CONSEQUENCE MODELING AND EVALUATION OF EXPORT GAS UNIT OF GAS REFINERY

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Abstract- Oil and gas related production, storage, processing, transmission and distribution infrastructure has, in general, a good safety record, but the possibility of accidents can never be discounted. Of primary concern is the accidental release of flammable or toxic material from pipe work, vessels and other equipment, which can affect personnel in the immediate vicinity and surrounding populations. The released material can be in the gaseous or liquid phase (including natural gas in its liquid form – LNG), flammable or toxic. In addition, there are circumstances where planned operations (e.g. flaring) have the potential for harm and need to be assessed accordingly. Consequence modeling is needed to understand the potential for harm of the many and varying release scenarios for operations in the oil and gas and chemical process industries.Export of gas to another units need to pressurize it. This purpose is obtained by using sets of compressors and their connective pipelines. Any leakage or failure has potential to create a fire or explosion. The main objective of this article is to study the consequences of gas dispersion and its results in Export Gas Compression unit (106) from Gas Refinery of South Pars Gas Field in Persian Golf . The effect of three scenarios (gas dispersion, jet fire, explosion.) is analyzed and plotted. PHAST software v. 6.53.1 software was used for performing the simulations.

Keywords- Consequence Modeling, Fire Zone, Gas Dispersion, Jet fire, Explosion PHAST.

I. INTRODUCTION

South Pars gas field is one of the largest independent gas reservoirs in the world lyingon the territorial border between Iran and the State of Qatar in the Persian Gulf. It isone of the country's main energy resources.This gas field covers an area of 9700square kilometers, of which 3700 square kilometers belongs to Iran. The Iranianportion is estimated to contain some 14 TCM of gas reserves. This amounts to roughly7.5 % of the world gas reserves and approximately half of the Iran's gas reserves.Presently, some precise and sophisticated projects have been designed fordevelopment of 24phases to produce 790 million cubic meters of gas per day. SouthPars gas field development shall meet the growing demands of natural gas, injectioninto oil fields, gas and condensate export as feedstock for petrochemical industries.As a result, Assalouyeh and Tombak ports, some 270 and 220 kilometers south eastof Bushehr respectively, have been selected as onshore locations for the constructionof onshore installations of the phased development.

Consequence modeling involves the determination of the impacts of process accidents involving hazardous materials on people, the environment and the process. The amount and form of hazardous material released is determined for toxic materials, flammables, and explosives (called the source term). The dispersion of the released material through and beyond the facility is studied. The distance traveled and area covered are determined. For toxic materials, their effects on people and the environment are evaluated. For flammables, the impact of the heat radiation from a fire on people and equipment is calculated. For explosive materials, the impact of blast overpressures on people, equipment and structures are calculated. Models tailored to each particular situation are used to evaluate consequences. Gas, two-phase, and liquid releases are modeled and their discharge rates are calculated. Dispersion is modeled for buoyant or heavy gases, as appropriate, taking account of the range of atmospheric conditions possible at the time of release. Toxicity data and dose-response models are used to model toxic effects. Various types of fires are modeled including pool, jet, flash, fireball, and warehouse fires. Types of explosions modeled include confined, unconfined, and dust explosions as well as BLEVEs (Boiling Liquid Expanding Vapor Explosion), thermal decompositions, and runaway reactions. One of the best software for modeling the consequences is PHAST. At this study we are resolution to Modeling and evaluation of Gas dispersion, Jet fire and Explosion of EXPORT GAS COMPRESSION UNIT of SPGFD-13 project using PHAST software.

II. DESIGN BASISAND ASSUMPTIONS

A. Process Description:

The lean gas from the four ethane recovery units is compressed in this unit in order to achieve the pressure required by the pipeline system, 91 Bara at the tie in for export. A single unit has been foreseen for both phases with six trains working in (4+2) configuration. One common header delivers the lean gas to the compressor trains.Purpose of this unit is exporting gas to IGAT with appropriate pressure. Properties of entering feed is, treated gas from unit 105 with

pressure of 32 barg and temperature of 50 ?C. Product has pressure of 90 barg and temperature of 58 ?C with at least 82% methane.Treated gas from 4 ethane recovery unit (unit 105) enters to this unit by a main line. This unit contains 6 independent trains that designed for phase 13. A header delivers treated gas to compressors. Driving force of Export Gas Compressors is provided by Gas Turbines (GT) and gas is pressurized to needed pressure (91 Bara).

