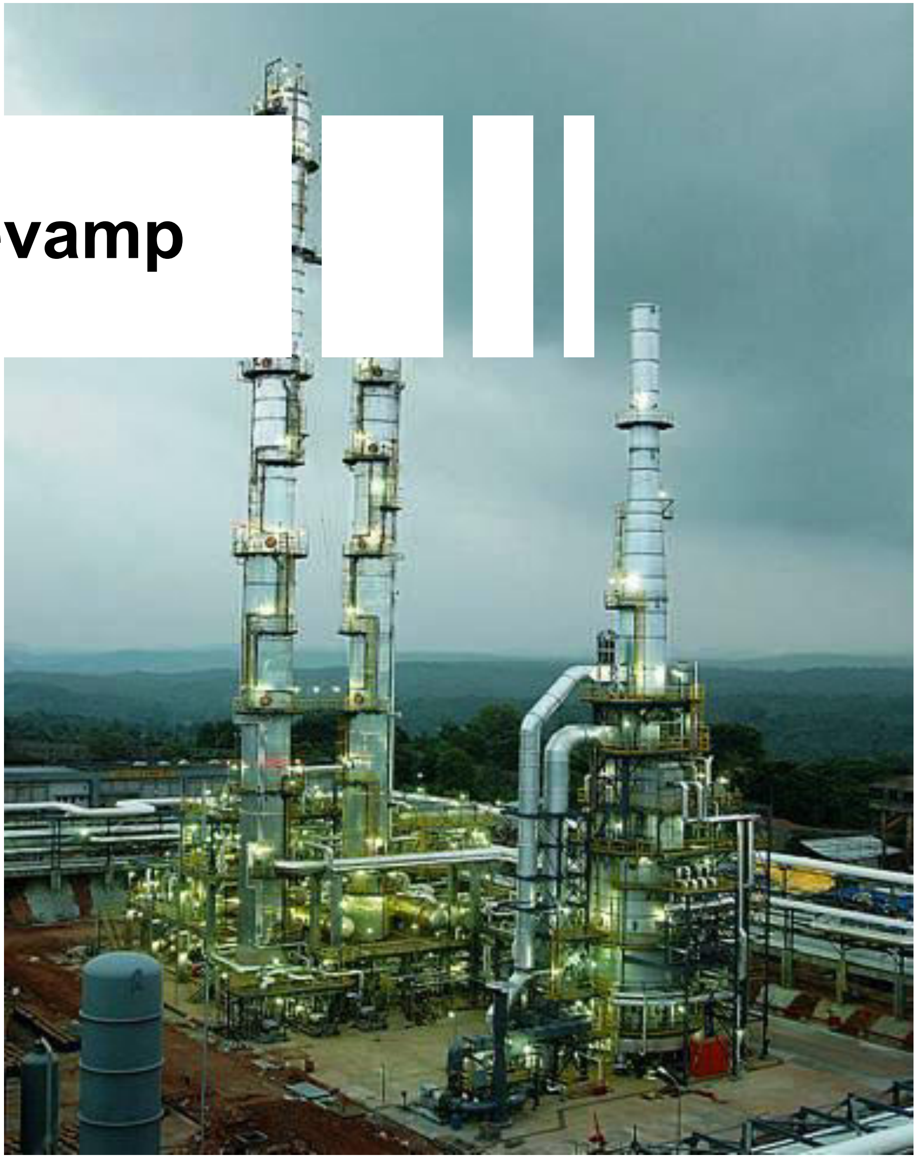


Flare Load Reduction – Other Options

- Other Best Practices
  - Leak source monitoring and control
    - Acoustic monitoring
    - Temperature monitoring
    - Flare gas analysis
  - Start-up/ shutdown planning
  - Load shedding plans
  - Root Cause analysis of flaring events



Case Study for Refinery Revamp



Flare Load Reductions – Case Studies

- Case Study - for Indian Client
  - Two separate trains with all major process units proposed in the refinery
  - New flares for both Train-1 and Train-2
  - Combined LP Flare for Train-1 and Train-2 Units
  - Combined HP Flare for Train-1 & 2
- Flare Load Reduction Measures:
  - High Integrity Protection System (HIPS)
  - Other mitigation measures like – Steam Turbine drive for Cooling Water Pumps, Steam Turbine drive for Reflux Pumps

