

	PROGETTISTA  Tecnologia Ricerca Rischi	COMMESSA NQ/R21300/L01	UNITA' -
	LOCALITA' PORTO TORRES (SS) (SARDEGNA)	001-CI-E-60001	
	PROGETTO / IMPIANTO FSRU Porto Torres e Opere Connesse	Allegato C.4.2_1	Rev. 00

Rif. TRR: 72556

FSRU di PORTO TORRES e OPERE CONNESSE

Rapporto Preliminare di Sicurezza ai sensi del D.Lgs. 105/15

ALLEGATO C.4.2_1

ELABORATI DI CALCOLO 2R-B

0	Emissione per permessi	A.VISIGOTI	V.ROMANO	G.ROMANO	AGOSTO 2024
Rev.	Descrizione	Elaborato	Verificato	Approvato	Data

Input Report

Workspace: 1RiempFSRU-2R

Riempimento FSRU-ME7

Study

1RiempFSRU-2R

Tab	Group	Field	Value
Context of calculations	Selection of context	Weathers to use for this study	Weather folder
		Parameters to use for this study	Parameter set ME4
		Obstructions to use for this study	Multi-Energy obstruction set
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Default terrain
		Type of pool substrate and bunds	No bund
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected
		Building type (downwind building type)	Buildings\Building type

2Rb Compressore BOG HD

Pressure vessel

1RiempFSRU-2R\RIEMPIMENTO FSRU-ME7

Tab	Group	Field	Value	Units
Material	Material	Material	GAS NATURALE	
		Specify volume inventory?	Yes	
		Mass inventory	111,69	kg
		Volume inventory	19,8	m3
		Material to track	GAS NATURALE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	-110	degC
		Pressure (gauge)	2,96	bar
		Fluid state	Vapour	
		Liquid mole fraction	0	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	17	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe	Pipe roughness	0,045	mm

	characteristics			
	Frequencies	Frequency of bends in pipe	0	/m
		Frequency of couplings in pipe	0	/m
		Frequency of junctions in pipe	0	/m
	Frequencies of valves	Frequency of excess flow valves	0	/m
		Frequency of non-return valves	0	/m
		Frequency of shut-off valves	0	/m
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	bar
	Inventory data for time-varying releases	Tank volume	19,8	m ³
		Tank vapour volume	19,8	m ³
		Tank liquid volume	0	m ³
		Tank liquid level	0	m
		Maximum vapour release height	0	m

		Minimum mass inventory	0,1	kg
		Maximum mass inventory	1E+09	kg
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Default terrain	
		Type of pool substrate and bunds	No bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	None	
		Wind or release angle from North	0	deg
		Handling of	Trapped	

		droplets		
		Indoor mass modification factor	3	
Explosion parameters	Explosion method (Consequence calculations only)	Explosion method	Multi-Energy: Uniform confined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	3	
		Intensity levels	4; 12,5; 37,5	kW/m2
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	
		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	
		TNO model flame temperature	1726,85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	

	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	3; 5; 7; 12,5; 37,5	kW/m2
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	
		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	20	s
	Cone model data	Horizontal options	Use standard method	
		Correlation	Recommended	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	3; 5; 7; 12,5; 37,5	kW/m2
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	



		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Radiative fraction for general fires	0,4	fraction
		Pool fire maximum exposure duration	20	s
Geometry	Geometry	East	0	m
		North	0	m

25mm

Leak

1RiempFSRU-2R\ Riempimento FSRU-ME7\ 2Rb Compressore BOG HD

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	25	mm
		Use specified discharge coefficient?	Yes	
		Discharge coefficient	0,62	fraction
	Release location	Elevation	17	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Material	Material	Material characteristics	Flammable only	
		Material to track	GAS NATURALE	
		Type of risk effects to model	Flammable only	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - continuous	Do not force correlation	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest		ppm
		Distances of interest		m
		Averaging time for		

		concentrations and distances of interest		
		Specify user-defined averaging time	No	
		User defined averaging time		s
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Default terrain	
		Type of pool substrate and bunds	No bund	
Explosion parameters	Explosion method	Explosion method	Multi-Energy: Uniform confined	
	Ignition	Supply late ignition location	No ignition location	
		Location of late ignition		m
	Vapour liquid method	Use explosion mass modification factor	Yes	
		Explosion mass modification factor	3	
Fireball	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	3	
		Intensity levels	4; 12,5; 37,5	kW/m ²
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	
		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Mass modification factor	3	
		Fireball maximum exposure duration	20	s
	Calculation method	Fireball model	Martinsen time varying	

