

HPCL JAMMU LPG Storage & Bottling Plant Risk Analysis

Response to SEAC Comments

1. The Consultant needs to use temperature data of Jammu in risk assessment modelling,

Response:

In the risk assessment report for HPCL Jammu LPG Plant, the weather parameters 25 °C and atmospheric stability class D were taken to represent conservative conditions in day time.

During day time neutral atmospheric stability class D occurs when solar radiation is slight.

The risk analysis has now been revised considering the maximum ambient temperature of 40 °C prevailing at day time in Jammu. As this temperature condition occurs when solar radiation is high, the corresponding atmospheric stability class B is considered.

The weather parameters for risk assessment modeling in the original report and revised report are shown in the following Table.

Table: Weather Parameters for Risk Assessment Modeling

Description	Original Report	Revised
Ambient Temperature (°C)	25	40
Wind speed (m/s)	3	3
Atmospheric Stability	D	B

The results of consequence analysis for maximum credible scenario with the above two weather parameters are shown in the following Table for comparison.

Table: Results of Consequence Analysis for HPCL Jammu LPG Plant

S.No.	Description	Parameter	Downwind Distance (metres)	
			Weather (Wind speed, Stability & Ambient Temperature)	
			3 m/s; D; 25°C (Original Report)	3 m/s; B; 40°C (Revised)
Maximum Credible Scenario				
1.	LPG Bullet Liquid Line Leak			
	Pool Fire Radiation Intensity	4 kW/m ²	54	52
		12.5 kW/m ²	35	33
		37.5 kW/m ²	18	16
	VCE Overpressure	0.02 bar	41	40
		0.07 bar	23	22
		0.2 bar	17	16
2.	LPG Pump Discharge Line Leak			
	Pool Fire Radiation Intensity	4 kW/m ²	56	54
		12.5 kW/m ²	36	35
		37.5 kW/m ²	19	17
	VCE Overpressure	0.02 bar	42	41
		0.07 bar	23	23
		0.2 bar	17	17
3.	LPG Vapour Compressor Discharge Line Leak			
	Jet Fire Radiation Intensity	4 kW/m ²	20	20
		12.5 kW/m ²	16	16
		37.5 kW/m ²	9	9

It can be seen that the downwind effect distances for ambient temperature of 40 °C do not exceed those shown in the original risk assessment report.

The summary reports taken from Phast software are enclosed for reference.

Results for individual risk (risk contours) and societal risk (FN curve) taking into account the off-site population of 5100 in the nearby Kartholi village are shown in the following figures.