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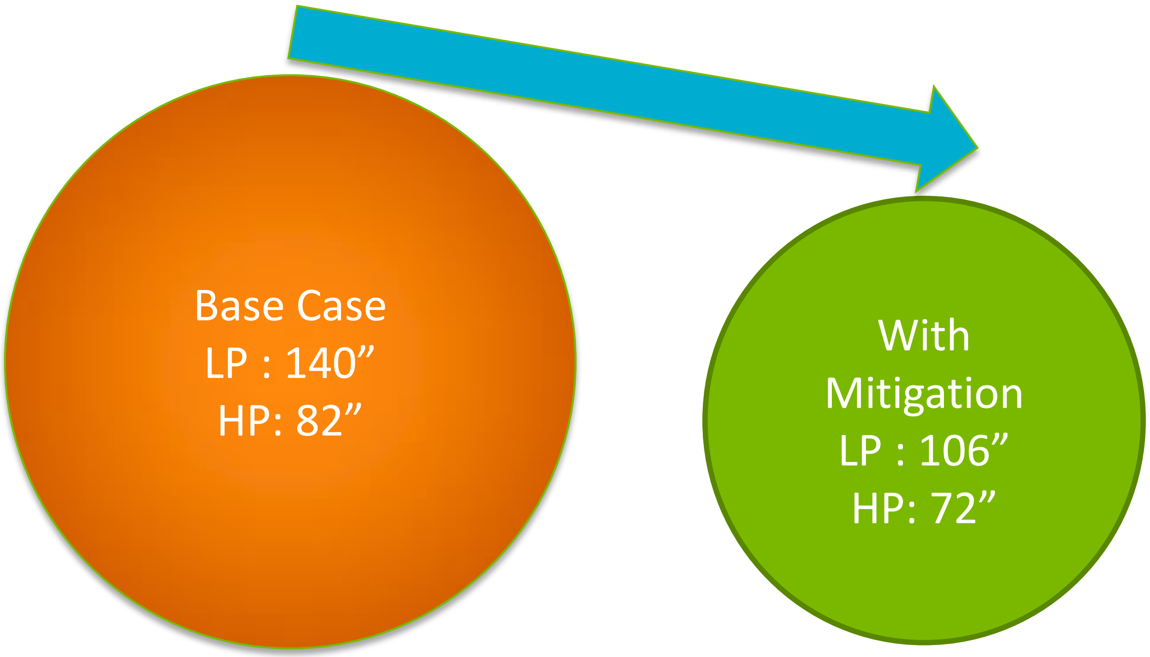
Flare Load Reductions – Case Studies