		TNO model flame temperature	1726,85	degC
Jet fire	Jet fire method	Selection for jet fire method	Automatic selection / DNV recommended	
	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input radiation levels	5	
		Intensity levels	3; 5; 7; 12,5; 37,5	kW/m2
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	
		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Rate modification factor	3	
		Jet fire maximum exposure duration	20	s
	Cone model data	Correlation	Recommended	
		Horizontal options	Use standard method	
		Flame-shape adjustment if grounded	Yes	
	Surface emissive power	Calculation method for surface emissive power	Calculate SEP	
		Flame emissive power		kW/m2
		Emissivity fraction		fraction
Pool fire	Result types to calculate	Calculate probit	No	
		Calculate dose	No	
		Calculate lethality	No	
	Radiation levels	Number of input	5	

		radiation levels		
		Intensity levels	3; 5; 7; 12,5; 37,5	kW/m2
		Probit levels	2,73; 3,72; 7,5	
		Dose levels	1,27E+06; 5,8E+06; 2,51E+07	
		Lethality levels	0,01; 0,1; 0,99	fraction
	Parameters	Radiative fraction for general fires	0,4	fraction
		Pool fire maximum exposure duration	20	s



Discharge Report

Workspace: 1RiempFSRU-2R

Study: Riempimento FSRU-ME7

Equipment Item: 2Rb Compressore BOG HD

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 25mm

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD\25mm

Weather: Category 2/F

INPUT DATA

Inventory data

Mass in vessel	111,69	kg
----------------	---------------	----

Stagnation Data (upstream end for long pipe)

Initial pressure (gauge)	2,96	bar
Initial temperature	-110	degC
Fluid state	Pressurized gas	

Scenario data

Phase to be released	Vapour	
Hole diameter	25	mm
Discharge coefficient	0,62	fraction

OUTPUT DATA

Mass flow rate	0,304187	kg/s
Release duration	367,176	s

Orifice or pipe exit data (before atmospheric expansion)

Pressure	2,16547	bar
----------	---------	-----



Temperature	-133,123	degC
Liquid mass fraction	0	fraction
Velocity at vena contracta (at exit for pipe releases)	282,429	m/s
Discharge coefficient	0,62	

Final Data (after atmospheric expansion)

Temperature	-138,027	degC
Liquid mass fraction	0	fraction
Droplet diameter	0	um
Expanded diameter	0,0277725	m
Velocity	300	m/s



Weather: Category 5/D

INPUT DATA

Inventory data

Mass in vessel	111,69	kg
----------------	--------	----

Stagnation Data (upstream end for long pipe)

Initial pressure (gauge)	2,96	bar
Initial temperature	-110	degC
Fluid state	Pressurized gas	

Scenario data

Phase to be released	Vapour	
Hole diameter	25	mm
Discharge coefficient	0,62	fraction

OUTPUT DATA

Mass flow rate	0,304187	kg/s
Release duration	367,176	s

Orifice or pipe exit data (before atmospheric expansion)

Pressure	2,16547	bar
Temperature	-133,123	degC
Liquid mass fraction	0	fraction
Velocity at vena contracta (at exit for pipe releases)	282,429	m/s
Discharge coefficient	0,62	

Final Data (after atmospheric expansion)

Temperature	-138,027	degC
Liquid mass fraction	0	fraction
Droplet diameter	0	um
Expanded diameter	0,0277725	m
Velocity	300	m/s





Dispersion Report

Workspace: 1RiempFSRU-2R

Study: Riempimento FSRU-ME7

Equipment Item: 2Rb Compressore BOG HD

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 25mm

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD\25mm

Material to track	GAS NATURALE
-------------------	---------------------

Weather: Category 2/F

Wind speed [m/s]	2
Pasquill stability	F stable - night with moderate clouds and light/moderate wind
Atmospheric temperature [degC]	25
Relative humidity [fraction]	0,75
Solar radiation flux [kW/m2]	0,5
Mixing layer height [m]	100

Observer Release Data and Observer Mass Data

Observer number	Release type	Start time [s]	Start downwind distance [m]	Unit	Masses or mass rates		
					Release	Rainout	Final
1	Continuous	0	0	kg/s	0,304187	0	0,304187
2	Continuous	367,176	0	kg/s	0,304187	0	0,304187

Weather: Category 5/D

Wind speed [m/s]	5
Pasquill stability	D neutral - little sun and high wind or overcast/windy night
Atmospheric temperature [degC]	25
Relative humidity [fraction]	0,75
Solar radiation flux [kW/m2]	0,5
Mixing layer height [m]	800

Observer Release Data and Observer Mass Data

Observer number	Release type	Start time [s]	Start downwind distance [m]	Unit	Masses or mass rates		
					Release	Rainout	Final
1	Continuous	0	0	kg/s	0,304187	0	0,304187
2	Continuous	367,176	0	kg/s	0,304187	0	0,304187



