

	<b>PROGETTISTA</b>  <b>Tecnologia Ricerca Rischi</b>	<b>COMMESSA</b> NQ/R21300/L01	<b>UNITA'</b> -
	<b>LOCALITA'</b> PORTO TORRES (SS) (SARDEGNA)	<b>001-CI-E-60001</b>	
	<b>PROGETTO / IMPIANTO</b> FSRU Porto Torres e Opere Connesse	Allegato C.4.2_1	<b>Rev.</b> 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 6R

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

# Input Report

## Workspace: 1RiempFSRU-6R

### Riempimento FSRU-ME4

Study

1RiempFSRU-6R

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

## 6R Linee ricircolo GNL durante riempimento FSRU

Pressure vessel

1RiempFSRU-6R\Riempimento FSRU-ME4

Tab	Group	Field	Value	Units
Material	Material	Material	GAS NATURALE	
		Specify volume inventory?	Yes	
		Mass inventory	777,539	kg
		Volume inventory	1,71	m3
		Material to track	GAS NATURALE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	-160	degC
		Pressure (gauge)	13,5	bar
		Fluid state	Liquid	
		Liquid mole fraction	1	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	1,71	m3
		Tank vapour volume	0	m3
		Tank liquid volume	1,71	m3
		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



## 65mm-Q6,4

User defined source

1RiempFSRU-6R\RIEMPIMENTO FSRU-ME4\6R Linee ricircolo GNL durante riempimento FSRU

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0; 3600	s
		Release phase	Liquid; Liquid	
		Mass flow	6,4; 6,4	kg/s
		Final velocity	76,9707; 76,9707	m/s
		Final temperature	-160,343; -160,343	degC
		Liquid fraction	1; 1	fraction
		Droplet diameter	246,403; 246,403	um
		Pool radius	-9,95E+36; -9,95E+36	m
		Pre-dilution air rate	0; 0	kg/s
		Downstream calculation status	No errors detected	
	Release location	Elevation	17	m
		Tank head	0	m
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge		bar
	Jet fire Miller model hole size	Orifice diameter	0	mm
Material	Material	Material characteristics	Flammable only	

		Material to track	GAS NATURALE	
		Type of risk effects to model	Flammable only	
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/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	
	Automatic selection of method	Jet fire method to be used in calculations	Cone model	
	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	Yes	

		adjustment if grounded		
	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





# Dispersion Report

## Workspace: 1RiempFSRU-6R

### Study: Riempimento FSRU-ME4

#### Equipment Item: 6R Linee ricircolo GNL durante riempimento FSRU

1RiempFSRU-6R\Riempimento FSRU-ME4\6R Linee ricircolo GNL durante riempimento FSRU

Material	GAS NATURALE	
East	0	m
North	0	m

#### Scenario (User defined source) : 65mm-Q6,4

1RiempFSRU-6R\Riempimento FSRU-ME4\6R Linee ricircolo GNL durante riempimento FSRU\65mm-Q6,4

Material to track	GAS NATURALE
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#### 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	6,4	0	6,4
2	Continuous	3600	0	kg/s	6,4	0	6,4

**Weather: Category 5/D**

<b>Wind speed [m/s]</b>	<b>5</b>
<b>Pasquill stability</b>	<b>D neutral - little sun and high wind or overcast/windy night</b>
<b>Atmospheric temperature [degC]</b>	25
<b>Relative humidity [fraction]</b>	0,75
<b>Solar radiation flux [kW/m2]</b>	0,5
<b>Mixing layer height [m]</b>	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	6,4	0	6,4
2	Continuous	3600	0	kg/s	6,4	0	6,4





# Jet Fire

## Workspace: 1RiempFSRU-6R

### Study: Riempimento FSRU-ME4

#### Equipment Item: 6R Linee ricircolo GNL durante riempimento FSRU

1RiempFSRU-6R\Riempimento FSRU-ME4\6R Linee ricircolo GNL durante riempimento FSRU

Material	GAS NATURALE	
East	0	m
North	0	m

#### Scenario (User defined source) : 65mm-Q6,4

1RiempFSRU-6R\Riempimento FSRU-ME4\6R Linee ricircolo GNL durante riempimento FSRU\65mm-Q6,4