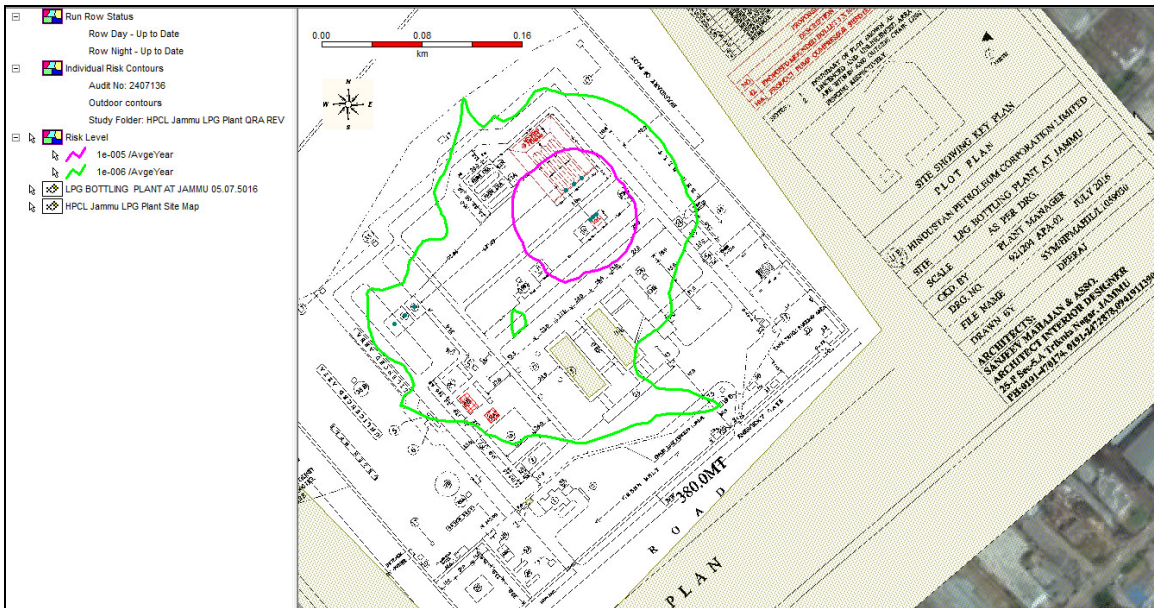


Figure: Risk Contours for individual risk revised including Kartholi population

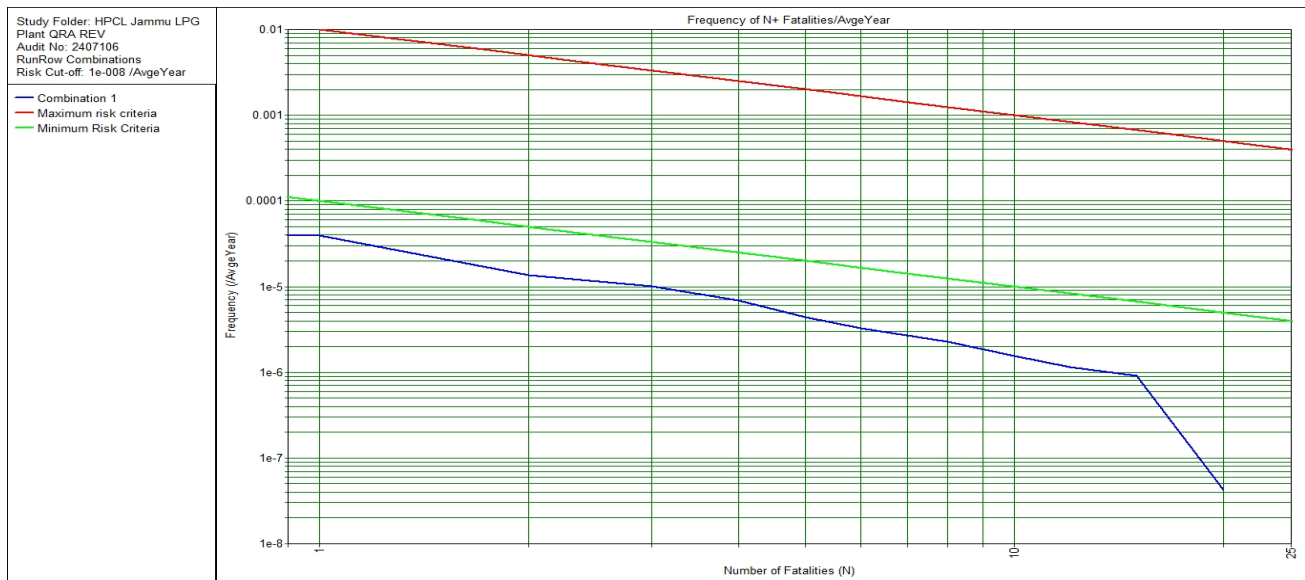


Figure: FN curve for societal risk revised including Kartholi population

It is seen that the individual risk and societal risk parameters are within specified criteria as explained in the original report.

The screen shot for population data input to Phast software is enclosed for reference.

2. The consultant needs to submit certificate to the effect that the data projected for analysis thereof and that the proposed project design of storage facility is authentic and satisfactorily within the standard permissible limits of risk management.

Response:

The risk assessment modelling for HPCL Jammu LPG Storage & Bottling Plant has been carried out using the reputed Phast software of DNV-GL by Consultant having more than 15 years of experience. It is confirmed that the proposed LPG storage and bottling plant of HPCL at Jammu will comply with the requirements of OISD, PESO and other national/international codes and standards.



Study Folder

- HPCL Jammu LPG Plant QRA
 - Population Category Set
 - Day Ignition
 - Transformer
 - MCC
 - Night Population
 - Filling shed
 - Unloading shed
 - Security cabin
 - Kartholi village
 - Night Ignition
 - Transformer
 - MCC
 - Day Population
 - Pump house
 - TTL Gantry
 - Valve changing shed
 - Filling shed
 - Unloading shed
 - Loading shed
 - MCC
 - Retesting shed
 - Admin building
 - Security cabin
 - Kartholi village

example

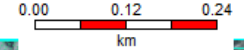
- Day Population
- [None]
- Day Ignition

