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Case Study and Design Flare Package System for Waste Gas

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Abstract

This study examines the important issue to determine flare header size extension from original location to new location of acid flare to prevent damage caused by overpressure. *Gas flaring is a common practice used in many industrial processes such as refinery, petrochemical, and oil-gas industry to release flue gas. It is a must-have safety requirement which is installed to reduce excess pressure when the plant is shut down for annual repair, start up or emergency circumstance. With case study and design flare packages system will get additional information because acid flare system has been designed based on the largest single risk with consideration of acid content. Methods flare design studies will be using thermo-hydraulic model. The modelling will be simulated using AspenTechs FLARENET software with some scenario from existing acid flare system design basis for non-simultaneous relieving load and then new acid flare will receive additional load from new unit. From the result of simulation, without changing the size of tailpipe will cause the failure of PSV when the fire case occurred. So, start up without changing size of pipes is not recommended, change some tailpipe 3" into 4" to ensure sufficient back pressure during fire case, for CV failure scenario to ensure back pressure sufficient during CV fail scenario, change type PSV from balance to pilot type*

Keywords: *Flare, Waste Gas, Flare Header, AspenTechs FLARENET*

1. Introduction

Flare is the last defense of handling emergency occurred in oil and gas industry. Flare system is used to release or refine product from refinery, releasing gas from blast furnace, gas from coke ovens or possibly separating gas from water processed in chemistry industry. This case study is related to the Refinery Development Master Plan by building unit process facility. Utility and support unit (facilities unit), as the existence of facilities development, it will advance revamp CDU unit. The aim of developing Refinery is:

- Escalating margin from existing refinery unit.
- Increasing gasoline supply and diesel to fulfill market needs.
- Upgrading refinery unit in order to enable processing high Sulphur crude.
- Final product can fulfill specification euro V diesel and gasoline.

With the existence of escalating capacities above, so it is necessary to make case study, redesign for translocation and building new flare system.

2. Methods

The case study will only discuss about Acid Flare System that has highest risk because of containing acid. Acid Flare System has been already existed before however it needs to move because it will get more waste gas from new unit. For modelling will be used thermo-hydraulic, thermo-hydraulic modelling serves a key role in flare design. From thermo-hydraulic enables to use parameters such as Mach, temperature, pressure and others parameters to modelling or modification flare systems. For tool will be using AspenTech's FLARENET, this software common use many flare system design engineers as steady state modelling tool. AspenTechs FLARENET are accurate and reliable modelling of system thermo-hydraulic especially for back-pressure, as we know back pressure is critical in the flare system design. Step of this study is:

- Modelling FLARENET

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- Run simulation for over pressure scenario
- Analyze and discuss the back pressure build up in the flare system design
- Recommendation from the impact of back pressure relieving devices and get mitigating measures

2.1 Process Design Basis

2.1.1 Existing Acid Flare System Design Basis

Existing acid flare is designed based on the largest single risk with consideration of acid content. Normally sour gas produced from the Sour Water Stripper unit and plant 38 will be sent to treating facility. During start-up activities, normal operating and shut down the new Sour Water Stripper plant may have potential emergency condition which could endanger the unit and environment. one of the emergency conditions is caused by overpressure exceed the design pressure. In emergency situation when the system gets failure the switch valves from sour gas line to other gas processing will be closed then divert the sour gas to the flare. The new existing acid flare is built to handle emergency situation from plant 7 or plant 17.

2.1.2 New Acid Flare System Design Basis

Acid flare system at new location shall be designed with the following basis:
The acid gas flare shall be designed with same basis of existing acid gas flare as above

