

	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 13R

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

Input Report

Workspace: 3InvioGN-13R

Invio GN a metanodotto

Study

3InvioGN-13R

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	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

13R Metanodotto onshore

Pressure vessel

3InvioGN-13R\Invio GN a metanodotto

Tab	Group	Field	Value	Units
Material	Material	Material	GAS NATURALE	
		Specify volume inventory?	Yes	
		Mass inventory	4488,39	kg
		Volume inventory	78,04	m3
		Material to track	GAS NATURALE	
	Phase	Specified condition	Pressure/temperature	
		Temperature	50	degC
		Pressure (gauge)	75	bar
		Fluid state	Vapour	
		Liquid mole fraction	0	fraction
Scenario	Pipe dimensions	Pipe length		m
	Release location	Elevation	0	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	78,04	m ³
		Tank vapour volume	78,04	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

50mm

Leak

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore

Tab	Group	Field	Value	Units
Scenario	Hole	Orifice diameter	50	mm
		Use specified discharge coefficient?	Yes	
		Discharge coefficient	0,62	fraction
	Release location	Elevation	0	m
		Tank head	0	m
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	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: 3InvioGN-13R

Study: Invio GN a metanodotto

Equipment Item: 13R Metanodotto onshore

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 50mm

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore\50mm

Weather: Category 2/F

INPUT DATA

Inventory data

Mass in vessel	4488,39	kg
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Stagnation Data (upstream end for long pipe)

Initial pressure (gauge)	75	bar
Initial temperature	50	degC
Fluid state	Pressurized gas	

Scenario data

Phase to be released	Vapour	
Hole diameter	50	mm
Discharge coefficient	0,62	fraction

OUTPUT DATA

Mass flow rate	17,2154	kg/s
Release duration	260,719	s

Orifice or pipe exit data (before atmospheric expansion)

Pressure	41,119	bar
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Temperature	5,2336	degC
Liquid mass fraction	0	fraction
Velocity at vena contracta (at exit for pipe releases)	387,063	m/s
Discharge coefficient	0,62	

Final Data (after atmospheric expansion)

Temperature	-7,03143	degC
Liquid mass fraction	0	fraction
Droplet diameter	0	um
Expanded diameter	0,296312	m
Velocity	300	m/s



Weather: Category 5/D

INPUT DATA

Inventory data

Mass in vessel	4488,39	kg
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Stagnation Data (upstream end for long pipe)

Initial pressure (gauge)	75	bar
Initial temperature	50	degC
Fluid state	Pressurized gas	

Scenario data

Phase to be released	Vapour	
Hole diameter	50	mm
Discharge coefficient	0,62	fraction

OUTPUT DATA

Mass flow rate	17,2154	kg/s
Release duration	260,719	s

Orifice or pipe exit data (before atmospheric expansion)

Pressure	41,119	bar
Temperature	5,2336	degC
Liquid mass fraction	0	fraction
Velocity at vena contracta (at exit for pipe releases)	387,063	m/s
Discharge coefficient	0,62	

Final Data (after atmospheric expansion)

Temperature	-7,03143	degC
Liquid mass fraction	0	fraction
Droplet diameter	0	um
Expanded diameter	0,296312	m
Velocity	300	m/s







Dispersion Report

Workspace: 3InvioGN-13R

Study: Invio GN a metanodotto

Equipment Item: 13R Metanodotto onshore

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 50mm

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore\50mm

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	17,2154	0	17,2154
2	Continuous	260,719	0	kg/s	17,2154	0	17,2154



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	17,2154	0	17,2154
2	Continuous	260,719	0	kg/s	17,2154	0	17,2154





Jet Fire

Workspace: 3InvioGN-13R

Study: Invio GN a metanodotto

Equipment Item: 13R Metanodotto onshore

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore

Material	GAS NATURALE	
East	0	m
North	0	m

Scenario (Leak) : 50mm

3InvioGN-13R\Invio GN a metanodotto\13R Metanodotto onshore\50mm

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	0	m
Release angle from horizontal	90	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	
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Automatic selection of method

Jet fire method used in calculations	Cone model	
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Calculated inputs

Mass flow rate	17,2154	kg/s
Temperature after atmospheric expansion	-7,03143	degC
Liquid fraction	0	fraction
Velocity after atmospheric expansion (input)	300	m/s
Rainout fraction time averaged	0	fraction

OUTPUT DATA

Flame emissive power	164,191	kW/m2
Fraction of emissivity	0,189687	fraction
Jet velocity	300	m/s
Flame length	41,45	m
Frustum length	34,1502	m
Frustum base width	3,60836	m
Frustum tip width	12,1854	m
Frustum lift-off distance	7,35411	m
Flame length in still air	57,6369	m
Hole to flame angle	7,67853	deg
Expanded diameter	0,296312	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]	Ellipse centre downwind distance [m]	Effect downwind distance [m]	Ellipse area [m ²]
3	0	0,0182713	-1,38321	865.119	50,0185	49,7244	4,16509	54,1836	7813,57
5	0,000174704	0,0304522	0,360367	1.709.491	33,6693	33,1454	3,96688	37,6362	3505,97
7	0,02405	0,0426331	1,50883	2.677.313	23,4905	23,2924	3,21227	26,7028	1718,93
12,5	6,52536	0,0761306	3,48789	5.800.162	5,95967	8,5286	4,71686	10,7804	159,68
37,5	98,7381	0,228392	7,23773	25.094.924	Not reached	Not reached		n/a	n/a

Radiation v Distance Results

INPUT DATA

Maximum distance	54,1836	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	12,9597	0,0824409
1,10579	13,153	0,090401



