NISOC	نگهداشت و افزایش تولید میدان نفتی بینک سطح الارض احداث ردیف تراکم گاز در ایستگاه جمع آوری بینک							
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طرح نگهداشت و افزایش تولید 27 مخزن

Flare Radiation & Dispersion Study Report

نگهداشت و افزایش تولید میدان نفتی بینک

D01	JUN. 2022	IFA	M.Aryafar	M.Fakharian	M.Mehrshad	
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Status:

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IFC: Issued For Comment
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AFC: Approved For Construction
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REVISION RECORD SHEET

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CONTENTS

1.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 25 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

As a part of the Project, a New Gas Compressor Station (adjacent to existing Binak GCS) shall be constructed to gather of 15 MMSCFD (approx.) associated gases and compress & transfer them to Siahmakan GIS.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – Surface Fcilities; New Gas Compressor Station
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection (D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

2.0 SCOPE

The purpose of this document is to define the safety limits for radiation and dispersion of relief gases to be burnt/dispersed in flare stacks of the “BIMAK NEW Gas Compressor Station”.

3.0 NORMATIVE REFERENCES

3.1 LOCAL CODES AND STANDARDS

- IPS-E-PR-450 — Process Design Of Pressure Relieving Systems Inclusive Safety Relief Valves
- IPS-E-PR-460 — Process Design Of Flare And Blowdown Systems
- IPS-G-SF-860 — General Standard for Air Pollution Control

3.2 INTERNATIONAL CODES AND STANDARDS

- API-RP-521 — "Guide for Pressure-Relieving and Depressurizing Systems" Fifth Edition, 2007.
- API-RP-520 — "Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part 1-Sizing and Selection", Eighth Edition, 2008.

3.3 THE PROJECT DOCUMENTS

- BK-GNRAL-PEDCO-000-PR-DB-0001 — Process Basis of Design
- BK-GNRAL-PEDCO-000-PR-DC-0001 — Process Design Criteria
- BK-GCS-PEDCO-120-PR-RT-0001 — Flare Network Study Report
- BK-GCS-PEDCO-120-PR-LI-0008 — Relief Load Summery
- BK-GCS-PEDCO-120-PR-PH-0003 — Flare,Blow Down And Relief Philosophy

3.4 ENVIRONMENTAL DATA

Refer to "Process Basis of Design; Doc. No. BK-GNRAL-PEDCO-000-PR-DB-0001".

4.0 RADIATION STUDY

4.1 FLARE SYSTEM

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In case of any conflict between the contents of this document or any discrepancy between this document and other project documents or reference standards, this issue must be reported to the CLIENT. The final decision in this situation will be made by CLIENT. All relief devices capable of relieving hydrocarbons under any failure mode shall relieve to a closed flare system. Hydrocarbons shall not be relieved to the atmosphere directly from relief devices wherever possible. In certain cases where the routing of hydrocarbon vents to a closed relief system is not possible, discharges may be routed to atmosphere at safe location.

The function of the flare system unit is to collect and burn all gases that are vented from the unit due to both continuous and emergency operations. The system must be able to handle the volume of gas through the depressurizing operation during emergencies and shut down.

Vapor relief headers should be sized in accordance with API-RP-521 and IPS-E-PR-460. In order to reduce the relief header loads and prevents surges due to two-phase gas/liquid flow as much as possible, it is advised to direct the disposed liquids into a separate closed hydrocarbon drain system. This system should be designed based on IPS-E-PR-460 .

One flare systems have been considered for BINAK NEW Gas Compressor Station:The flare system capable to relieved gas from pressure source between 5.5 barg to 54.1 barg.

The flare network is including of independent 10” flare stack, ignition system, knock-out drum have been considered for hydrocarbons in order to reduce the effects of backpressure into low pressure relief systems. The stack has minimum three pilots to guarantee flame light.

4.2 RADIATION PERMISSIBLE DESIGN LEVEL

A safe level of heat radiation intensity for continuous flaring for a limited time exposure of up to 3 minutes shall be 4.73 kw/m2 (1500 BTU/hr-ft2). If it is necessary to work within this radiation circle, protective measures must be taken to ensure safety. 6.31 kw/m2 (2000 BTU/hr-ft2) of heat intensity in areas where emergency actions lasting up to 1 minute may be required by personnel without shielding but with appropriate clothing.

Personnel access to the radiation intensity circle of 9.46 kw/m2 (3000 BTU/hr-ft2) in the plant shall be prohibited. Protection shall be required for equipment in this area.

