



## MySep Customer Care Program

### Vessel Process Design Report

#### 3-Phase Separator

Project reference: Sensitivity & Operating Envelope  
Design revision:  
Design date:  
Designed by:  
Company (MySep licensee): MySep Pte Ltd  
Report generated on: 30-Jun-21



The design in this report has been created by licensee using MySep v5.0.2 software by:



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*In this report, numbers in blue are user input values. Numbers in black are calculated values.*

## 1 Input data

		Case 1	Case 2	Case 3	Case 4
<b>Operating conditions</b>					
Operating pressure	barg	30.00	30.00	30.00	15.00
Operating temperature	°C	20.00	20.00	20.00	20.00
<b>Gas</b>					
Gas flow rate	MMSCFD	75	60	50	50
Gas molecular weight	kg/kmol	21.00	21.00	21.00	21.00
Gas density	kg/m <sup>3</sup>	28.00	28.00	28.00	14.46
Compressibility factor	-	0.954	0.954	0.954	0.954
Gas viscosity	cP	0.0120	0.0120	0.0120	0.0120
Determine gas density by gas law?	yes				
<b>Hydrocarbon liquid</b>					
HC liquid flow rate	bbl/d	30,000	35,000	20,000	20,000
HC liquid density	kg/m <sup>3</sup>	600.00	600.00	600.00	600.00
HC liquid viscosity	cP	1.00	1.00	1.00	1.00
HC liquid surface tension	dyne/cm	20.00	20.00	20.00	20.00
<b>Aqueous liquid</b>					
Aqueous liquid flow rate	bbl/d	10,000	15,000	20,000	20,000
Aqueous liquid density	kg/m <sup>3</sup>	1000.00	1000.00	1000.00	1000.00
Aqueous liquid viscosity	cP	0.50	0.50	0.50	0.50
Aqueous liquid surface tension	dyne/cm	70.00	70.00	70.00	70.00

### Case title definitions:

- Case 1: Case 1
- Case 2: Case 2
- Case 3: Case 3
- Case 4: Case 4 Low Pres

## 2 Vessel Design overview

### 2.1 Summary

Mode	Design
Vessel orientation	Horizontal
Separation type	3-phase
Vessel ID (mm)	2500
Vessel Tan-Tan (mm)	8750
Head type	Elliptical
Weir	yes
Split flow	no
Weir to downstr Tan distance (mm)	1000
Boot?	no

#### Gas side summary

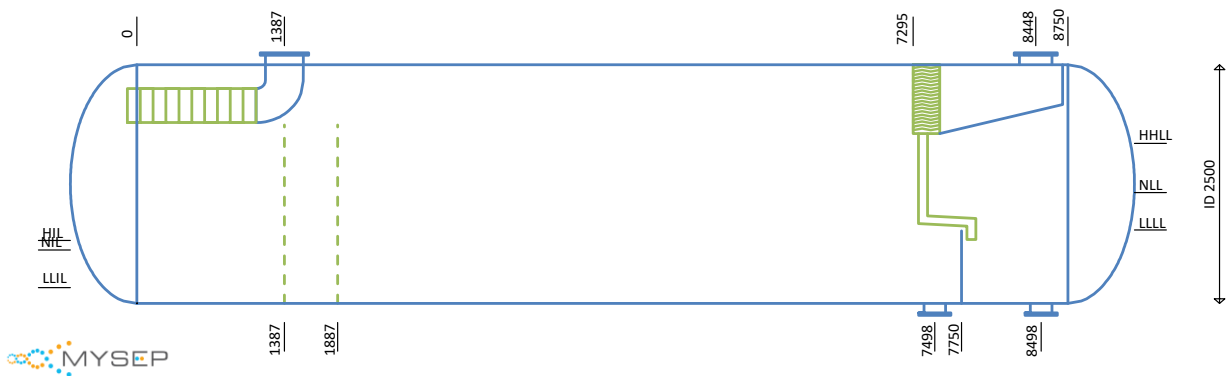
		Case 1	Case 2	Case 3	Case 4	Max
Vessel K-value	m/s	0.122	0.098	0.081	0.112	0.122
Gas velocity	m/s	0.552	0.442	0.368	0.713	0.713
Inlet section	mbar	32	30	22	40	40
Distribution baffles	mbar	0	0	0	0	0
Agglomerator (none)	mbar	0	0	0	0	0
Vane pack	mbar	2	2	1	2	2
Demisting #2 (none)	mbar	0	0	0	0	0
Gas outlet nozzle	mbar	7	4	3	6	7
Total	mbar	41	36	26	48	48

Gas outlet d100	micron	69	59	52	74	74
Total carryover	m <sup>3</sup> /hr	0.364	0.042	0.003	0.564	0.564
	USG/MMSCF	30.78	4.44	0.43	71.56	71.56
Vessel separation efficiency	%	99.86%	99.99%	100.00%	99.79%	100.00%