Run Rows

Row Day

Calculation Mode

Consequence & Risk

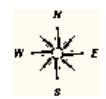
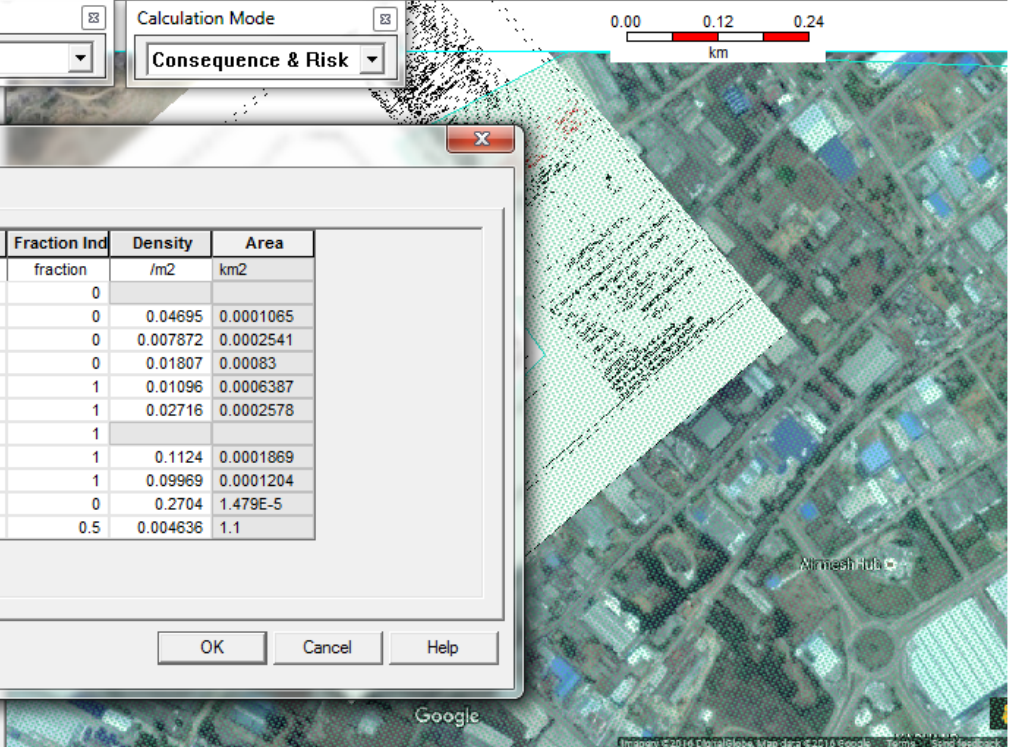


Editing population set Day Population

Set FAR factor

Name	Category	Population	Fraction Ind	Density	Area
			fraction	/m2	km2
Pump house	[None]	1	0		
TTL Gantry	[None]	5	0	0.04695	0.0001065
Valve changing shed	[None]	2	0	0.007872	0.0002541
Filling shed	[None]	15	0	0.01807	0.00083
Unloading shed	[None]	7	1	0.01096	0.0006387
Loading shed	[None]	7	1	0.02716	0.0002578
MCC	[None]	3	1		
Retesting shed	[None]	21	1	0.1124	0.0001869
Admin building	[None]	12	1	0.09969	0.0001204
Security cabin	[None]	4	0	0.2704	1.479E-5
Kartholi village	[None]	5100	0.5	0.004636	1.1

OK Cancel Help



Display Order Groups

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

HPCL Jammu LPG Plant CA-REV

Study

LPG Compressor Discharge Line - 25 mm leak

Base Case

CASE Name: Data

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

User-Defined Data

Material

Material Identifier	LPG
Material to Track	LPG
Type of Vessel	Pressurized Gas
Pressure Specification	Pressure specified
Storage Pressure - gauge	10 bar
Temperature	80 degC
Mass Inventory	200 kg

Scenario

Scenario Type	Leak
Phase to be Released	Vapor
Hole Diameter	25 mm
Building Wake Effect	None

Location

[Elevation	1 m]
Use ERPG averaging time	ERPG not selected
Use IDLH averaging time	IDLH not selected
Use STEL averaging time	STEL not selected
Supply a user defined averaging time	Not supplied

Bund

Status of Bund	No bund present
[Type of Bund Surface	Concrete]
[Bund Height	0 m]
[Bund Failure Modeling	Bund cannot fail]

Indoor/Outdoor

Location of release	Open air release
Outdoor Release Direction	Horizontal

Flammable

Jet Fire Method	Cone Model
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Dispersion

Late Ignition Location	No ignition location
Mass Inventory of material to Disperse	200 kg