In the following table permissible design levels for radiation have been specified as per API 521:

Permissible design level *K* kW/m^2 (Btu/h·ft^2)	Conditions
9,46 (3 000)	Maximum radiant heat intensity at any location where urgent emergency action by personnel is required. When personnel enter or work in an area with the potential for radiant heat intensity greater than 6,31 kW/m^2 (2 000 Btu/h·ft^2), then radiation shielding and/or special protective apparel (e.g. a fire approach suit) should be considered. **SAFETY PRECAUTION — It is important to recognize that personnel with appropriate clothing [a] cannot tolerate thermal radiation at 6,31 kW/m^2 (2 000 Btu/h·ft^2) for more than a few seconds.**
6,31 (2 000)	Maximum radiant heat intensity in areas where emergency actions lasting up to 30 s can be required by personnel without shielding but with appropriate clothing [a]
4,73 (1 500)	Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing [a]
1,58 (500)	Maximum radiant heat intensity at any location where personnel with appropriate clothing [a] can be continuously exposed

[a] Appropriate clothing consists of hard hat, long-sleeved shirts with cuffs buttoned, work gloves, long-legged pants and work shoes. Appropriate clothing minimizes direct skin exposure to thermal radiation.

4.3 FALRE RADIATION SCENARIOS

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For radiation from the flare, a scenario has been considered:

1. Emergency depressurizing at compressor station by PCV-2152 (Depressurizing Fire Case)

The maximum load from this scenario is included in Table 1 applied in flare radiation study. Radiation study the arrangement and stack height calculated, reported based on worst scenario (Depressurizing by PCV-2152):

Table 1: Flaring scenario

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Scenarios	(Depressurizing by PCV-2152)
Vapour Fraction	1.00
Temperature [C]	59.4
Molecular Weight	24.58
Molar Flow [MMSCFD]	14.03
Mass Flow [kg/h]	17171
Cp/Cv	1.456
Z Factor	0.82.54
Viscosity [cP]	0.141
Master Comp Mole Frac	
Mole Frac (H2O)	0.0002
Mole Frac (CO2)	0.0319
Mole Frac (H2S)	0.0540
Mole Frac (Methane)	0.6461
Mole Frac (Ethane)	0.1390
Mole Frac (Propane)	0.0781
Mole Frac (i-Butane)	0.0085
Mole Frac (n-Butane)	0.0188
Mole Frac (i-Pentane)	0.0070
Mole Frac (n-Pentane)	0.0038
Mole Frac (n-Hexane)	0.0066
Mole Frac (n-Heptane)	0.0020
Mole Frac (n-Octane)	0.0006
Mole Frac (n-Nonane)	0.0003
Mole Frac (n-Decane)	0.0001
Mole Frac (Nitrogen)	0.0030

4.4 ASSUMPTIONS

1- Maximum 0.5 Mach for sizing of riser diameters is considered. (Sub Sonic type)
2- Maximum radiation level is 1.58 kw/m^2 at fence of BINAK NEW Gas Compressor Station.
3- Maximum radiation level is 4.73 kw/m2 outside of sterile area of flare at maximum relieving rate mentioned in Table 1.
4- Generic Pipe Method has been considered for fraction of combustion heat radiated from a flame.
5- The Flaresim API method is used to model the flame length in these simulations.