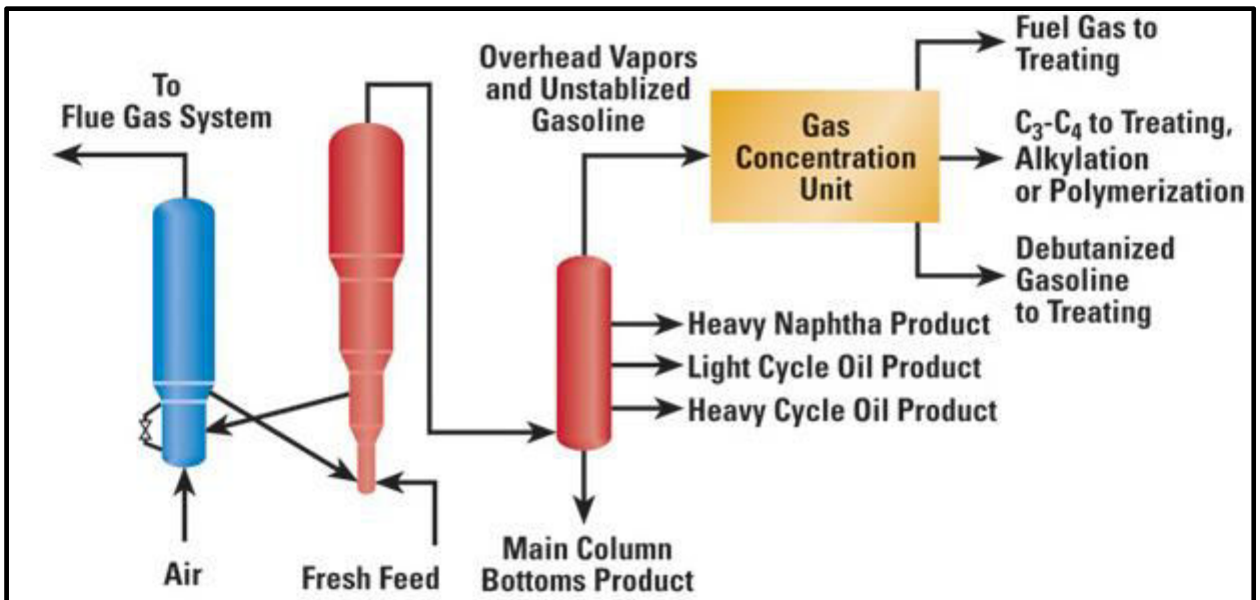


- 50% reduction in LP flare load and 35% reduction in HP flare load
- Less sterile area requirement
- Less purging requirement

Case Study for FCC/RFCC units

Flare Mitigation Strategies in FCC/RFCC units

- Fluidized Catalytic Cracking Unit (FCCU) is a work horse of petroleum refining industry producing good quality motor gasoline, LPG, Propylene and other products by upgrading residue
- Major sections – Reactor & Regenerator, Main Fractionator and Gascon unit
- Higher demand of propylene calls for more severe operation and leads to more flare load



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Flare Mitigation Strategies in FCC/RFCC units

- Major contributor to flare load
  - Main Fractionator
  - Stabilizer
  - C3/C4 Splitter
  - C3 Splitter
- Main Fractionator:
  - Power Failure – Relief load can be eliminated or significantly reduced by considering motor driven feed pump
  - Realistic estimation of relief load by Dynamic Simulation
- Stabilizer and C3/C4 splitter:
  - Relief load can be eliminated by application of HIPS
  - High High pressure will cut steam input to Reboiler

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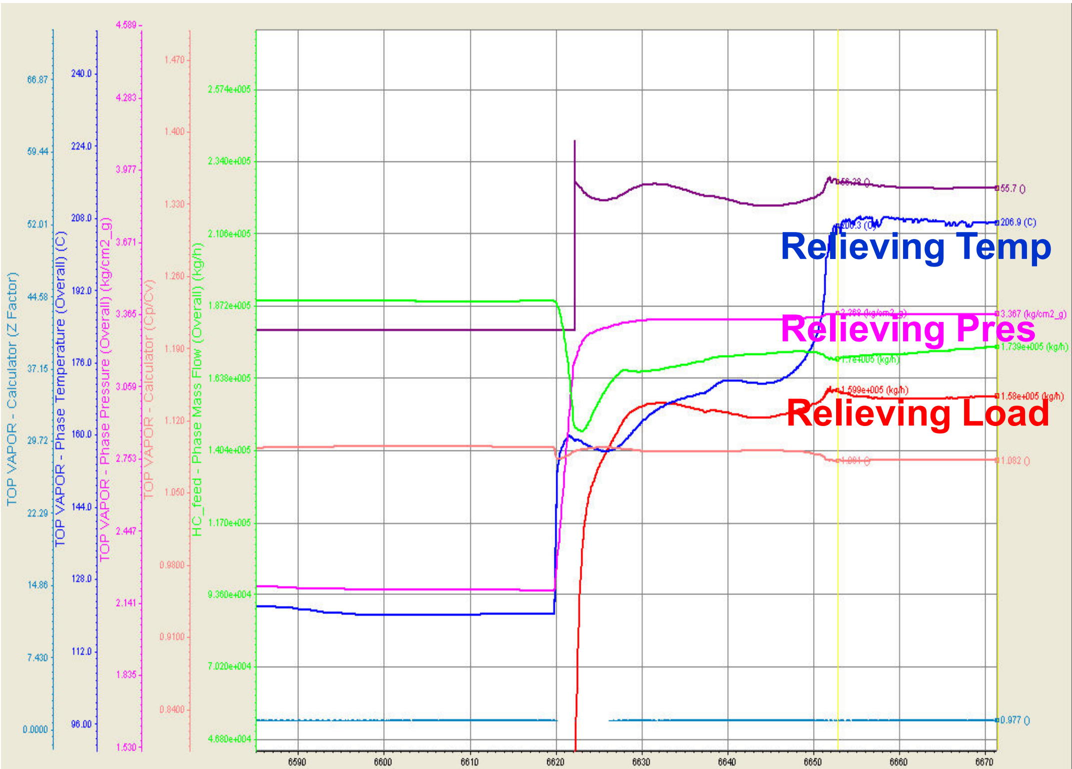
Realistic Estimation of Relief Load for FCC main fractionator

