

	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 9R

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

Input Report

Workspace: 2FSRURegas-9R

FSRU in rigassificazione

Study

2FSRURegas-9R

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
		Obstructions to use for this study	
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)	

9R Linee mandata pompe HP

Pressure vessel

2FSRURegas-9R\FSRU in rigassificazione

Tab	Group	Field	Value	Units
Material	Material	Material	GAS NATURALE	
		Specify volume inventory?	Yes	
		Mass inventory	9092,38	kg
		Volume inventory	20,7	m3
		Material to track	GAS NATURALE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	-150	degC
		Pressure (gauge)	206	bar
		Fluid state	Liquid	
		Liquid mole fraction	1	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	21,5	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	20,7	m3
		Tank vapour volume	0	m3
		Tank liquid volume	20,7	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

60mm-96,7kg/s

User defined source

2FSRURegas-9R\FSRU in rigassificazione\9R Linee mandata pompe HP

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	Two-phase; Two-phase	
		Mass flow	96,7; 96,7	kg/s
		Final velocity	300; 300	m/s
		Final temperature	-160,343; -160,343	degC
		Liquid fraction	0,965597; 0,965597	fraction
		Droplet diameter	44,958; 44,958	um
		Pool radius		m
		Pre-dilution air rate	0; 0	kg/s
		Downstream calculation status	No errors detected	
	Release location	Elevation	21,5	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 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





Dispersion Report

Workspace: 2FSRURegas-9R

Study: FSRU in rigassificazione

Equipment Item: 9R Linee mandata pompe HP

2FSRURegas-9R\FSRU in rigassificazione\9R Linee mandata pompe HP

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (User defined source) : 60mm-96,7kg/s

2FSRURegas-9R\FSRU in rigassificazione\9R Linee mandata pompe HP\60mm-96,7kg/s

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	96,7	0	96,7
2	Continuous	3600	0	kg/s	96,7	0	96,7



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	96,7	0	96,7
2	Continuous	3600	0	kg/s	96,7	0	96,7



Jet Fire

Workspace: 2FSRURegas-9R

Study: FSRU in rigassificazione

Equipment Item: 9R Linee mandata pompe HP

2FSRURegas-9R\FSRU in rigassificazione\9R Linee mandata pompe HP

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (User defined source) : 60mm-96,7kg/s

2FSRURegas-9R\FSRU in rigassificazione\9R Linee mandata pompe HP\60mm-96,7kg/s

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	21,5	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
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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	96,7	kg/s
Temperature after atmospheric expansion	-160,343	degC
Liquid fraction	0,965597	fraction
Velocity after atmospheric expansion (input)	300	m/s
Rainout fraction time averaged	0	fraction

OUTPUT DATA

Flame emissive power	148,842	kW/m2
Fraction of emissivity	0,189687	fraction
Jet velocity	300	m/s
Flame length	106,393	m
Frustum length	104,797	m
Frustum base width	0,629907	m
Frustum tip width	31,2771	m
Frustum lift-off distance	1,5959	m
Flame length in still air	95,6744	m
Hole to flame angle	0	deg
Expanded diameter	0,0883697	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
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Exposure duration	20	s
Height of interest	1,7	m

OUTPUT DATA

Radiation intensity

Incident radiation [kW/m ²]	Lethality [%]	View factor	Probability	Dose [(W/m ²) ^{ProbitN.s}]	Ellipse half-length [m]	Ellipse half-width [m]	Ellipse centre downwind distance [m]	Effect downwind distance [m]	Ellipse area [m ²]
3	0	0,0201556	-1,38321	865.119	106,304	124,941	85,0601	191,364	41725,9
5	0,000174704	0,0335926	0,360367	1.709.491	88,7222	97,1242	81,8235	170,546	27071,3
7	0,02405	0,0470297	1,50883	2.677.313	78,8356	81,751	80,031	158,867	20247,2
12,5	6,52536	0,0839816	3,48789	5.800.162	65,6626	59,4717	75,8098	141,472	12268,1
37,5	98,7381	0,251945	7,23773	25.094.924	36,9541	25,6122	77,6472	114,601	2973,44

Radiation v Distance Results

INPUT DATA

Maximum distance	212,786	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	6,41245	7,52258E-05
4,34258	8,71336	0,00303624