Fireball Parameters

[Mass Modification Factor	3]
[Calculation method for fireball	DNV Recommended]
[TNO model flame temperature	1727 degC]

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Toxic Parameters

[Indoor Calculations	Unselected]
[Wind Dependent Exchange Rate	Case Specified]
[Building Exchange Rate	4 /hr]
[Tail Time	1800 s]
[Set averaging time equal to exposure time	Use a fixed averaging time]
[Cut-off fraction of toxic load for exposure time calculation	0.05 fraction]
[Cut-off concentration for exposure time calculations	0 fraction]

Geometry

Shape	Point
Dimension	2D
System	Absolute
East(1)	70 m
North(1)	-56 m

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

Discharge Data

User-Defined Quantities

Material	LPG
Temperature	80.00 degC
Pressure	11.01 bar
Inventory	200.00 kg
Scenario	Leak
Fixed Duration	n/a s

Calculated Quantities

Weather: Global Weathers\3D-Rev0

Mass Flow of Air (Vent from Vapor Space Only) n/a

Average Values for Segment Number 1

Liquid Fraction	0.00 fraction
Final Temperature	20.63 degC
Final Velocity	405.90 m/s
Droplet Diameter	0.00 um

Continuous Release Data:

Mass Flowrate	1.32025E+000 kg/s
Release Duration	151.49 s
Orifice Velocity	220.94 m/s
Exit Pressure	6.64 bar
Exit Temperature	61.69 degC
Discharge Coefficient	0.88
Expanded Radius	0.02 m

Weather: Global Weathers\3D-Rev1

Mass Flow of Air (Vent from Vapor Space Only) n/a

Average Values for Segment Number 1

Liquid Fraction	0.00 fraction
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SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

FinalTemperature	20.63 degC
Final Velocity	405.90 m/s
Droplet Diameter	0.00 um
Continuous Release Data:	
Mass Flowrate	1.32025E+000 kg/s
Release Duration	151.49 s
Orifice Velocity	220.94 m/s
Exit Pressure	6.64 bar
Exit Temperature	61.69 degC
Discharge Coefficient	0.88
Expanded Radius	0.02 m



Consequence Results

Distance to Concentration Results

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

The height for user defined concentrations is the user defined height 0 m
 All toxic results are reported at the toxic effect height 0 m
 All flammable results are reported at the cloud centreline height

Concentration(ppm)	Averaging Time		3D-Rev0	3D-Rev1
UFL (92271.5)	18.75	s	1.94755	2.0043
LFL (16986.2)	18.75	s	8.55081	8.38003
LFL Frac (16986.2)	18.75	s	8.55081	8.38003

Concentration(ppm)	Averaging Time		3D-Rev0	3D-Rev1	Heights (m) for above distances
UFL (92271.5)	18.75	s	0.999821	0.999791	
LFL (16986.2)	18.75	s	0.990884	0.990554	
LFL Frac (16986.2)	18.75	s	0.990884	0.990554	

Jet Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

Jet fire method used: Cone model - DNV recommended

	3D-Rev0	3D-Rev1
Jet Fire Status	Hazard	Hazard
Flame Direction	Horizontal	Horizontal

Radiation Effects: Jet Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

This table gives the distances to the specified radiation levels for each jet fire listed in the above hazard table

			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	19.5555	19.752
Radiation Level	12.5	kW/m2	15.7737	15.9224
Radiation Level	37.5	kW/m2	8.88819	Not Reached

Radiation Effects: Jet Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

	3D-Rev0	3D-Rev1	Radiation Level (kW/m2)

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Flash Fire Envelope

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

All flammable results are reported at the cloud centreline height

				Distance (m)	
				3D-Rev0	3D-Rev1
Furthest Extent	16986.2	ppm	8.55081	8.38003	
Furthest Extent	16986.2	ppm	8.55081	8.38003	
				Heights (m) for above distances	
				3D-Rev0	3D-Rev1
Furthest Extent	16986.2	ppm	0.990884	0.990554	
Furthest Extent	16986.2	ppm	0.990884	0.990554	

Weather Conditions

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Compressor Discharge Line - 25 mm leak

			3D-Rev0	3D-Rev1
Wind Speed	m/s		3	3
Pasquill Stability			D	B
Surface Roughness Length	mm		183.156	183.156
Surface Roughness Parameter			0.0999999	0.0999999
Atmospheric Temperature	degC		25	40
Surface Temperature	degC		25	40
Relative Humidity	fraction		0.7	0.7