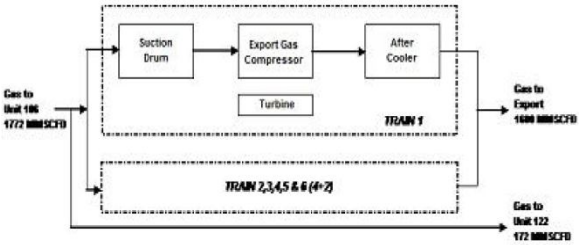


Figure1- flowchart of unit 106

Table 1. Sale GAS Specification

Specification	Value
C1	min. 82 mol %
C2	Max. 12 mol %
C3	Max. 4 mol %
C4	Max. 1 mol %
C5+	Max. 0.4 mol %
N2	Max. 5.5 mol %
CO2	Max. 2.0 mol %
H2S	Max. 4.8 mg / Nm3
COS	Max. 8 ppm mol
Mercaptans (as RSH)	Max. 15 mg / Nm3
Total sulfur (as S)	Max. 141 mg / Nm3
Sulfur daily avg.	Max. 100 mg / Nm3
Water dew point at 44 barg	Max. -10 °C
HC dew point at 55	Max. -10± 5 °C (note1)
Gross Heating Value	min. 9000 Kcal / Nm3 (note 2)

(1)- Normal - 10°C, Maximum -5 °C, No minimum value

(2)- Calculation method for Gross Heating Value: NGPSA 1998 edition

B. Weather Condition:

The meteorological conditions envisaged for the simulations are the following:

i. ambient temperature : 10°C (the average of the minimum temperature of the 5 colder months)
ii. relative humidity : 64 % (the average of the relative humidity for the 5 same months)
iii. surface roughness : 0.1
iv. solar radiation : 0.98 kW/m2 (310 BTU/hr/ft²)
v. For jet fire and dispersion, the simulations are made with 2 wind speeds: 2 m/s and 5 m/s is Considered a neutral atmosphere (Pasquill D)

Note: 2/D : condition 2 m/s and Pasquill D and
5/D : condition 5 m/s and Pasquill D

C. Composition:

The following table includes Composition of material into Gas Export Compression:

Table 2. Composition of Export Gas Compression

Comp.	% mole
C1	93.39
C2	2.042
C3	0.0608
N2	3.8154
CO2	0.6832

D. Allowable radiation:

All radiation levels in follow table are inclusive of sun radiation:

Table 4. Allowable Radiation level summery

	Emergencyfla kW*/m²	Max.continuousfla kW*/m²
Impactedarea	2	1.6
Restrictedarea	4.7	3.2
Permanentpersonnel	4	2.0
Beamedstructure	15.8	9.5
Flaredrum	6	4.7
Flarepiping	9.5	4.7
HeliportandEER	3	2.0
Atmosphericstorage	3	2.4
Pressurevesselstorage	2	1.6
Processequipment	4	3.2
Offices	2	1.6
warehouses	3	2.4

III. CRITERIA

For modeling, the criteria considered are the following:

A. Fire Zone:

According to SP-SEC-253, “the partition into fire zones is such that the consequences of a fire, a flammable gas leak, or an explosion corresponding to the credible event likely to occur in the concerned fire zone shall not impact other fire zones to an extend where their integrity could be put at risk”. A credible event is incident not unlikely to occur within the concerned area. The incident shall not bear effect on public, but only on the facility located inside the restricted area.

The fire zone shall not overlap inside the unit. The overlap is admitted if inside the overlapped area no

equipment are installed but only piping and pipe rack that shall be fireproofed.

The main principle adopted for the partition of the plant into fire zones is that it is not generally acceptable that asingle credible event could result in the total loss of function of the plant. The set of credible events taken as scenario are:

A.1 Gas dispersion (unionized gas/spray cloud):

i. Leak hole diameter: 20 mm
ii. Flows remains constant for 10 minutes
iii. Leakage flow rate limited to the maximum nominal flow rate (discharge of pump or Compressor)
iv. Sizing criteria: 100% LFL (averaging time 18.75 s)

A.2 Jet fire:

i. Leak hole diameter: 20 mm
ii. Sizing criteria: 9.5 kW/m2 (3,000 BTU/hr/ft²),
iii. 15.8 kW/m2 for ESDV or piping (5,000 BTU/hr/ft²)

Note: radiation includes solar radiation

A.3 Vapor cloud explosion:

i. Largest unit 50% full of gas at stoichiometry
ii. Maximum over-pressure: 50,000 Pa for congested unit
iii. 35,000 Pa for less congested unit
iv. Sizing criteria: 17,000 Pa for building, equipment, storage 30,000 Pa for ESDV

B. Restricted Area: [1]

The restricted area is the area within the boundaries of the installation and hence under the control of the Company, which is affected:

i. Either permanently by normal operation of the facility (radiation, …)
ii. Or exceptionally by the consequences of an emergency situation caused by a major failure of the facility.