- Scenario 1: Continuous off-gas flaring from Plant 7 and HCU Plant 17
- Scenario 2: Control valve failure from Plant 17 and HCU Plant 017
- Scenario 3: External fire from HCU PLANT 17
- Scenario 4: CV is failed to open for plant 7, 17 and 079-PSV-001- A/B
- Scenario 5: Block outlet in Plant 7, HCU Plant 17 067-PSV-104 A/B
- Scenario 6: Total power failure 17-PSV-066 A/B, 067-PSV-003 A/B, 067-PSV-103 A/B, 079-PSV-14 A/B/C
- Scenario 7: Liquid overfill 067-PSV-001 A/B, Plant 7 and HCU Plant 17
- The acid gas flare will receive relieving load from Plant 007 and Plant 017 as per basis design existing philosophy
- Non-RFCC Plant 067 and Amine Regeneration Unit 079 will be flowed to new acid flare
- Acid flare will be relocated 300 m from starting point
- Horizontal Velocity:

  $$U_h < \frac{L_1}{H_1} \times U_t \quad (1)$$

  Uh : Horizontal Velocity (m/s)
  L1 : Inlet Nozzle to Outlet Nozzle (m)
  H1 : Vapor Space (Diameter to HHLL) (m)
  Ut : Terminal velocity (m/s)
- Pipe Design
  Erosion Velocity
  From API 14E 5th edition, 2013 section 2.5 following:

  $$V \leq C/\sqrt{\rho} \quad (2)$$

  V Velocity (m/s)
  C Erosional Constant
  Solid free continuous flow C: 122
  Solid free intermittent flow C: 152.5
  Solid free non-corrosive continuous flow C: 183 – 244
  Solid free non-corrosive intermittent flow C: 305
  p average vapor density (kg/m3)

3. Result and Discussion

Some relief load data scenario will be used for evaluation of existing location: gas treating trip, incinerator trip, external fire, power failure. For new flare system will be evaluated based on: continuous flaring, external fire, control valve failure, block outlet, total power failure. Liquid overfills.

For length equivalent indicated based on piping isometric drawing and using common engineering practice with assumption typical tail pipe arrangement with other PSV will be used and distance between tee of each PSV tail pipe is 20 m, each tail pipe length 50 m, and minimum heating value 200 BTU/SCF.

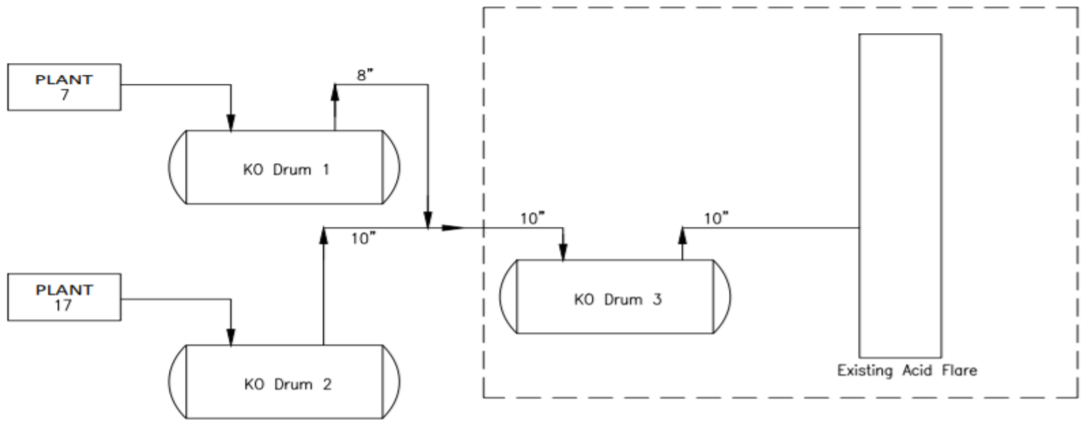

Figure 1. Flow Diagram Existing Flare Header

3.1 Existing Flare Header

From the result of simulation of existing flare header report and running Hysis can be concluded as the following Table 1. The Result of existing Acid Flare header simulation

Table 1. The Result of Existing Acid Flare Header Simulation

No	Scenario	Back Pressure		Remark
		MABP	Calculated	
1	Plant 17	1.8958	1,57749	ok
2	Plant 7	1.8958	1,52873	ok
3	Power Failure PLANT-17	2.38619	2.67101	Back pressure higher than MABP
4	External Fire PLANT-17-16	2.38619	2.67101	ok
	External Fire PLANT-17-023	2.38619	1.91641	ok
5	External fire PLANT-17-023	2.38619	2.29342	ok
	External fire PLANT-17-16	2.38619	2.63771	Back pressure higher than MABP

Simulation of existing flare configuration has been conducted and summary has been reported as the following Table 1. The Result of Existing Acid Flare Header Simulation, several highlighted concern as followings:

- External fire case scenario for plant 7 resulting that calculated back pressure of PSV-16A/B is higher than maximum allowable back pressure

- Power failure case scenario for plant 17 resulting that calculated back pressure of 17-PSV-16A/B is higher than maximum allowable back pressure

3.2 New Acid Flare System

By using simulation study of FLARENET with new configuration gets the result seen in Table 3. The Result of New Acid Flare Header simulation.