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6



HPCL Jammu LPG Plant CA-REV



Study

LPG Pump Discharge Line - 25 mm Leak

Base Case

CASE Name: Data

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

User-Defined Data

Material

Material Identifier	LPG
Material to Track	LPG
Type of Vessel	Padded Liquid
Pressure Specification	Pressure specified
Storage Pressure - gauge	10 bar
Temperature	30 degC
Mass Inventory	500 kg

Scenario

Scenario Type	Leak
Phase to be Released	Liquid
Hole Diameter	25 mm
Building Wake Effect	None
Tank Head	0 m

Location

[Elevation	1 m]
Use ERPG averaging time	ERPG not selected
Use IDLH averaging time	IDLH not selected
Use STEL averaging time	STEL not selected
Supply a user defined averaging time	Not supplied

Bund

Status of Bund	No bund present
[Type of Bund Surface	Concrete]
[Bund Height	0 m]
[Bund Failure Modeling	Bund cannot fail]

Indoor/Outdoor

Location of release	Open air release
Outdoor Release Direction	Down - Impinging on the Ground

Flammable

Location of Late Ignition	10 m
Explosion Method	TNT
Jet Fire Method	Cone Model

Dispersion

Late Ignition Location	Ignition location supplied
Mass Inventory of material to Disperse	500 kg

Fireball Parameters

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

[Mass Modification Factor 3]
[Calculation method for fireball DNV Recommended]
[TNO model flame temperature 1727 degC]

Toxic Parameters

[Indoor Calculations Unselected]
[Wind Dependent Exchange Rate Case Specified]
[Building Exchange Rate 4 /hr]
[Tail Time 1800 s]
[Set averaging time equal to exposure time Use a fixed averaging time]
[Cut-off fraction of toxic load for exposure time calculation 0.05 fraction]
[Cut-off concentration for exposure time calculations 0 fraction]

Geometry

Shape Point
Dimension 2D
System Absolute
East(1) 82 m
North(1) -46 m

Path: HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

Discharge Data

User-Defined Quantities

Material LPG
Temperature 30.00 degC
Pressure 11.01 bar
Inventory 500.00 kg
Scenario Leak
Fixed Duration n/a s

Calculated Quantities

Weather: Global Weathers\3D-Rev0

Mass Flow of Air (Vent from Vapor Space Only) n/a

Average Values for Segment Number 1

Liquid Fraction 0.69 fraction
FinalTemperature -28.02 degC
Final Velocity 155.34 m/s
Droplet Diameter 7.07 um

Continuous Release Data:

Mass Flowrate 9.96309E+000 kg/s
Release Duration 50.19 s
Orifice Velocity 63.68 m/s
Exit Pressure 1.01 bar
Exit Temperature 29.27 degC
Discharge Coefficient 0.60
Expanded Radius 0.05 m

Weather: Global Weathers\3D-Rev1

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Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Mass Flow of Air (Vent from Vapor Space Only)		n/a
Average Values for Segment Number	1	
Liquid Fraction		0.69 fraction
Final Temperature		-28.02 degC
Final Velocity		155.34 m/s
Droplet Diameter		7.51 um
Continuous Release Data:		
Mass Flowrate		9.96309E+000 kg/s
Release Duration		50.19 s
Orifice Velocity		63.68 m/s
Exit Pressure		1.01 bar
Exit Temperature		29.27 degC
Discharge Coefficient		0.60
Expanded Radius		0.05 m

SUMMARY REPORT

Unique Audit Number:

629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Consequence Results

Pool Vaporization Results

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

			3D-Rev0	3D-Rev1
		Release Segment 1		
Release Duration		s	50.1852	50.1852
Liquid Rainout		fraction	0.689264	0.689257
		Release Segment 1 Cloud Segment 1		
Cloud Segment Duration		s	40.6406	78.9852
Pool Vaporization Rate		kg/s	2.07773	2.42529
Total Vapor Flowrate		kg/s	5.17362	5.52125
		Release Segment 1 Cloud Segment 2		
Cloud Segment Duration		s	35.6971	334.913
Pool Vaporization Rate		kg/s	2.35367	0.395396
Total Vapor Flowrate		kg/s	5.44957	2.42529
		Release Segment 1 Cloud Segment 3		
Cloud Segment Duration		s	391.078	
Pool Vaporization Rate		kg/s	0.387325	
Total Vapor Flowrate		kg/s	2.35367	0.395396
Maximum Pool Radius		m	4.89736	4.72924