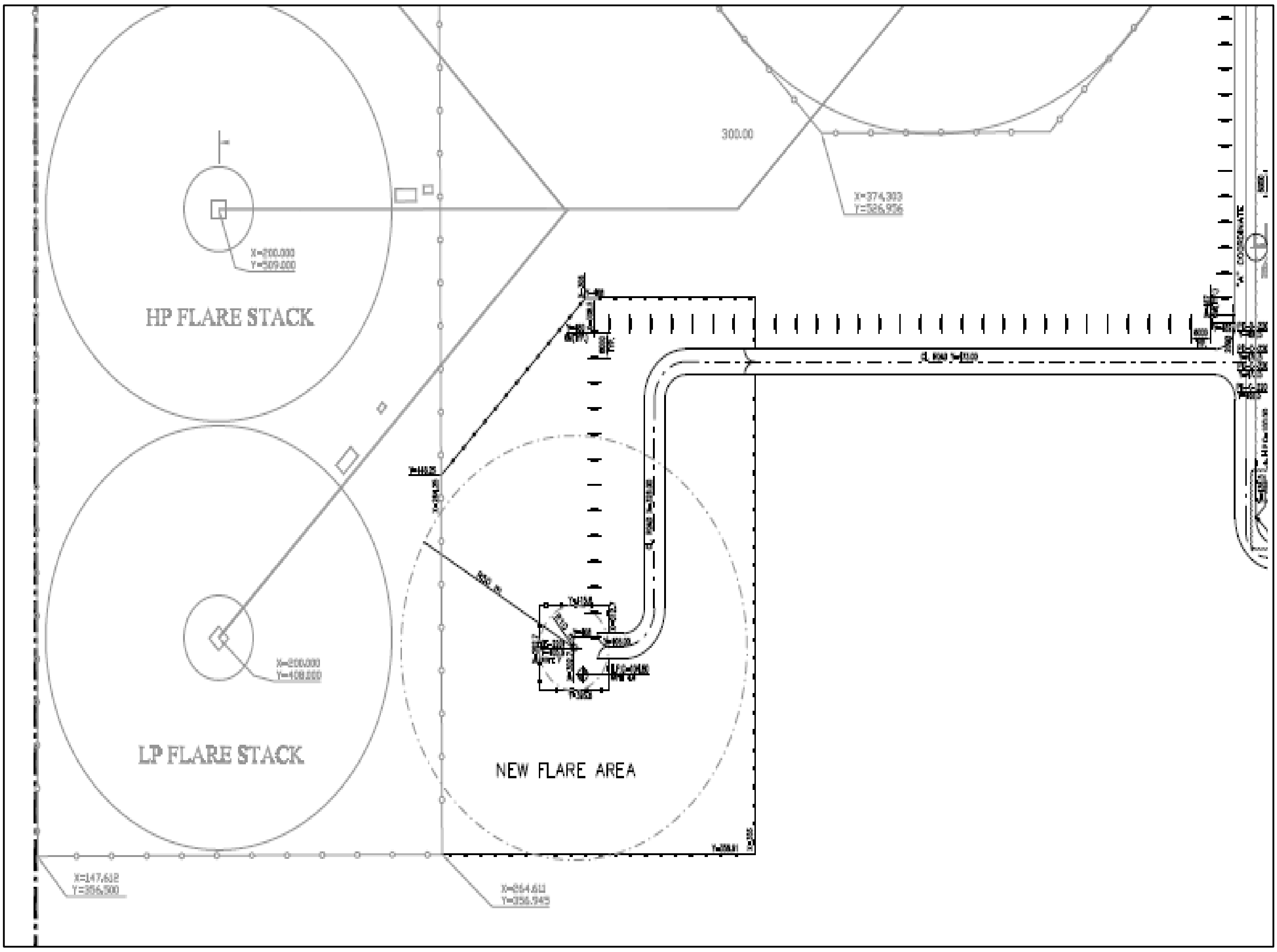


Figure 1: Stack distance

4.5 ENVIRONMENTAL DATA

Table 2: Environmental Data

Atmosphere					
Pressure	1.007 bar	Temperature	49.36 C	Humidity	34.94%
Wind Speed	Flare thermal radiation = 10 m/s	Wind Direction	NW to SE		
Background					
Background Noise	60.0 dB	Solar Radiation	1.040 kW/m2		
Inc. Background Noise	Active	Inc. Solar Radiation	Active		

4.6 RESULTS

D01

Each study on radiation from the flare resulted into the minimum required flare stack height.

Table 3: Flare Stack Design Results

Description	Stack height (m)	Riser diameter (in)
FLARE (Smokeless operation)	16.78	10

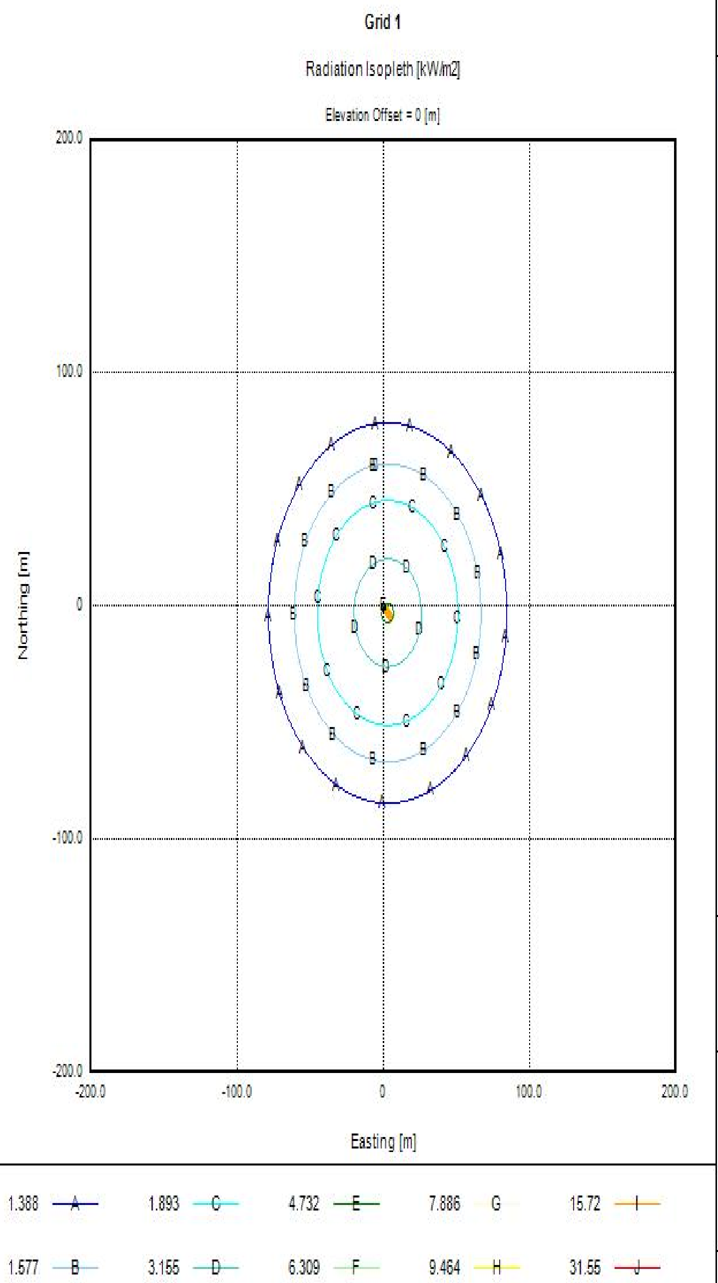
Worst case condition for sizing based on table 1 is of the flare and the results for worst scenario (Emergency depressurized) are presented in the following:

4.7 FLARE RADIATION STUDY BASE ON WIND VELOCITY 10M/S

D01

Table 4: Flare tip calculation result

TIP RESULTS					
Flame Length	16.11	Heat Release	224121 KW		
API Flame Length	32.21 m	F (factor) Heat Radiated	0.143		
Exit Temperature	33.0 C	Actual Volume Flow	19360 m3/h		
Wind Speed At Tip	10 m/s				
ASSIST FLUID					
Fluid	Air	Mass Flow	94440 kg/h	Flow Ratio	5
VELOCITIES and PRESSURE DROP					
Exit Velocity	96.49 m/s	Tip Outlet pres.	1.007 bar	Total Tip Outlet pres.	1.062 bar
Exit Mach Number	0.2660	Tip Inlet pres.	1.016 bar	Total Tip Inlet pres.	1.070 bar
Contraction Coeff.	1	Seal Inlet pres.	1.024 bar	Total Seal Inlet pres.	1.078 bar
		Stack Inlet pres.	1.071 bar	Total Stack Inlet pres.	1.122 bar
		Tip Pressure Drop	0.0086 bar	Tip Total Pressure Drop	0.0081 bar
		Seal Pressure Drop	0.0085 bar	Seal Total Pressure Drop	0.0080bar
		Stack Pressure Drop 0.0465bar		Stack Total Pressure Drop	0.004424 bar



flaresim limited

Tip Data	Units	Tip 1
Tip Type		Pipe
No. of Burners		1
Tip Length	m	3.000
Tip Diameter	mm	254.0
Angle to Horiz.	°	90.00
Angle to North	°	0
Flowrate	kg/h	18888
Calorific Value	kJ/kg	42717
Mol. Wt.		24.57
Heat Release	kW	224120
Frac.Radiated		0.1431
Temperature	C	33.00
Stack Data	**Units**	**Stack 1**
Stack Length	m	16.78
Stack to Horiz.	°	90.00
Stack to North	°	0
Environment	**Units**	
Wind Speed	m/s	10.00
Wind From North	°	315.0
Solar Radiation	kW/m2	1.040
Transmissivity		1.000

Flaresim Ltd
Job
Revision

By | Chkd

Figure 2: Radiation Results

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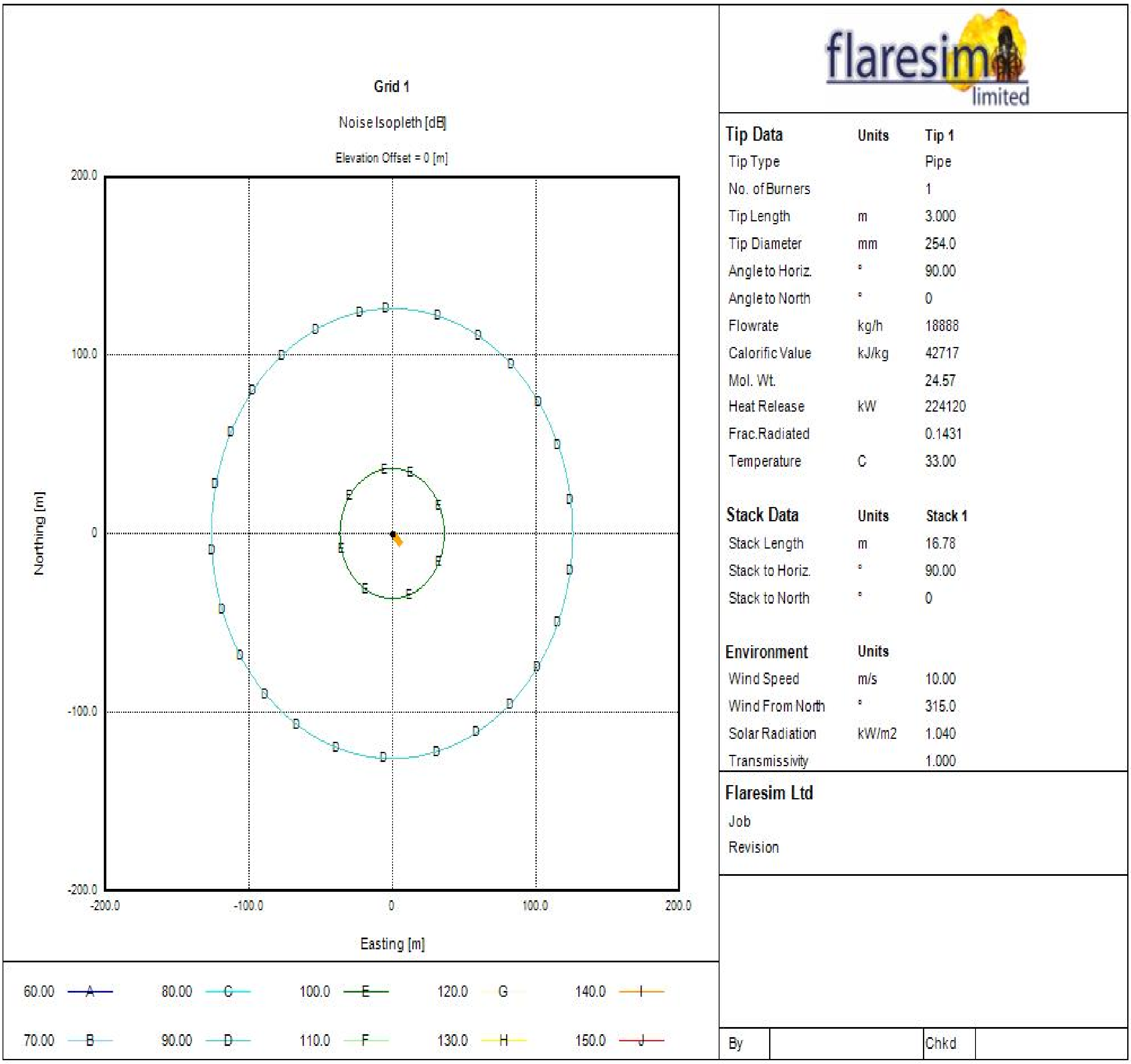