Table 2. The Result of New Acid Flare Header Simulation

NO	Case Scenario	PSV Tag No	MABP	Calculated
Case- 1	Plan-7 and Plan t-17 Continuous Flaring	Plant-17 Continue	1. 6997	1.4734
		Plant-7 Continue	1.6997	1.5435
Case-2	External Fire Plant -7	7-PSV-023A/ B	2.3862	2.1508
		7-PSV-16 A/ B	2.3862	2.2409
		Plant-17 Continue	1. 6997	1.50 83
Case-3	External Fire Plant-17	17-PSV-023A/ B	2.3862	1.5789
		17-PSV-16A/ B	2.3862	1.6061
		Plant-7 Continue	1.6997	1.4840
Case-4	CV Fail Open	079-PSV-001A/ B	2.5823	3.5543
		Plant -17	1. 6997	1.6332
		Plant- 7	1.6997	1.6892
Case-5	Block Out let	06 7-PSV-104A/ B	2.386 2	1.7193
		Plant-17	1.6997	1.4691
		Plant-7	1. 6997	1.4587
Case-6	Total Power Failure	17-PSV-16A/ B	2.3862	2.3369
		067-PSV-003A/B	2.464 6	2.3617
		067-PSV-103A/ B	4.1906	2.3677
		079-PSV-14A/B / C	2.4646	2.4259
Case -7	Liquid Overfill	067-PSV·001A/ B	2.5823	1 .8132
		Plant-1 7	1.6997	1 .4873
		Plant-7	1. 6997	1.5444

Simulation of existing flare configuration has been conducted and summary has been reported as the following Table 2. The Result of New Acid Flare Header Simulation, several highlighted concern as followings:

- For existing facilities maintain as per existing configuration, 10” existing header applied up to inlet new acid gas KO drum
- Header size from inlet new KO drum up to tie in connection from new Sour Water Stripper plant and New Amine Regeneration Unit plant using 12” to minimize changes of upstream facilities
- New header from new Sour Water Stripper tie in connection to new flare location estimated based on new load due to new load is governing case
- CV fail scenario of 079-PSV-001A/B is higher than maximum allowable back pressure, increasing tail pipe and new header to more than 20” not significant to reduce back pressure
- CV fail scenario of 079-PSV-001A/B, high back pressure flaring from plant 7 will impact to change of operating condition of plant 7
- CV fail scenario of 079-PSV-001A/B, high back pressure of continuous flaring from plant 17 will impact to change of operating condition
- Total power failure case scenario, calculated back pressure of 17-PSV-16A/B is higher than maximum allowable back pressure

The summary of hydraulic calculation results is attached in Table 1. The Result of existing Acid Flare Header Simulation and Table 2. The result of New Acid Flare Header Simulation, as we know tailpipes are connected with flare network and tailpipes are the first contact of the discharge but they are designed to handle maximum, it is why some tailpipes shall be changed based on modelling from FLARENET. Others concern is utility failure it is considering high back pressure during total power failure to make decision and some recommendations:

- For tail pipe of 7-PSV-16A/B with external fire case for plant 7 shall be increase from 3" become 4" to ensure sufficient back pressure during fire case and from simulation we get over back pressure also happen in existing configuration.
- CV fail scenario for 079-PSV-001A/B, to ensure back pressure is sufficient during CV fail scenario PSV type shall be changed from balance to PSV pilot type.
- CV fail scenario for 079-PSV-001A/B, high back pressure flaring from plant 7 can be solved with change header size
- To maintenance operating condition plant 17 during CV fail scenario for 079-PSV-001A/B pipe outlet plant 17 to header change from 4" become 6"
- For Total power failure case scenario, to ensure sufficient back pressure during power failure scenario and avoiding change of PSV type PSV-16A/B/C to pilot type and for existing header shall be replaced to 12" and then continue to 16" .
- New header size is calculated based on power failure from load new Sour Water Stripper plant and Amine Regeneration Unit plant selected size 20", for future connection from new Sour Water Stripper and Amine Regeneration Unit plant shall be located close to flare stack with size tie in 20"