FCC Main Fractionator (Recently executed by Technip India): Reflux Failure case



35% less relief load compared to conventional estimation

Conventional Method				Dynamic Simulation			
Relief Load (kg/hr)	Relieving Pres. Kg/cm^2g	Relieving Temp. Deg C	MW	**Relief Load (kg/hr)**	Relieving Pres. Kg/cm^2g	Relieving Temp. Deg C	MW
258,571	3.9	222.7	106.2	168,300	3.9	206.9	55.7

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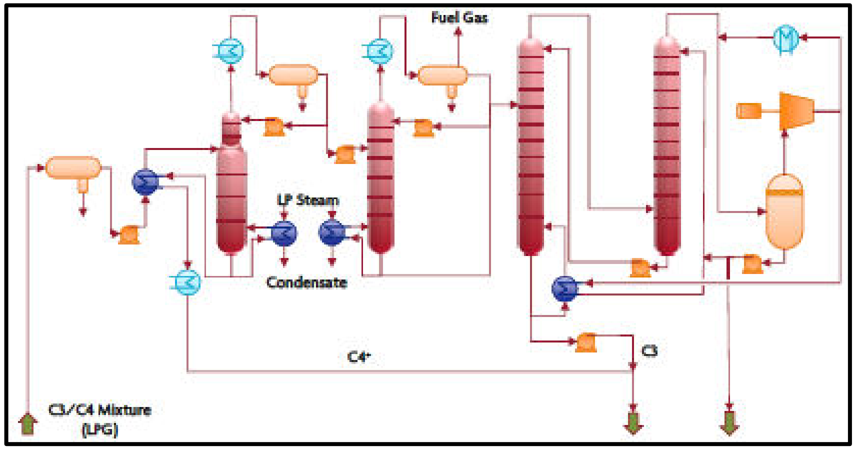
Flare Mitigation Strategies in FCC/RFCC units

- **C3 Splitter:**
  - Conventional C3 Splitter with steam reboiler – HIPS can be applied to cut steam input to Reboiler at column High High pressure
  - C3 Splitter with Heat Pump – Motor driven compressor can be selected to stop heat input during power failure resulting no relief load
  - C3 Splitter with Heat Pump – Turbine driven compressor
    - ➢ failure of reflux (partial or total) during power failure case will lead to high pressure/temperature at compressor inlet
    - ➢ High high suction pressure/temperature will trip compressor



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Flare Load Mitigation – A Comprehensive Approach

Process Scheme

Realistic Est of Cum Load

Conclusion

Conclusion

- Flare plays a critical role as an ultimate safety device in refineries
- Typically flares are designed with unduly high safety margins
- A comprehensive approach to Flare Load mitigation
  - Less plot area requirement
  - Less operating cost – less purging
  - Less turnaround time during revamp
  - Less emission to atmosphere
- In present day context when several refineries are taking up Revamp and/or fuel upgradation projects, Flare Load mitigation has great relevance as it meets both economic and environmental objectives
- Technip India executed several flare projects recently – Grass Root Refinery, Revamp and Upgradation Projects for Refineries and Ethylene Complex

Thank You

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