Figure 3: Noise Results

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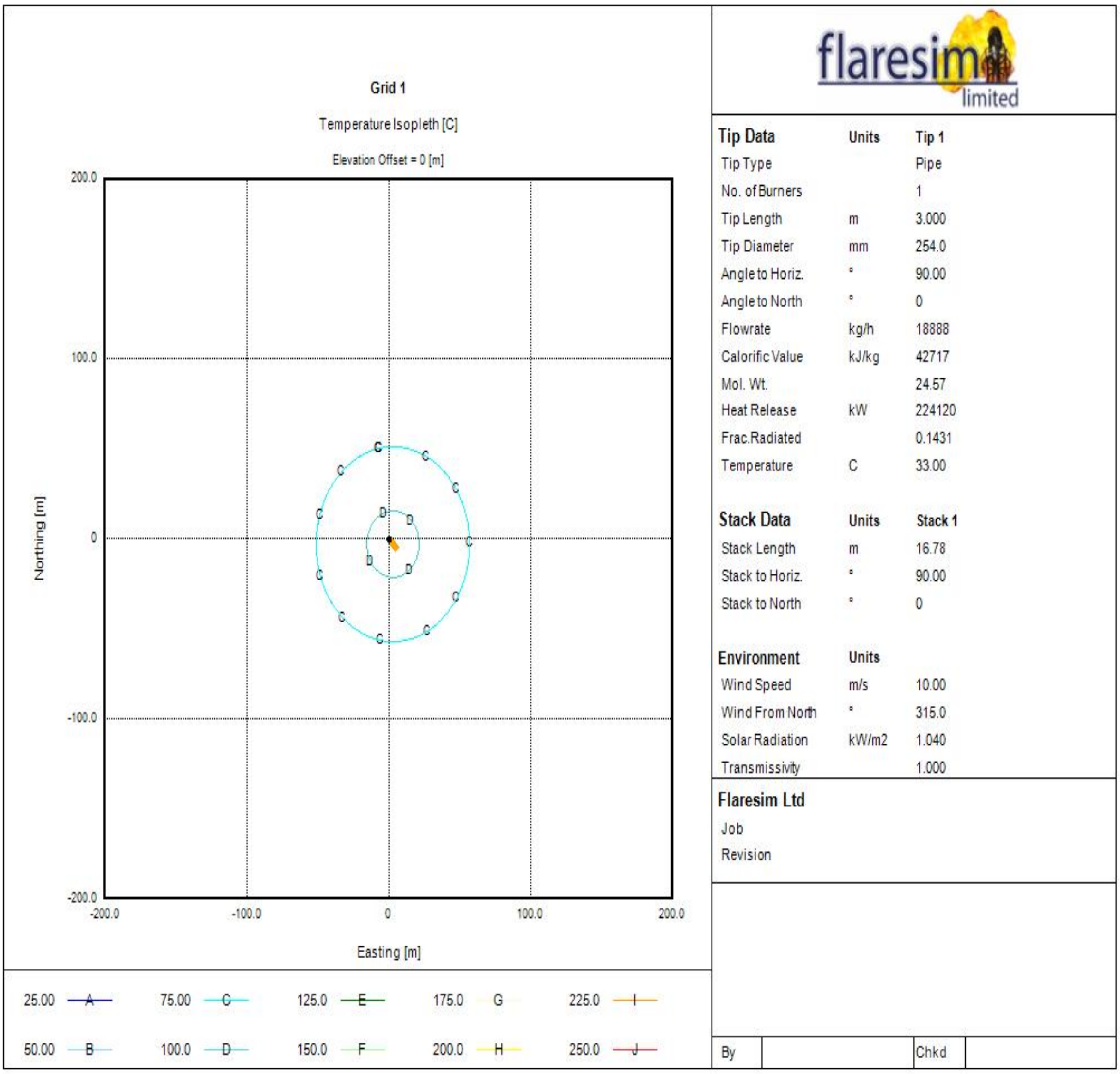