Jet Fire

Workspace: 1RiempFSRU-2R

Study: Riempimento FSRU-ME7

Equipment Item: 2Rb Compressore BOG HD

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 25mm

1RiempFSRU-2R\Riempimento FSRU-ME7\2Rb Compressore BOG HD\25mm

Weather: Category 2/F

Wind speed [m/s]	2
Pasquill stability	F stable - night with moderate clouds and light/moderate wind
Atmospheric temperature [degC]	25
Relative humidity [fraction]	0,75
Solar radiation flux [kW/m2]	0,5

Jet fire model results

INPUT DATA

Scenario

Elevation	17	m
Release angle from horizontal	0	deg

Jet fire method

Selection for jet fire method	Automatic selection / DNV recommended
-------------------------------	---------------------------------------

Jet Fire Parameters

Wind orientation about the z-axis (anti-clockwise from the East)	0	deg
Rotation about the z-axis (anti-clockwise from the east)	0	deg



Rate modification factor	3
--------------------------	---

Automatic selection of method

Jet fire method used in calculations	Cone model
--------------------------------------	------------

Calculated inputs

Mass flow rate	0,304187	kg/s
Temperature after atmospheric expansion	-138,027	degC
Liquid fraction	0	fraction
Velocity after atmospheric expansion (input)	300	m/s
Rainout fraction time averaged	0	fraction

OUTPUT DATA

Flame emissive power	73,7891	kW/m2
Fraction of emissivity	0,0872577	fraction
Jet velocity	300	m/s
Flame length	8,19008	m
Frustum length	6,75787	m
Frustum base width	0,277291	m
Frustum tip width	1,26539	m
Frustum lift-off distance	1,45911	m
Flame length in still air	9,87385	m
Hole to flame angle	12,1446	deg
Expanded diameter	0,0277725	m
Plane angular rotation	0	deg

Radiation Intensity Ellipse Results

INPUT DATA

For ellipses 'observer direction' refers to whether inclination is 'fixed' or 'variable'. Orientation is always variable.

Observer direction	Variable	
Exposure duration	20	s

Height of interest	1,7	m
--------------------	------------	---

OUTPUT DATA

Radiation intensity

Incident radiation [kW/m ²]	Lethality [%]	View factor	Probit	Dose [(W/m ²) ^{Probit} N.s]	Ellipse half-length [m]	Ellipse half-width [m]	Effect downwind distance [m]	Ellipse area [m ²]
3	0	0,0406564	-1,38321	865.119	Not reached	Not reached	n/a	n/a
5	0,000174704	0,0677607	0,360367	1.709.491	Not reached	Not reached	n/a	n/a
7	0,02405	0,094865	1,50883	2.677.313	Not reached	Not reached	n/a	n/a
12,5	6,52536	0,169402	3,48789	5.800.162	Not reached	Not reached	n/a	n/a
37,5	98,7381	0,508205	7,23773	25.094.924	Not reached	Not reached	n/a	n/a

Radiation v Distance Results

INPUT DATA

Maximum distance	16,1315	m
Observer type radiation modelling flag	Planar	
Observer direction	Variable	
Height of interest	1,7	m

OUTPUT DATA

Downwind distance [m]	Maximum incident radiation [kW/m ²]	Lethality level [fraction]
-----------------------	---	----------------------------



0	0,30271	0
0,329214	0,308525	0
0,658427	0,314153	0
0,987641	0,319572	0
1,31685	0,32476	0
1,64607	0,329694	0
1,97528	0,334353	0
2,3045	0,338717	0
2,63371	0,342766	0
2,96292	0,346481	0
3,29214	0,349846	0
3,62135	0,352912	0
3,95056	0,357366	0
4,27978	0,361302	0
4,60899	0,364697	0
4,93821	0,367586	0
5,26742	0,369938	0
5,59663	0,3717	0
5,92585	0,372865	0
6,25506	0,373427	0
6,58427	0,373388	0
6,91349	0,372752	0
7,2427	0,371527	0
7,57191	0,369726	0
7,90113	0,367363	0
8,23034	0,364459	0
8,55956	0,361036	0
8,88877	0,357119	0
9,21798	0,352735	0
9,5472	0,347914	0
9,87641	0,342687	0
10,2056	0,337088	0
10,5348	0,331415	0
10,8641	0,32626	0
11,1933	0,320893	0



11,5225	0,315336	0
11,8517	0,310469	0
12,1809	0,306074	0
12,5101	0,301512	0
12,8393	0,296804	0
13,1685	0,291966	0
13,4978	0,287016	0
13,827	0,28197	0
14,1562	0,276846	0
14,4854	0,271659	0
14,8146	0,266424	0
15,1438	0,261155	0
15,473	0,255865	0
15,8023	0,250568	0
16,1315	0,245275	0