Distance to Concentration Results

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

The height for user defined concentrations is the user defined height 0 m
 All toxic results are reported at the toxic effect height 0 m
 All flammable results are reported at the cloud centreline height

Concentration(ppm)	Averaging Time			3D-Rev0	3D-Rev1
UFL (92271.5)	18.75	s		31.9234	31.1506
LFL (16986.2)	18.75	s		73.4407	67.9531
LFL Frac (16986.2)	18.75	s		73.4407	67.9531
Concentration(ppm)	Averaging Time			3D-Rev0	Heights (m) for above distances
UFL (92271.5)	18.75	s		0	3D-Rev1
LFL (16986.2)	18.75	s		0	0
LFL Frac (16986.2)	18.75	s		0	0

Jet Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

Jet fire method used: Cone model - DNV recommended

	3D-Rev0	3D-Rev1
Jet Fire Status	Truncated	Truncated
Flame Direction	Along Ground	Along Ground

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Radiation Effects: Jet Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

This table gives the distances to the specified radiation levels for each jet fire listed in the above hazard table

			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	46.9255	45.2626
Radiation Level	12.5	kW/m2	27.5152	26.7411
Radiation Level	37.5	kW/m2	21.6609	21.4662

Radiation Effects: Jet Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Radiation Level (kW/m2)		

Early Pool Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Early Pool Fire Status	Hazard	Hazard

Radiation Effects: Early Pool Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	49.8287	49.3076
Radiation Level	12.5	kW/m2	31.6508	31.3734
Radiation Level	37.5	kW/m2	15.828	14.9327

Radiation Effects: Early Pool Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Radiation Level (kW/m2)		

Late Pool Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Late Pool Fire Status	Hazard	Hazard

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Radiation Effects: Late Pool Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	55.8956	53.6865
Radiation Level	12.5	kW/m2	35.4453	34.1216
Radiation Level	37.5	kW/m2	18.0497	16.4659

Radiation Effects: Late Pool Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Radiation Level (kW/m2)		

Flash Fire Envelope

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

All flammable results are reported at the cloud centreline height

			3D-Rev0	3D-Rev1
Furthest Extent	16986.2	ppm	73.4407	67.9531
Furthest Extent	16986.2	ppm	73.4407	67.9531

			3D-Rev0	3D-Rev1
Furthest Extent	16986.2	ppm	0	0
Furthest Extent	16986.2	ppm	0	0

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Explosion Effects: Late Ignition

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

Explosion Model Used : TNT

Explosion Location Criterion: Cloud Front (LFL Fraction)

All distances are measured from the Source

All flammable results are reported at the cloud centreline height

			Maximum Distance (m) at Overpressure Level	
			3D-Rev0	3D-Rev1
Overpressure	0.02068	bar	41.1199	40.5112
Overpressure	0.0689476	bar	22.7854	22.5353
Overpressure	0.2068	bar	16.2349	16.1129

			Supplementary Data at 0.02068 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.841768	0.79333
Used Flammable Mass		kg	0.841768	0.79333
Overpressure Radius		m	31.1199	30.5112
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

			Supplementary Data at 0.0689476 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.841768	0.79333
Used Flammable Mass		kg	0.841768	0.79333
Overpressure Radius		m	12.7854	12.5353
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

			Supplementary Data at 0.2068 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.841768	0.79333
Used Flammable Mass		kg	0.841768	0.79333
Overpressure Radius		m	6.23488	6.11292
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

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Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Weather Conditions

Path: \HPCL Jammu LPG Plant CA-REV\Study\LPG Pump Discharge Line - 25 mm Leak

		3D-Rev0	3D-Rev1
Wind Speed	m/s	3	3
Pasquill Stability		D	B
Surface Roughness Length	mm	183.156	183.156
Surface Roughness Parameter		0.0999999	0.0999999
Atmospheric Temperature	degC	25	40
Surface Temperature	degC	25	40
Relative Humidity	fraction	0.7	0.7

SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

HPCL Jammu LPG Plant CA-REV

Study

New MSV 2 Liquid Line - 25 mm Leak

Base Case

CASE Name: Data

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

User-Defined Data

Material

Material Identifier	LPG
Material to Track	LPG
Type of Vessel	Saturated Liquid (Equilibrium vapor/liquid)
Pressure Specification	Pressure not used
Temperature	30 degC
Mass Inventory	500 kg

Scenario

Scenario Type	Leak
Phase to be Released	Liquid
Hole Diameter	25 mm
Building Wake Effect	None
Tank Head	0 m