Figure 4: Temperature Results

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Table 5: Flare Results max Radiation/Noise/Temperature

D01

Maximum Radiation (near stack)								
Sizing Limit	-----		Find Max. Rad.	TRUE		Initial Grid Points	-	
Radiation	**4.728 kW/m2**		Northing	0 m		Easting	0.0 m	
Noise	**106.4**							
Temperature	**115.3**							
Maximum Radiation (stack fence area)								
Sizing Limit	-----		Find Max. Rad.	TRUE		Initial Grid Points	-	
Radiation	**1.927 kW/m2**		Northing	0 m		Easting	50.0 m	
Noise	**97.7**							
Temperature	**77.52**							
Radiation near unit								
Sizing Limit	-----		Find Max. Rad.	TRUE		Initial Grid Points	-	
Radiation	**1.112 kW/m2**		Northing	0 m		Easting	190.0 m	
Noise	**86.33**							
Temperature	**65.83**							

5.0 PROCESS CONSEQUENCE MODELING

5.1 BASIC OF THE CALCULATION

5.1.1 APPLIED DOCUMENTS AND USED SOFTWARE

The calculations for the consequences analysis are made according to the Total Exploration Production document TOTAL-GS-SF-253 General Specification Safety of Impacted Area, Restricted Area and Fire Zones. The software used for the consequence analysis has been PHAST 8 (DNV).

5.1.2 PROCESS DATA

The data used is the design data available at detail stage of the project, such as noted in PFD's, Process Heat and Material Balances, P&ID and in some cases equipment data sheets. For each case, the most conservative process data are taken into consideration to perform the simulation.

Based on Total GS-EP-SAF-253; the table below gives the definition of the main typical scenarios outcomes applicable to Vents and Flare Operation.

Table 6: typical scenarios and chance of occurrence

Scenario outcome	Definition	Specific conditions
Flare normal operation	Maximum Continuous Flaring (MCF): flaring the largest allowable steady flow of combustible gas in normal operating conditions (Client). Emergency Flaring (EF): flaring a peak flow of combustible gas in upset or emergency operating conditions (Client).	It will be studied.
Flare flame out: flammable and/or toxic	Unignited flare gas release.	It will be studied.
Cold vents	Vent handling significant flow rates generally from pressurized equipment. The word "cold" meaning without flame (Client).	Cold vent is not in scope of this project, so this scenario will not be studied.
Degassing vents	Vent handling low flow rates, generally from atmospheric equipment. A degassing vent is a non-ignited vent to atmosphere. (Client).	There is no such a case in this project, so this scenario will not be studied.

5.1.3 SENSITIVITY OF EFFECTIVE PROCESS PARAMETER ON OUTCOMES

Sensitivity of each process parameters on outcomes has been illustrated in this section:

5.1.3.1 PRESSURE

Pressure has MAJOR effect on Fire & Dispersion scenarios. Increase in pressure leads to more momentum of discharging material from hole and consequently bigger jet fire, and dispersion effect (toxic or flammable).

5.1.3.2 TEMPERATURE

Temperature has MINOR effect on Fire & Dispersion scenarios. The prediction of behavior of discharging material by changing temperature is not easy, but generally cold material has bigger dispersion effect. This effect could be different depending on material composition, pressure and etc.

5.1.3.3 INVENTORY

Inventory has NO effect in Fire Zone study and Minor effect on Restricted and Impacted area study.

As TOTAL-GS-SF-253 mentioned, for “Flammability” and “Thermal radiation” calculation, release flow rate shall be “Initial release rate for 10 minutes” and therefore the inventory has NO effect at all.

In Restricted and Impacted scenarios, where the “release flow rate of leak” is less than “flow rate of inlet line to vessel”, inventory has NO effect at all. In comparison, for scenarios that leak flow rates are less than “flow rate of inlet line to vessel”, inventory has Minor effect on “discharging material flow rate”, unless the inventory is very low.

5.1.3.4 RELEASE DIRECTION

In most gas releases, Horizontal impingement causes bigger dispersion effect in comparison to Horizontal. For volatile liquid cases, normally Horizontal release leads more dispersion effect than of Horizontal Impingement. Furthermore, Horizontal impingement scenario reduces the effect of Jet Fire significantly almost in all scenarios.

6.0 FLARE RADIATION AND DISPERSION

6.1 FLARE DESCRIPTION

The function of the Flare System Unit is to collect and burn all gases that are vented from the other units of the plant due to both continuous and emergency operations. It must also cater for the possibility of depressurization of equipment during emergencies.