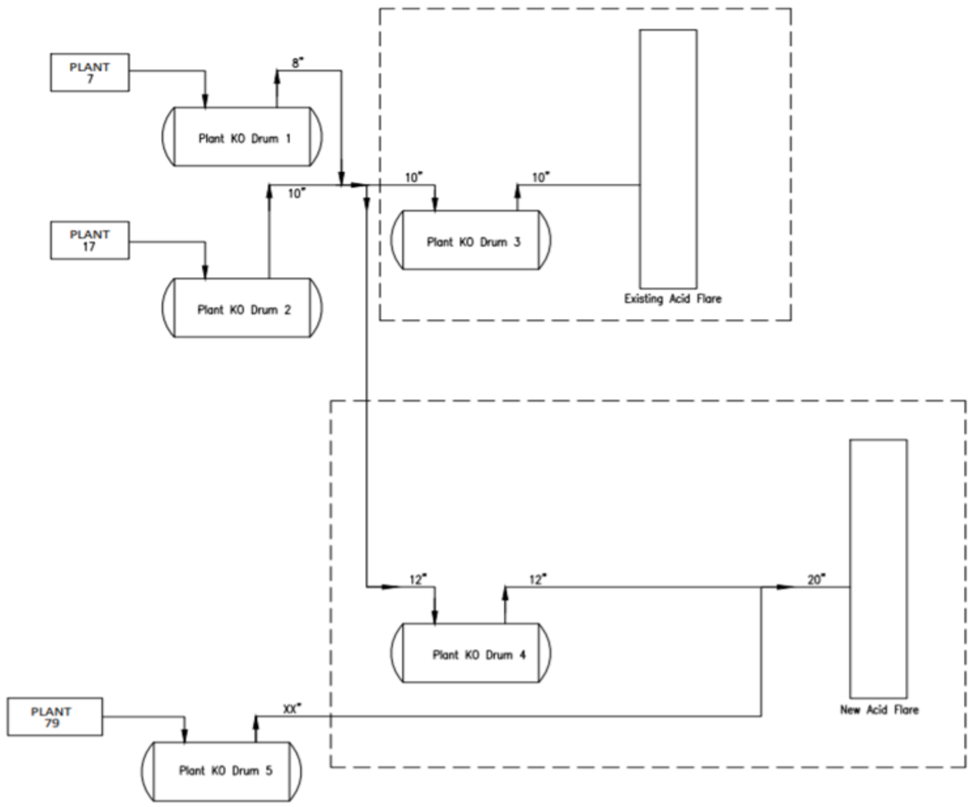

Figure 2. Flow Diagram New Existing Acid Flare

4. Conclusion

- From the result of simulation, without changing the size of tailpipe 7-PSV-16 A/B in Plant 7 will cause the failure of PSV when the fire case occurred. So, start up without changing size of pipes from 7-PSV-16 A/B is not recommended.
- Recommended to change tailpipe 7-PSV-16 A/B from 3” into 4”
- Recommended for CV failure scenario 079-PSV-001 A/B, change type PSV from balance to pilot type
- Recommended for Power failure scenario to change of PSV type of 17-PSV-16A/B/C to pilot type as above, existing header shall be replaced to 12” and continued with 16”
- Recommended for new header pipe size is 20”, new header size determined based general power failure of plant new Sour Water Stripper and new Amine Regeneration Unit.
- The accordance with the calculating KO drum acid gas and pump can be concluded:

KO drum inside diameter	: 1200 mm
T/T	: 2700 mm
Pump Normal Capacity	: 5 m3/hr.
Rated	: 5.5 m3/hr
Head pump	: 56.89 m
NPSHa	: 2.99 m
Maximum suction pressure	: 0.68 kg/cm2

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