8,68515	11,4863	0,0358698
13,0277	15,1724	0,197445
17,3703	17,9256	0,389117
21,7129	21,406	0,627042
26,0555	24,9868	0,802885
30,398	28,6389	0,906183
34,7406	32,3461	0,958461
39,0832	36,0979	0,98247
43,4258	39,8902	0,99283
47,7683	43,721	0,997124
52,1109	47,5855	0,998858
56,4535	51,4902	0,99955
60,7961	55,4227	0,999822
65,1387	59,3922	0,99993
69,4812	63,4201	0,999972
73,8238	67,4202	0,999989
78,1664	71,4578	0,999995
82,509	75,6526	0,999998
86,8515	79,3935	0,999999
91,1941	83,0086	1
95,5367	85,6639	1
99,8793	84,6984	1
104,222	51,7826	0,99958
108,564	50,0323	0,999363
112,907	41,0564	0,994567
117,25	33,0511	0,964594
121,592	27,0941	0,870412
125,935	22,6937	0,699657
130,277	19,0455	0,470197
134,62	16,0904	0,257755
138,962	13,6937	0,114915
143,305	11,7074	0,0413083
147,648	10,0641	0,0121628
151,99	8,70306	0,00299912
156,333	7,5718	0,000633991



160,675	6,62693	0,000117518
165,018	5,83398	1,95297E-05
169,36	5,16438	2,96282E-06
173,703	4,59577	4,17319E-07
178,046	4,11006	5,53408E-08
182,388	3,6928	0
186,731	3,33239	0
191,073	3,01944	0
195,416	2,74635	0
199,759	2,50688	0
204,101	2,29597	0
208,444	2,10935	0
212,786	1,94365	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	21,5	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	96,7	kg/s
Temperature after atmospheric expansion	-160,343	degC
Liquid fraction	0,965597	fraction
Velocity after atmospheric expansion (input)	300	m/s



Rainout fraction time averaged	0	fraction
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OUTPUT DATA

Flame emissive power	209,023	kW/m2
Fraction of emissivity	0,189687	fraction
Jet velocity	300	m/s
Flame length	82,7023	m
Frustum length	81,4618	m
Frustum base width	0,998951	m
Frustum tip width	27,7143	m
Frustum lift-off distance	1,24053	m
Flame length in still air	95,6744	m
Hole to flame angle	0	deg
Expanded diameter	0,0883697	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/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	0,0143525	-1,38321	865.119	103,296	124,546	69,2687	172,565	40417,1



5	0,00017 4704	0,0239 208	0,360 367	1.709.491	85,34 23	96,87 22	65,694	151,036	2597 2,5
7	0,02405	0,0334 892	1,508 83	2.677.313	75,08 22	81,94 84	63,9458	139,028	1932 9,8
12,5	6,52536	0,0598 021	3,487 89	5.800.162	59,75 72	60,48 75	61,5534	121,311	1135 5,5
37,5	98,7381	0,1794 06	7,237 73	25.094.924	35,68 15	29,07 71	59,0804	94,7619	3259, 44

Radiation v Distance Results

INPUT DATA

Maximum distance	172,565	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	10,9981	0,0256457
3,52173	14,083	0,134555
7,04346	18,0113	0,395368
10,5652	21,5635	0,636476
14,0869	25,7342	0,829598
17,6087	30,0818	0,931279
21,1304	34,5535	0,97491
24,6521	39,1161	0,991385
28,1738	43,7472	0,997142
31,6956	48,4317	0,999067
35,2173	53,1584	0,999697
38,739	57,919	0,999901
42,2608	62,704	0,999967
45,7825	67,5058	0,999989
49,3042	72,308	0,999996
52,826	77,092	0,999999



56,3477	81,8168	1
59,8694	86,4184	1
63,3912	90,7741	1
66,9129	95,9279	1
70,4346	97,2373	1
73,9563	97,1482	1
77,4781	89,7754	1
80,9998	66,2192	0,999985
84,5215	56,4151	0,999859
88,0433	51,7165	0,999573
91,565	43,6461	0,997072
95,0867	36,9311	0,985576
98,6085	31,4071	0,948717
102,13	26,8598	0,864049
105,652	23,0807	0,719423
109,174	19,9244	0,531566
112,695	17,2833	0,342311
116,217	15,0714	0,191172
119,739	13,2254	0,0934891
123,261	11,6678	0,0402967
126,782	10,3351	0,0153384
130,304	9,1926	0,00521712
133,826	8,21018	0,00160507
137,347	7,36309	0,000452463
140,869	6,62955	0,000118141
144,391	5,99202	2,88831E-05
147,913	5,43559	6,67303E-06
151,434	4,94801	1,46922E-06
154,956	4,51906	3,10571E-07
158,478	4,14023	6,34429E-08
162	3,80442	1,25962E-08
165,521	3,50565	0
169,043	3,23892	0
172,565	2,99999	0