In this report, two main scenarios have been studied which summarized in below table:

D01

Table 7 - Flare studied scenarios

	Flare (Depressurizing by PCV-2152)
Diameter (in)	16
Default Height (m)	12
Temperature (C)	26.21
Flow rate (kg/hr)	17171
Mol. Wt.	24.58
H2O	0.0002
CO	0.0319
H2S	0.0540
Methane	0.6460
Ethane	0.1390
Propane	0.0781
i-Butane	0.0085
n-Butane	0.0188
i-Pentane	0.0070
n-Pentane	0.0038
n-Hexane	0.0066
n-Heptane	0.0020
n-Octane	0.0006
n-Nonane	0.0003
n-Decane	0.0001
Nitrogen	0.0030

D01

6.2 RESTRICTED AREA (STERILE ZONE) RESULT FOR FLARE

According to the results of flare radiation and dispersion modeling which have been reported as below tables, current available /sterile zones for flare are 50m and 55m respectively.

- **Restricted Area:**
  - FLAMMABLE GAS DISPERSION (FLAME OUT GAS/SPRAY CLOUD):
    - Release height 19.78 m
      - Sizing criteria: 100% LFL
- **Restricted Area:**

- TOXIC GAS DISPERSION (FLAME OUT GAS/SPRAY CLOUD):
  - Release height 19.78 m
    - Sizing criteria: 472 ppm H2S for emergency flaring

- **IMPACTED Area:**

- TOXIC GAS DISPERSION (FLAME OUT GAS/SPRAY CLOUD):
  - Release height 19.78 m
    - Sizing criteria: 100ppm H2S for emergency flaring

Table 8 - Flare Radiation and Dispersion Results based on 19.78 meter heights- Emergency flaring (Depressurizing by PCV-2152)

D01

Scenario	Weather Condition	LFL gas cloud maximum distance and minimum height (m) from source and ground level	H2S TOXIC gas cloud maximum distance and minimum height (m) from source and ground level
Flare FST-2201; Restricted Area	Summer 2/F	3.4/20	21.9/20
	Summer 5.2/D	4.3/20	24.3/20
	Summer 7/D	4.7/20	24.8/20
	Summer 11.2/D	5.3/20	23.6/20
	Winter 2/F	3.2/20	19.6/20
	Winter 5.2/D	4.1/20	22.7/20
	Winter 7/D	4.5/20	23.5/20
	Winter 11.2/D	5.1/20	22.3/20
Flare FST-201; Impacted Area	Summer 2/F	N.A	127/20
	Summer 5.2/D	N.A	84.8/20
	Summer 7/D	N.A	75.7/20
	Summer 11.2/D	N.A	63.3/20
	Winter 2/F	N.A	116/20
	Winter 5.2/D	N.A	82.8/20
	Winter 7/D	N.A	73.1/20
	Winter 11.2/D	N.A	61/20

As seen in the above tabled, Fuel gas normal flaring will not have radiation impacts on surrounding facilities due to low flow rate of burning gas.

D01

Based on the results and with considering of 19.78 m stack height, no areas will be affected by fire radiation of 4.73 kw/m^2.

Impacted area for emergency flaring will be around 55 m .The impacted area is not under the control of Client but agreement shall be formalized with Local Authorities to minimize presence of public (e.g. to limit construction of buildings, in particular permanent settlements, or operation of transportation means open to public).

With considering of flare height of 15m and based on the result of this study, there is no any chance of reaching the 100% LFL flaring gas and toxic material (H2S) in flare flameout condition to the ground level. The selected height of flare system is adequate to dilute venting gas during emergency condition in downwind of wind direction.

6.3 FLARE DISPERSION

D01

The objective of this section is to determine the required exclusion zone around the relief area and determine the design requirement to ensure personnel safety during emergency hydrocarbon flare relief. The scope of this study includes:

- Modelling of dispersion of flammable gas from flare for emergency depressurisation (emergency flaring, i.e. flame-out);
- Modelling of dispersion of H2S from flare for emergency depressurisation (emergency flaring , i.e. flame-out);

Flare Restricted area affected zone by flammable gas dispersion (m)	Not Reached	Flare Impacted area affected zone by flammable gas dispersion (m)	Not Reached
Flare Restricted area affected zone by toxic gas dispersion (m)	Not Reached	Flare Impacted area affected zone by toxic gas dispersion (m)	Not Reached