The fire zones are always included in the restricted area.

The operator shall have the control, either automatically through appropriate systems or manually by means of alarms and signals, of all possible sources of ignition, including traffic means such as trucks and helicopters, likely to be present in the restricted area. The level of risk prevailing in a restricted area is not compatible with the presence, even temporary, of public.The set of major failures taken as scenarios are:

B.1 Gas dispersion (unignited gas/spray cloud):

Leak hole diameter: 80 mm for 4'' ≤ pipe diameter ≤10"

i. 100 mm for pipe diameter ≤ 16''
ii. 120mm for pipe diameter ≤ 24''
iii. 140mm for pipe diameter > 24 ''
iv. Isolation time : 90 s, with a release duration of 400s, if there are two ESDV or SDV600s, with a release duration of 600s, if there is one ESDV or SDV
v. Sizing criteria: 100% LFL (averaging time 18.75 s)

B.2 LC0% for H2S toxic dispersion:

i. 1000 ppm for 60 s
ii. 800 ppm for 300 s
iii. 700 ppm for 600
iv. 600 ppm for 1800s

IV. SCENARIOS AND OPERATING CONDITIONS

A. Scenarios Considered forGas Export Compression:

1. LFL gas dispersion of Export Gas Unit
2. Horizontal jet fire of Export Gas Unit
3. Explosion of Export Gas Unit

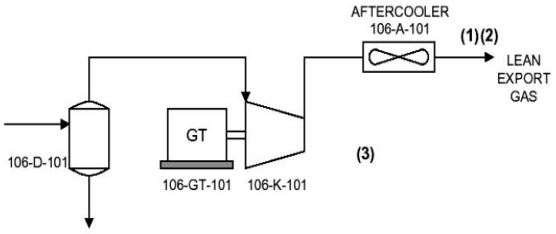


Figure 2- Condition of Scenarios ConsideredforGas Export Compression Unit

The gas considered is the lean export gas; out stream the export gas compressor after cooler.

Operating pressure: 92.8 Bara
Operating temperature: 58 ° C

B. Scenarios Considered for 42" Export Gas line:[3]

1. LFL gas dispersion downstream the ESDV export valve

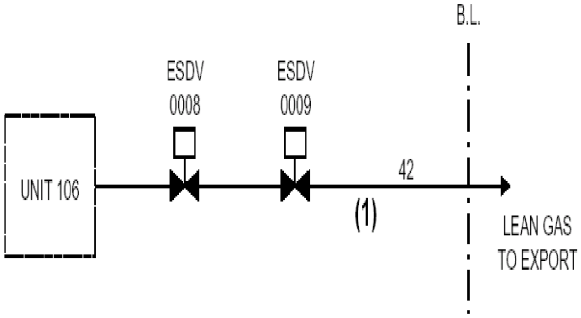


Figure 3- Condition of Scenario Considered for 42" Export Gas line

The gas leak is defined following the specification GS-SEC-253. It shall be considered that the 42" export gas line has an aboveground routing. For the 42'' export gas line, the diameter of the leak is assumed to be: 140 mm.

We considered that the necessary time to isolate the leak is greater than 10 minutes for the part of the line downstream the ESDV.

Operating pressure: 90.8 Bara
Operating temperature: 57.4 ° C
Nominal mass rate: 416.6kg/s

V. GRAPHICAL RESULT



Figure 4- LFL gas dispersion of Export Gas Unit (Category 2/D)



Figure 5- LFL gas dispersion of Export Gas Unit (Category 5/D)

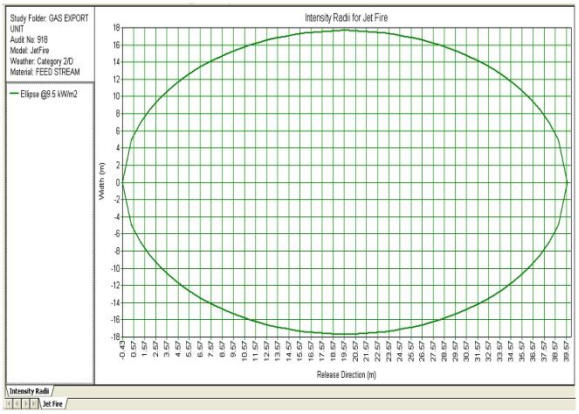


Figure 6- Horizontal jet fire of Export Gas Unit (9.5 KW/m2-category 2/D)