#### 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
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#### 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
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### Calculated inputs

Mass flow rate	6,4	kg/s
Temperature after atmospheric expansion	-160,343	degC
Liquid fraction	1	fraction
Velocity after atmospheric expansion (input)	<b>76,9707</b>	m/s
Rainout fraction time averaged	0	fraction

### OUTPUT DATA

Flame emissive power	76,9785	kW/m2
Fraction of emissivity	0,273775	fraction
Jet velocity	76,9707	m/s
Flame length	39,9589	m
Frustum length	39,3595	m
Frustum base width	0,65113	m
Frustum tip width	14,5663	m
Frustum lift-off distance	0,599383	m
Flame length in still air	35,9332	m
Hole to flame angle	0	deg
Expanded diameter	0,0152502	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	<b>1,7</b>	m

## OUTPUT DATA

### Radiation intensity

Incident radiation [kW/m <sup>2</sup> ]	Lethality [%]	View factor	Probit	Dose [(W/m <sup>2</sup> ) <sup>ProbitN.s</sup> ]	Ellipse half-length [m]	Ellipse half-width [m]	Ellipse centre downwind distance [m]	Effect downwind distance [m]	Ellipse area [m <sup>2</sup> ]
3	0	0,0389719	-1,38321	865.119	35,2877	38,4669	30,3274	65,6151	4264,43
5	0,000174704	0,0649532	0,360367	1.709.491	27,613	28,4236	29,4247	57,0376	2465,71
7	0,02405	0,0909345	1,50883	2.677.313	22,9871	22,5751	28,7931	51,7802	1630,28
12,5	6,52536	0,162383	3,48789	5.800.162	12,2422	12,6957	27,415	39,6572	488,274
37,5	98,7381	0,487149	7,23773	25.094.924	Not reached	Not reached		n/a	n/a

### Radiation v Distance Results

#### INPUT DATA

Maximum distance	79,9178	m
Observer type radiation modelling flag	Planar	
Observer direction	Variable	
Height of interest	<b>1,7</b>	m

#### OUTPUT DATA

Downwind distance [m]	Maximum incident radiation [kW/m <sup>2</sup> ]	Lethality level [fraction]
0	4,2203	9,04691E-08
1,63098	4,91808	1,32793E-06
3,26195	5,68593	1,3305E-05
4,89293	6,51386	9,31996E-05
6,5239	7,39194	0,000474576
8,15488	8,30985	0,00183229
9,78585	9,25798	0,00559184
11,4168	10,242	0,0141853
13,0478	11,2106	0,0298024
14,6788	12,2	0,0553541
16,3098	13,188	0,0918844
17,9407	14,1667	0,138984
19,5717	15,127	0,194616
21,2027	16,058	0,25554
22,8337	16,9444	0,317835
24,4646	17,7669	0,377527
26,0956	18,4973	0,430748
27,7266	19,0946	0,47369
29,3576	19,5033	0,502514
30,9885	19,642	0,512162
32,6195	19,3955	0,494964
34,2505	18,6275	0,440178
35,8815	17,2076	0,336821
37,5124	15,0434	0,18945
39,1434	12,8143	0,0767402
40,7744	11,7843	0,0433232
42,4054	11,6476	0,0397861
44,0363	11,0092	0,0258524
45,6673	10,1777	0,0134271
47,2983	9,28098	0,00572857
48,9293	8,39922	0,00205777
50,5602	7,57286	0,000635047
52,1912	6,81765	0,000171008



53,8222	6,13681	4,06957E-05
55,4532	5,52792	8,66127E-06
57,0841	4,98574	1,66651E-06
58,7151	4,50418	2,9299E-07
60,3461	4,07699	4,75572E-08
61,9771	3,6981	0
63,608	3,36208	0
65,239	3,06376	0
66,87	2,79861	0
68,501	2,56248	0
70,1319	2,35209	0
71,7629	2,16415	0
73,3939	1,99597	0
75,0249	1,84509	0
76,6558	1,70954	0
78,2868	1,5875	0
79,9178	1,47741	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
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##### 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
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##### Calculated inputs