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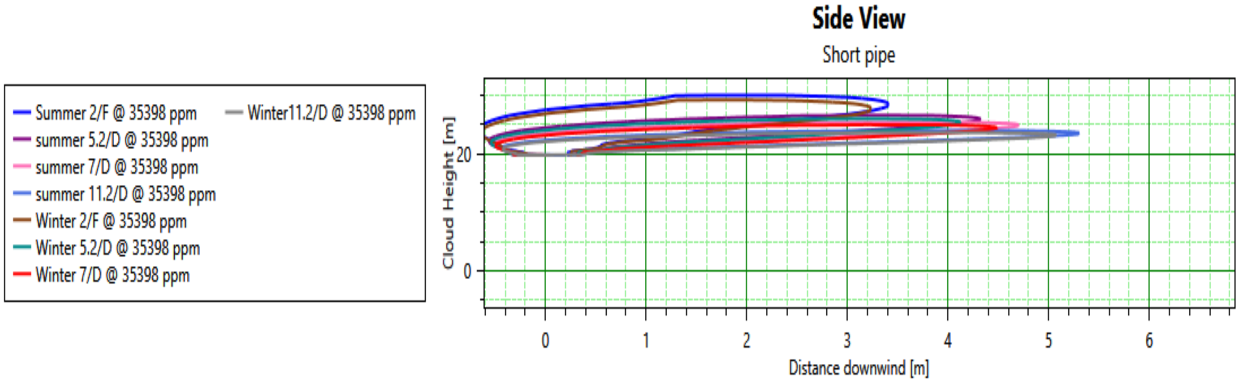

Figure 1 - Flare affected area-LFL Distribution for Flame out Case I (Restricted)

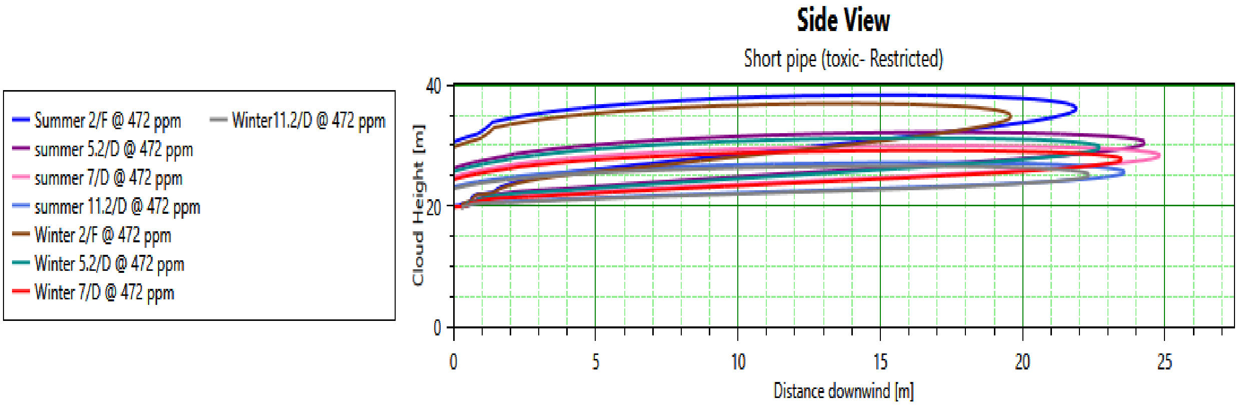

Figure 2 - Flare affected area-TOXIC GAS Distribution for Flame out Case I (Restricted)

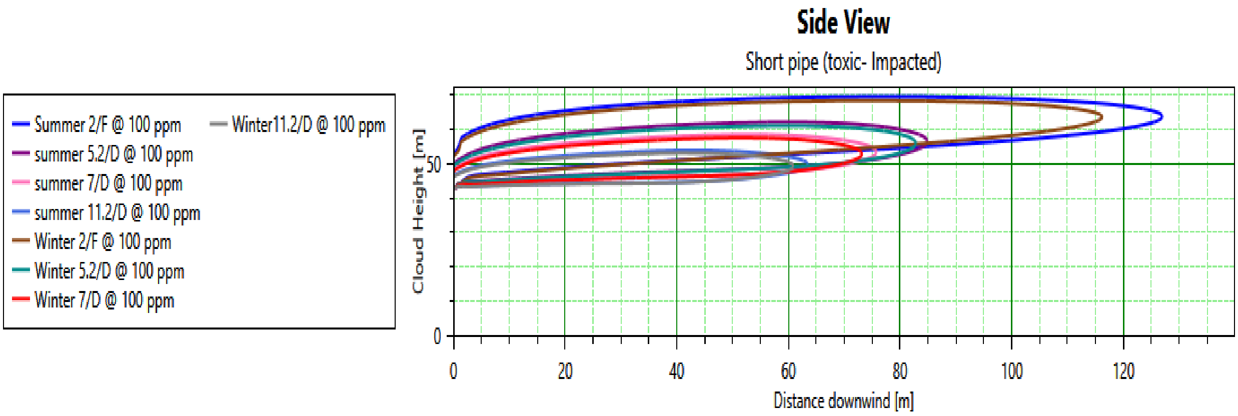

Figure 5 - Flare affected area- TOXIC GAS Distribution for Flame out Case I (Impacted)

7.0 CONCLUSION

Based on the results and with considering of 19.78 m stack height, no areas will be affected by fire radiation of 4.73 kw/m2.
With considering of flare height of 15m and based on the result of this study, there is no any chance of reaching the 100% LFL flaring gas to the ground level. The selected height of flare system (19.78 m) is adequate to dilute venting gas during emergency condition in downwind of wind direction.
Modelled flare tip in current design has 200 m distance from the plant while the calculated impacted area is not effected considered distance. So the location of flare is so good and no need to relocate it.