Location

[Elevation	1 m]
Use ERPG averaging time	ERPG not selected
Use IDLH averaging time	IDLH not selected
Use STEL averaging time	STEL not selected
Supply a user defined averaging time	Not supplied

Bund

Status of Bund	No bund present
[Type of Bund Surface	Concrete]
[Bund Height	0 m]
[Bund Failure Modeling	Bund cannot fail]

Indoor/Outdoor

Location of release	Open air release
Outdoor Release Direction	Down - Impinging on the Ground

Flammable

Location of Late Ignition	10 m
Explosion Method	TNT
Jet Fire Method	Cone Model

Dispersion

Late Ignition Location	Ignition location supplied
Mass Inventory of material to Disperse	500 kg

Fireball Parameters

[Mass Modification Factor	3]
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SUMMARY REPORT

Unique Audit Number: 629,066



Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

[Calculation method for fireball DNV Recommended]
[TNO model flame temperature 1727 degC]

Toxic Parameters

[Indoor Calculations Unselected]
[Wind Dependent Exchange Rate Case Specified]
[Building Exchange Rate 4 /hr]
[Tail Time 1800 s]
[Set averaging time equal to exposure time Use a fixed averaging time]
[Cut-off fraction of toxic load for exposure time calculation 0.05 fraction]
[Cut-off concentration for exposure time calculations 0 fraction]

Geometry

Shape Point
Dimension 2D
System Absolute
East(1) 67 m
North(1) -20 m

Path: HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

Discharge Data

User-Defined Quantities

Material LPG
Temperature 30.00 degC
Pressure 6.56 bar
Inventory 500.00 kg
Scenario Leak
Fixed Duration n/a s

Calculated Quantities

Weather: Global Weathers\3D-Rev0

Mass Flow of Air (Vent from Vapor Space Only) n/a

Average Values for Segment Number 1

Liquid Fraction 0.69 fraction
Final Temperature -28.02 degC
Final Velocity 150.35 m/s
Droplet Diameter 7.55 um

Continuous Release Data:

Mass Flowrate 7.42460E+000 kg/s
Release Duration 67.34 s
Orifice Velocity 47.49 m/s
Exit Pressure 1.01 bar
Exit Temperature 29.59 degC
Discharge Coefficient 0.60
Expanded Radius 0.04 m

Weather: Global Weathers\3D-Rev1

Mass Flow of Air (Vent from Vapor Space Only) n/a

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Average Values for Segment Number

1

Liquid Fraction	0.69 fraction
Final Temperature	-28.02 degC
Final Velocity	150.35 m/s
Droplet Diameter	8.02 um
Continuous Release Data:	
Mass Flowrate	7.42460E+000 kg/s
Release Duration	67.34 s
Orifice Velocity	47.49 m/s
Exit Pressure	1.01 bar
Exit Temperature	29.59 degC
Discharge Coefficient	0.60
Expanded Radius	0.04 m

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Consequence Results

Pool Vaporization Results

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

			3D-Rev0	3D-Rev1
		Release Segment 1		
Release Duration	s		67.3437	67.3437
Liquid Rainout	fraction		0.687539	0.687507
		Release Segment 1 Cloud Segment 1		
Cloud Segment Duration	s		50.41	37.5156
Pool Vaporization Rate	kg/s		1.72773	1.73543
Total Vapor Flowrate	kg/s		4.04763	4.05556
		Release Segment 1 Cloud Segment 2		
Cloud Segment Duration	s		39.0587	23.715
Pool Vaporization Rate	kg/s		2.20853	2.75434
Total Vapor Flowrate	kg/s		4.52843	5.07448
		Release Segment 1 Cloud Segment 3		
Cloud Segment Duration	s		389.834	29.665
Pool Vaporization Rate	kg/s		0.373622	2.15255
Total Vapor Flowrate	kg/s		2.20853	4.47268
		Release Segment 1 Cloud Segment 4		
Cloud Segment Duration	s			334.188
Pool Vaporization Rate	kg/s			0.384806
Total Vapor Flowrate	kg/s		0.373622	2.15255
Maximum Pool Radius	m		4.69634	4.51085

Distance to Concentration Results

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

The height for user defined concentrations is the user defined height 0 m
 All toxic results are reported at the toxic effect height 0 m
 All flammable results are reported at the cloud centreline height