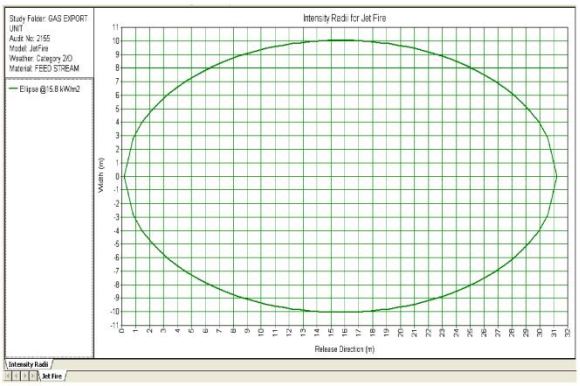


Figure 7- Horizontal jet fire of Export Gas Unit (15.8 KW/m2-category 2/D)

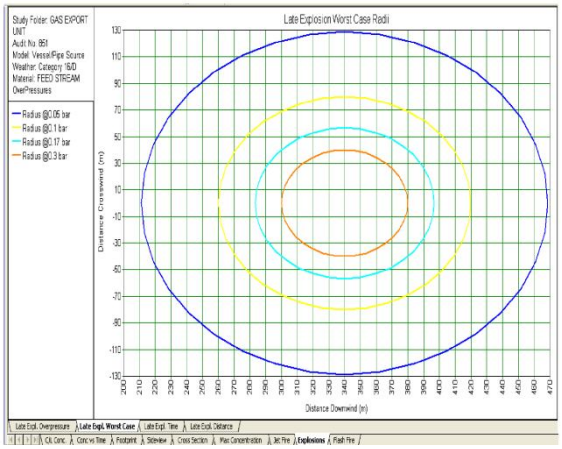


Figure 8- Explosion of Export Gas Unit (2/D)

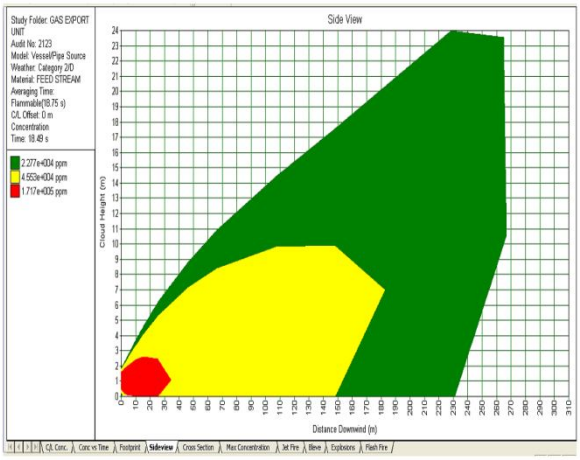


Figure 9- LFL gas dispersion of downstream the ESDV export valve (Category 2/D)

VI. SUMMARY RESULT

A. Summary Result ofGas Export Compression Unit:

Wind Speed m/s	2	5
LFL (m)	42.8 m	40.7 m
9.5 kW/m^2 (3 000 BTU/hr/ft^2)	39.57 m	39.57 m
15.8 kW/m^2 (5 000	31.2 m	31.2 m

Release rate: 4.49 kg/s

Explosion:
Volume congested: 32667 m3 (h=4m)
⇒half volume full of gas considered: 16333 m3

50 mbar	255 m
100 mbar	160 m
170 mbar	137 m
300 mbar	80 m

B. Downstream the export gas ESDV:
Release rate (initial and average): 229 kg/s
Restricted area:

		Wind Speed		
	Averaging time	2 m/s	5	16
LFL	18.75 s	268 m	304 m	371 m

CONCLUSION

According to result of Consequence Modeling in worst case in distance of 371 m from facilities of unit 106 there is no important danger for another persons and units.

REFERENCE

[1] TOTAL-GS (General Specification)-SAF (Safety)-253 “Impacted Area, Restricted Area and Fire Zones.” Pp. 9-16, rev. 02, December 2010.

[2] TOTAL-GS -SAF -262 “Pressure protection relief and hydrocarbon disposalSystems” pp. 32-33, rev. 02, December 2010.

[3] Process Specification of SPGFD-13–unit 106.

[4] Weather condition package of Bushehr, Iran.

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