Mass flow rate	6,4	kg/s
Temperature after atmospheric expansion	-160,343	degC
Liquid fraction	1	fraction
Velocity after atmospheric expansion (input)	<b>76,9707</b>	m/s



Rainout fraction time averaged	<b>0</b>	fraction
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### OUTPUT DATA

Flame emissive power	102,36	kW/m2
Fraction of emissivity	0,273775	fraction
Jet velocity	76,9707	m/s
Flame length	31,0611	m
Frustum length	30,5952	m
Frustum base width	1,01167	m
Frustum tip width	13,339	m
Frustum lift-off distance	0,465917	m
Flame length in still air	35,9332	m
Hole to flame angle	0	deg
Expanded diameter	0,0152502	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	<b>1,7</b>	m

#### OUTPUT DATA

##### Radiation intensity

Incident radiation [kW/m2]	Lethality [%]	View factor	Probit	Dose [(W/m2)^ProbitN.s]	Ellipse half-length [m]	Ellipse half-width [m]	Ellipse centre downwind distance [m]	Effect downwind distance [m]	Ellipse area [m2]
3	0	0,0293082	-1,38321	865.119	35,2058	38,3104	23,5848	58,7906	4237,22



5	0,00017 4704	0,0488 471	0,360 367	1.709.491	26,66 35	28,32 49	23,3979	50,0615	2372, 66
7	0,02405	0,0683 859	1,508 83	2.677.313	22,10 58	22,78 83	22,6848	44,7906	1582, 58
12,5	6,52536	0,1221 18	3,487 89	5.800.162	13,52 72	13,80 6	21,4143	34,9415	586,7 15
37,5	98,7381	0,3663 53	7,237 73	25.094.924	Not reach ed	Not reach ed		n/a	n/a

## Radiation v Distance Results

### INPUT DATA

Maximum distance	62,1223	m
Observer type radiation modelling flag	Planar	
Observer direction	Variable	
Height of interest	<b>1,7</b>	m

### OUTPUT DATA

Downwind distance [m]	Maximum incident radiation [kW/m <sup>2</sup> ]	Lethality level [fraction]
0	6,63089	0,00011846
1,2678	7,45598	0,000526931
2,5356	8,34051	0,00190724
3,8034	9,27362	0,00568452
5,07121	10,2462	0,0142359
6,33901	11,2489	0,0305987
7,60681	12,2721	0,0576378
8,87461	13,3062	0,0970125
10,1424	14,342	0,148495
11,4102	15,3693	0,209894
12,678	16,3771	0,277593
13,9458	17,3528	0,347357
15,2136	18,2823	0,415125
16,4814	19,1573	0,478151
17,7492	20,2452	0,553193



19,017	20,5863	0,575642
20,2848	21,0954	0,608008
21,5526	21,4054	0,627004
22,8204	21,4593	0,630247
24,0882	21,19	0,613865
25,356	20,5263	0,571732
26,6238	19,4067	0,495747
27,8916	17,8035	0,380203
29,1594	15,7557	0,235141
30,4272	14,325	0,147559
31,695	13,523	0,106823
32,9628	13,2223	0,0933575
34,2306	12,8348	0,0775287
35,4984	12,2084	0,055618
36,7662	11,4816	0,0357586
38,034	10,7106	0,0207026
39,3019	9,93652	0,0108526
40,5697	9,18601	0,00518049
41,8375	8,47422	0,00226399
43,1053	7,80858	0,00091031
44,3731	7,19218	0,000338558
45,6409	6,6249	0,000117038
46,9087	6,1051	3,77982E-05
48,1765	5,6302	1,14627E-05
49,4443	5,19717	3,28093E-06
50,7121	4,80279	8,90842E-07
51,9799	4,44381	2,30552E-07
53,2477	4,11724	5,71777E-08
54,5155	3,82026	1,36633E-08
55,7833	3,54964	0
57,0511	3,30315	0
58,3189	3,07831	0
59,5867	2,87332	0
60,8545	2,68608	0
62,1223	2,51486	0