#### Liquid side summary

Oil residence time	min	3.50	3.00	5.25	5.25	5.25
Water removal d100	micron	134	145	108	108	145
Water residence time	min	6.00	4.00	3.00	3.00	6.00
Oil removal d100	micron	69	86	101	101	101

### 2.2 General arrangement drawing



### 3 Inlet piping & nozzles

#### 3.1 Inlet piping

	-	N.B. (inch)	Actual I.D. (mm)
Inlet piping	-	14	355.60

Key liquid phase for gas-liquid calculations **HC liquid**  
 Override predicted max droplet size? **no**  
 Override predicted piping mist fraction? **no**

		Case 1	Case 2	Case 3	Case 4	Max
Max droplet size (predicted)	micron	956	1250	1556	803	1556
Mist fraction (predicted)	%	20.87%	6.59%	2.14%	19.44%	20.87%
Mist flow rate	m <sup>3</sup> /hr	55.309	21.841	5.667	51.512	55.309

#### 3.2 Nozzles

	Min. ID (mm)	N.B. (inch)	Actual I.D. (mm)
Inlet	345.57	14	355.60
Gas outlet	235.09	12	304.80
HC liquid outlet	202.49	8	203.20
Water outlet	153.07	8	203.20

		Case 1	Case 2	Case 3	Case 4	Max
Inlet velocity	m/s	8.58	7.20	5.97	10.86	10.86
Inlet momentum	kg/ms <sup>2</sup>	6,332	6,062	4,409	8,026	8,026
Gas outlet velocity	m/s	10.67	8.53	7.11	13.77	13.77
Gas outlet momentum	kg/ms <sup>2</sup>	3,185	2,039	1,416	2,742	3,185
HC liquid outlet velocity	m/s	1.70	1.99	1.13	1.13	1.99
Water outlet velocity	m/s	0.57	0.85	1.13	1.13	1.13

## 4 Liquid section

### 4.1 Input criteria

Criteria	Height (mm)	Time (mins)	Volume (m <sup>3</sup> )
HLL - HHLL	100	0.50	0.00
NLL - HLL	100	0.50	10.00
LLL - NLL	100	1.80	0.00
LLLL - LLL	100	0.50	0.00
Bottom Vessel - LLLL	100	0.50	0.00
HIL - Top of Weir	100	0.50	0.00
NIL - HIL	100	0.50	0.00
LIL - NIL	100	1.99	0.00
LIL-LLIL	100	0.50	0.00
Bottom Vessel - LLIL	100	0.50	0.00

### 4.2 Setpoints and residence time

Residence time and volume between levels		Time (min)				Volume (m <sup>3</sup> )
Level	Setpnt (mm)	Case 1	Case 2	Case 3	Case 4	
HHLL	1676	0.70	0.60	1.05	1.05	2.31
HLL	1576	3.02	2.59	4.53	4.53	10.00
NLL	1161	2.09	1.80	3.14	3.14	6.94
LLL	869	0.69	0.59	1.03	1.03	2.27
LLLL	769	0.58	0.50	0.87	0.87	1.93
Top of weir	760	1.67	1.11	0.84	0.84	1.85
HIL	660	1.59	1.06	0.79	0.79	1.75
NIL	560	3.98	2.65	1.99	1.99	4.39
LIL	266	1.02	0.68	0.51	0.51	1.12
LLIL	166	1.00	0.67	0.50	0.50	1.10

### 4.3 Degassing

Degassing length (mm) 6541

		Case 1	Case 2	Case 3	Case 4	Max
Oil degassing d100	micron	111	121	90	89	121
Water degassing d100	micron	44	54	64	63	64

### 4.4 Liquid-liquid separation

Design oil-water level (mm) 560  
 Separation length oil layer (mm) 6541  
 Separation length water layer (mm) 6541  
 Plate pack coalescer no

Oil layer (NIL - NLL)						Max
Oil residence time	min	3.50	3.00	5.25	5.25	5.25
Oil velocity	m/s	0.039	0.046	0.026	0.026	0.046
Water removal d100	micron	134	145	108	108	145
Oil Reynolds number	-	103,120	120,306	68,746	68,746	120,306
Water layer (BV - NIL mm)						
Water residence time	min	6.00	4.00	3.00	3.00	6.00
Water velocity	m/s	0.022	0.034	0.045	0.045	0.045
Oil removal d100	micron	69	86	101	101	101
Water Reynolds number	-	59,741	89,612	119,483	119,483	119,483

For further detailed calculations results, please refer to: Appendix - Liquid-liquid separation detailed calculations.

For distribution baffle calculations results, please refer to: Appendix - Perforated distribution baffles.