2,21157	14,5979	0,162918
3,31736	15,4515	0,215181
4,42315	15,6657	0,229173
5,52893	15,4083	0,2124
6,63472	14,8848	0,179806
7,74051	14,1791	0,139649
8,84629	13,5723	0,109127
9,95208	12,914	0,0806215
11,0579	12,2899	0,0582113
12,1637	11,7076	0,0413139
13,2694	11,1679	0,0289312
14,3752	10,6682	0,0200379
15,481	10,2051	0,013746
16,5868	9,77539	0,00935423
17,6926	9,37397	0,00630833
18,7984	8,99755	0,00421558
19,9042	8,64337	0,00279106
21,0099	8,30901	0,00183026
22,1157	7,99236	0,00118825
23,2215	7,74289	0,000825142
24,3273	7,5027	0,000568119
25,4331	7,26623	0,000384494
26,5389	7,03397	0,00025581
27,6447	6,80632	0,000167327
28,7505	6,59282	0,000109663
29,8562	6,37423	6,92796E-05
30,962	6,16114	4,30485E-05
32,0678	5,95378	2,63184E-05
33,1736	5,75229	1,58362E-05
34,2794	5,55675	9,38158E-06
35,3852	5,36721	5,47378E-06
36,491	5,18368	3,14662E-06
37,5968	5,00615	1,78285E-06
38,7025	4,83178	9,8637E-07
39,8083	4,66638	5,43887E-07



40,9141	4,50674	2,95945E-07
42,0199	4,35281	1,5902E-07
43,1257	4,20689	8,53132E-08
44,2315	4,06432	4,48505E-08
45,3373	3,92697	2,33098E-08
46,443	3,79473	1,19824E-08
47,5488	3,66746	0
48,6546	3,54501	0
49,7604	3,42723	0
50,8662	3,31398	0
51,972	3,2051	0
53,0778	3,10044	0
54,1836	2,99985	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	0	m
Release angle from horizontal	90	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	17,2154	kg/s
Temperature after atmospheric expansion	-7,03143	degC
Liquid fraction	0	fraction
Velocity after atmospheric expansion (input)	300	m/s



Rainout fraction time averaged	0	fraction
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OUTPUT DATA

Flame emissive power	222,814	kW/m2
Fraction of emissivity	0,189687	fraction
Jet velocity	300	m/s
Flame length	32,2203	m
Frustum length	27,6076	m
Frustum base width	3,41826	m
Frustum tip width	10,7973	m
Frustum lift-off distance	4,84252	m
Flame length in still air	57,6369	m
Hole to flame angle	19,1963	deg
Expanded diameter	0,296312	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	Probability	Dose [(W/m2)^ProbabilityN.s]	Ellipse half-length [m]	Ellipse half-width [m]	Ellipse centre downwind distance [m]	Effect downwind distance [m]	Ellipse area [m2]
3	0	0,0134642	-1,38321	865.119	53,2459	54,8329	6,7227	59,9686	9172,28



5	0,00017 4704	0,0224 403	0,360 367	1.709.491	39,64 53	40,58 85	7,35089	46,9962	5055, 28
7	0,02405	0,0314 164	1,508 83	2.677.313	31,82 65	32,29 62	7,53101	39,3575	3229, 16
12,5	6,52536	0,0561 007	3,487 89	5.800.162	19,95 46	19,16 99	6,91941	26,874	1201, 75
37,5	98,7381	0,1683 02	7,237 73	25.094.924	2,868 08	2,976 07	1,27342	4,1415	26,81 54

Radiation v Distance Results

INPUT DATA

Maximum distance	59,9686	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	43,4927	0,996963
1,22385	42,1108	0,995775
2,4477	43,4408	0,996925
3,67155	39,2949	0,991742
4,8954	33,4262	0,967497
6,11925	30,3427	0,935096
7,3431	28,0017	0,892662
8,56694	26,6855	0,859141
9,79079	25,5378	0,822888
11,0146	24,4312	0,780896
12,2385	23,3512	0,73267
13,4623	22,2333	0,674892
14,6862	21,1787	0,613167
15,91	20,1586	0,5474
17,1339	19,1757	0,479457
18,3577	18,2225	0,410772



19,5816	17,3787	0,349238
20,8054	16,4147	0,280225
22,0293	15,5596	0,222201
23,2531	14,7373	0,171029
24,477	13,9482	0,127574
25,7008	13,1929	0,0920937
26,9247	12,4715	0,0642695
28,1485	11,7844	0,0433272
29,3724	11,1315	0,0282039
30,5962	10,5125	0,0177255
31,8201	9,9268	0,0107573
33,0439	9,37376	0,00630695
34,2678	8,85241	0,0035747
35,4916	8,36167	0,00196041
36,7155	7,90031	0,00104136
37,9393	7,46895	0,000538105
39,1632	7,06215	0,000269134
40,387	6,68067	0,000130877
41,6109	6,32312	6,19696E-05
42,8347	5,98812	2,86117E-05
44,0586	5,6743	1,29002E-05
45,2824	5,38036	5,68814E-06
46,5063	5,10501	2,45635E-06
47,7301	4,84704	1,04031E-06
48,954	4,60531	4,32695E-07
50,1778	4,37871	1,76977E-07
51,4017	4,16622	7,12718E-08
52,6255	3,96686	2,82949E-08
53,8494	3,77975	1,10863E-08
55,0732	3,60402	0
56,2971	3,4389	0
57,5209	3,28365	0
58,7448	3,13758	0
59,9686	3,00008	0