Concentration(ppm)	Averaging Time			Distance (m)
				3D-Rev0
UFL (92271.5)	18.75	s		29.7642
LFL (16986.2)	18.75	s		66.7681
LFL Frac (16986.2)	18.75	s		66.7681
				3D-Rev1
				29.8444
				63.5459
				63.5459
Concentration(ppm)	Averaging Time			Heights (m) for above distances
				3D-Rev0
UFL (92271.5)	18.75	s		0
LFL (16986.2)	18.75	s		0
LFL Frac (16986.2)	18.75	s		0
				3D-Rev1
				0
				0
				0

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Jet Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

Jet fire method used: Cone model - DNV recommended

	3D-Rev0	3D-Rev1
Jet Fire Status	Truncated	Truncated
Flame Direction	Along Ground	Along Ground

Radiation Effects: Jet Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

This table gives the distances to the specified radiation levels for each jet fire listed in the above hazard table

			Distance (m)	
			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	41.0696	39.6704
Radiation Level	12.5	kW/m2	24.078	23.6206
Radiation Level	37.5	kW/m2	19.085	18.9208

Radiation Effects: Jet Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

	Radiation Level (kW/m2)	
	3D-Rev0	3D-Rev1

Early Pool Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Early Pool Fire Status	Hazard	Hazard

Radiation Effects: Early Pool Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

			Distance (m)	
			3D-Rev0	3D-Rev1
Radiation Level	4	kW/m2	43.8963	43.4897
Radiation Level	12.5	kW/m2	27.9335	27.712
Radiation Level	37.5	kW/m2	13.5902	12.8773

Radiation Effects: Early Pool Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

	Radiation Level (kW/m2)	
	3D-Rev0	3D-Rev1

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Late Pool Fire Hazard

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

	3D-Rev0	3D-Rev1
Late Pool Fire Status	Hazard	Hazard

Radiation Effects: Late Pool Fire Ellipse

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

			3D-Rev0	3D-Rev1
				Distance (m)
Radiation Level	4	kW/m2	53.9856	51.6313
Radiation Level	12.5	kW/m2	34.2491	32.8296
Radiation Level	37.5	kW/m2	17.3552	15.7544

Radiation Effects: Late Pool Fire Distance

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

	3D-Rev0	3D-Rev1
		Radiation Level (kW/m2)

Flash Fire Envelope

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

All flammable results are reported at the cloud centreline height

			3D-Rev0	3D-Rev1
				Distance (m)
Furthest Extent	16986.2	ppm	66.7681	63.5459
Furthest Extent	16986.2	ppm	66.7681	63.5459
				Heights (m) for above distances
			3D-Rev0	3D-Rev1
Furthest Extent	16986.2	ppm	0	0
Furthest Extent	16986.2	ppm	0	0

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Study Folder: HPCL Jammu LPG Plant CA-REV

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Explosion Effects: Late Ignition

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

Explosion Model Used : TNT

Explosion Location Criterion: Cloud Front (LFL Fraction)

All distances are measured from the Source

All flammable results are reported at the cloud centreline height

			Maximum Distance (m) at Overpressure Level	
			3D-Rev0	3D-Rev1
Overpressure	0.02068	bar	40.6126	39.9349
Overpressure	0.0689476	bar	22.5769	22.2985
Overpressure	0.2068	bar	16.1332	15.9975

			Supplementary Data at 0.02068 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.801267	0.749226
Used Flammable Mass		kg	0.801267	0.749226
Overpressure Radius		m	30.6126	29.9349
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

			Supplementary Data at 0.0689476 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.801267	0.749226
Used Flammable Mass		kg	0.801267	0.749226
Overpressure Radius		m	12.5769	12.2985
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

			Supplementary Data at 0.2068 bar	
			3D-Rev0	3D-Rev1
Supplied Flammable Mass		kg	0.801267	0.749226
Used Flammable Mass		kg	0.801267	0.749226
Overpressure Radius		m	6.13323	5.99747
Distance to:				
- Ignition Source		m	10	10
- Cloud Front/Centre		m	10	10
- Explosion Centre		m	10	10

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Study Folder: HPCL Jammu LPG Plant CA-REV

Phast 6.6

Weather Conditions

Path: \HPCL Jammu LPG Plant CA-REV\Study\New MSV 2 Liquid Line - 25 mm Leak

		3D-Rev0	3D-Rev1
Wind Speed	m/s	3	3
Pasquill Stability		D	B
Surface Roughness Length	mm	183.156	183.156
Surface Roughness Parameter		0.0999999	0.0999999
Atmospheric Temperature	degC	25	40
Surface Temperature	degC	25	40
Relative Humidity	fraction	0.7	0.7