## 5 Gas-liquid separation

### 5.1 Inlet device

Type **Vane type**  
 Length (mm) **1209**

Override predicted droplet removal d100? **no**  
 Override predicted separation efficiency? **no**

		Case 1	Case 2	Case 3	Case 4	Max
Removal d100 (predicted)	micron	0	0	0	0	0
Mist sep. effic. (predicted)	%	0.00%	0.00%	0.00%	0.00%	0.00%
Carryover rate	m <sup>3</sup> /hr	55.309	21.841	5.667	51.512	55.309
Section efficiency	%	79.13%	93.41%	97.86%	80.56%	97.86%

### 5.2 Gravity separation section

Design liquid level (mm) **1676**  
 Gas - liquid separation length (mm) **6931**  
 Vapour space height (mm) **824**

Override predicted droplet removal d100? **no**  
 Override predicted separation efficiency? **no**

		Case 1	Case 2	Case 3	Case 4	Max
Vessel K-value	m/s	0.122	0.098	0.081	0.112	0.122
Removal d100 (predicted)	micron	69	58	51	73	73
Sep. efficiency (predicted)	%	99.11%	99.77%	99.93%	98.25%	99.93%
Carryover rate	m <sup>3</sup> /hr	0.491	0.050	0.004	0.903	0.903
Section efficiency	%	99.11%	99.77%	99.93%	98.25%	99.93%

### 5.3 Demisting device #1

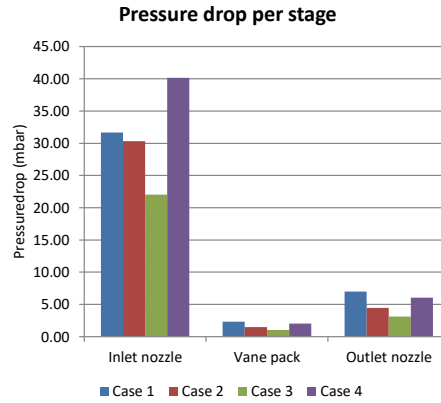
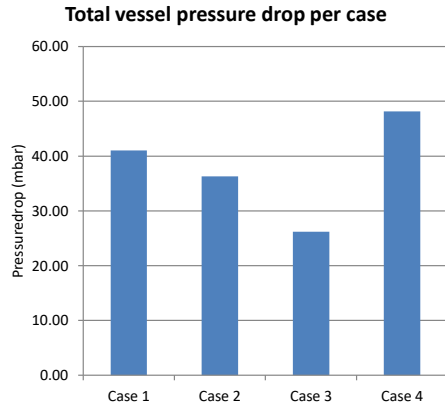
Type **Vane pack**  
 Device orientation **Vertical**  
 Max allowable K-value (m/s) **0.231**  
 Vane pack area (m<sup>2</sup>) **0.8500**  
 Bottom elevation (mm) **1779**  
 Assembly length (mm) **250**  
 Vane spacing (mm) **20.00**  
 Bend angle (°) **60.00**

Override predicted droplet removal d100? **no**  
 Override predicted separation efficiency? **no**

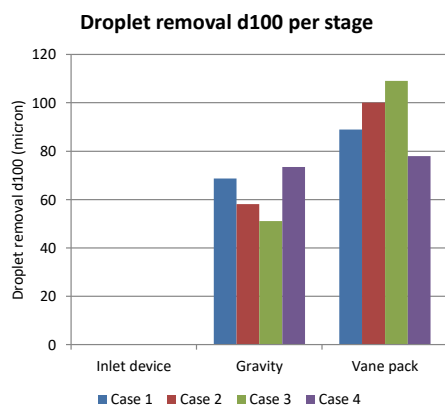
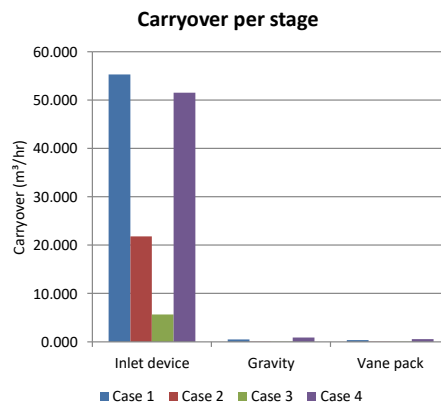
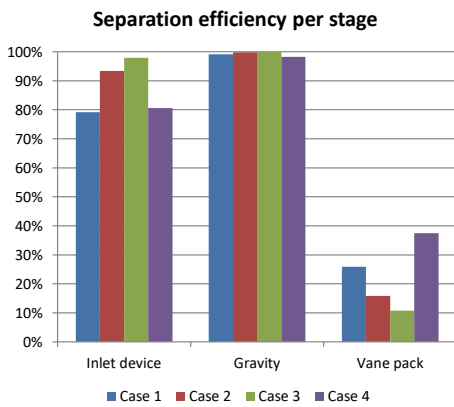
		Case 1	Case 2	Case 3	Case 4	Max
K-value	m/s	0.203	0.162	0.135	0.186	0.203
Gas velocity	m/s	0.916	0.732	0.610	1.182	1.182
Gas rho-v <sup>2</sup>	kg/ms <sup>2</sup>	23	15	10	20	23
Removal d100 (predicted)	micron	89	100	109	78	109
Sep. efficiency (predicted)	%	25.86%	15.88%	10.71%	37.50%	37.50%
Carryover rate	m <sup>3</sup> /hr	0.364	0.042	0.003	0.564	0.564
Device efficiency	%	25.86%	15.88%	10.71%	37.50%	37.50%