Weather: Category 5/D

Wind speed [m/s]	5
Pasquill stability	D neutral - little sun and high wind or overcast/windy night
Atmospheric temperature [degC]	25
Relative humidity [fraction]	0,75
Solar radiation flux [kW/m2]	0,5

Jet fire model results

INPUT DATA

Scenario

Elevation	17	m
Release angle from horizontal	0	deg

Jet fire method

Selection for jet fire method	Automatic selection / DNV recommended
-------------------------------	---------------------------------------

Jet Fire Parameters

Wind orientation about the z-axis (anti-clockwise from the East)	0	deg
Rotation about the z-axis (anti-clockwise from the east)	0	deg
Rate modification factor	3	

Automatic selection of method

Jet fire method used in calculations	Cone model
--------------------------------------	------------

Calculated inputs

Mass flow rate	0,304187	kg/s
Temperature after atmospheric expansion	-138,027	degC
Liquid fraction	0	fraction
Velocity after atmospheric expansion (input)	300	m/s



Rainout fraction time averaged	0	fraction
--------------------------------	---	----------

OUTPUT DATA

Flame emissive power	67,7995	kW/m ²
Fraction of emissivity	0,0773504	fraction
Jet velocity	300	m/s
Flame length	8,9751	m
Frustum length	7,52576	m
Frustum base width	0,277291	m
Frustum tip width	1,08502	m
Frustum lift-off distance	1,45911	m
Flame length in still air	9,87385	m
Hole to flame angle	7,24718	deg
Expanded diameter	0,0277725	m
Plane angular rotation	0	deg

Radiation Intensity Ellipse Results

INPUT DATA

For ellipses 'observer direction' refers to whether inclination is 'fixed' or 'variable'. Orientation is always variable.

Observer direction	Variable	
Exposure duration	20	s
Height of interest	1,7	m

OUTPUT DATA

Radiation intensity

Incident radiation [kW/m ²]	Lethality [%]	View factor	Probit	Dose [(W/m ²) ^{Probit} N.s]	Ellipse half-length [m]	Ellipse half-width [m]	Effect downwind distance [m]	Ellipse area [m ²]
3	0	0,0442481	-1,38321	865.119	Not reached	Not reached	n/a	n/a



5	0,000174 704	0,07374 69	0,3603 67	1.709.491	Not reach ed	Not reach ed	n/a	n/a
7	0,02405	0,10324 6	1,5088 3	2.677.313	Not reach ed	Not reach ed	n/a	n/a
12,5	6,52536	0,18436 7	3,4878 9	5.800.162	Not reach ed	Not reach ed	n/a	n/a
37,5	98,7381	0,55310 2	7,2377 3	25.094.924	Not reach ed	Not reach ed	n/a	n/a

Radiation v Distance Results

INPUT DATA

Maximum distance	17,8495	m
Observer type radiation modelling flag	Planar	
Observer direction	Variable	
Height of interest	1,7	m

OUTPUT DATA

Downwind distance [m]	Maximum incident radiation [kW/m ²]	Lethality level [fraction]
0	0,276379	0
0,364275	0,282277	0
0,728551	0,287982	0
1,09283	0,293465	0
1,4571	0,2987	0
1,82138	0,30366	0
2,18565	0,308318	0
2,54993	0,312651	0
2,9142	0,318472	0
3,27848	0,324008	0
3,64275	0,329095	0
4,00703	0,333663	0



4,37131	0,337643	0
4,73558	0,341005	0
5,09986	0,343724	0
5,46413	0,345781	0
5,82841	0,347161	0
6,19268	0,347854	0
6,55696	0,347857	0
6,92123	0,347172	0
7,28551	0,345807	0
7,64979	0,343775	0
8,01406	0,341094	0
8,37834	0,337789	0
8,74261	0,333887	0
9,10689	0,32942	0
9,47116	0,324425	0
9,83544	0,318939	0
10,1997	0,313217	0
10,564	0,308228	0
10,9283	0,302947	0
11,2925	0,298482	0
11,6568	0,293984	0
12,0211	0,28925	0
12,3854	0,284306	0
12,7496	0,279175	0
13,1139	0,273883	0
13,4782	0,268453	0
13,8425	0,262907	0
14,2067	0,25727	0
14,571	0,251561	0
14,9353	0,245802	0
15,2996	0,240012	0
15,6638	0,234209	0
16,0281	0,228409	0
16,3924	0,222629	0
16,7567	0,216882	0



17,1209	0,211182	0
17,4852	0,20554	0
17,8495	0,199967	0