## 6 Gas-liquid separation graphs

### 6.1 Pressure drop graphs

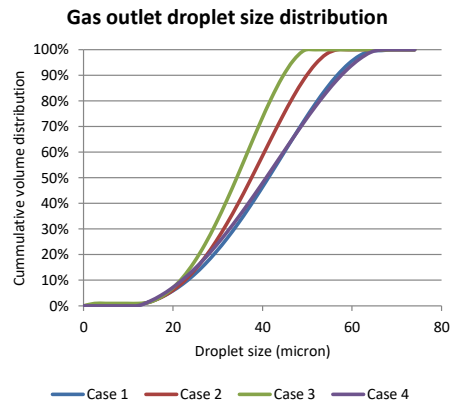
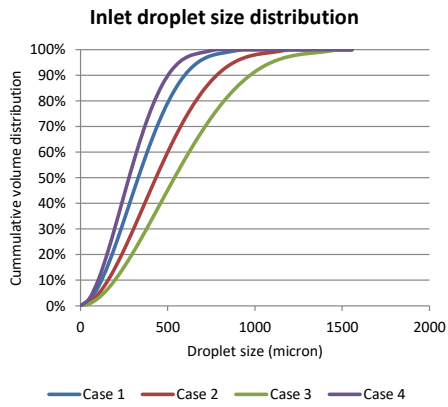


### 6.2 Performance graphs





### 6.3 Droplet size graphs



## 7 Design considerations and notes

### Design considerations generated by MySep:

<< No design notifications found. >>

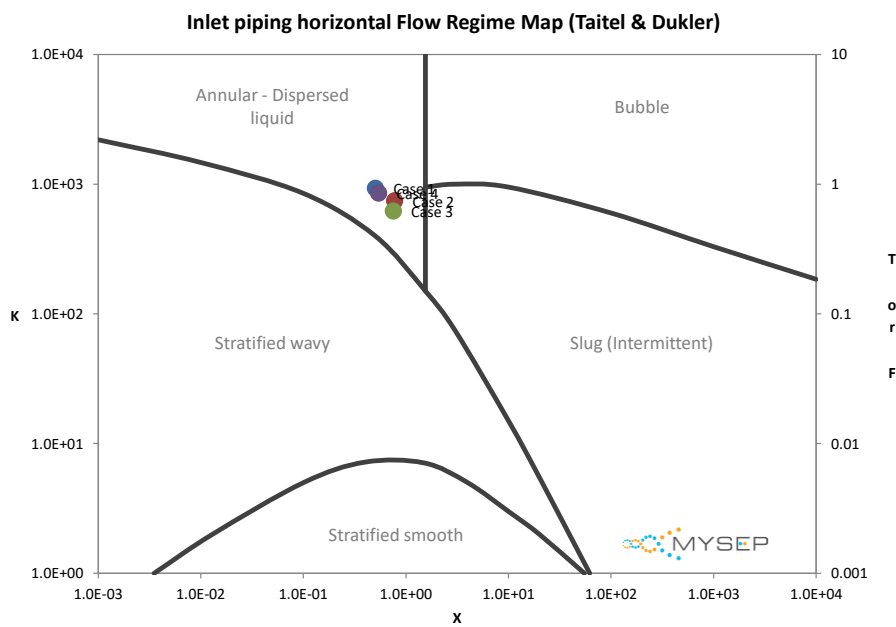
Note: ✓ means Accounted for by Designer.

### Design notes by Designer:

### Appendix 1 - Flow regime for horizontal inlet piping

Pipe roughness mm 0.0460

		Case 1	Case 2	Case 3	Case 4	Max
Flow regime	-	Annular	Annular	Annular	Annular	-
Lockhart-Martinelli parameter	-	5.0E-01	7.7E-01	7.5E-01	5.4E-01	7.7E-01
Liquid fraction	% v/v	8.64%	12.88%	12.42%	6.83%	12.88%
Liquid hold-up	% v/v	11.58%	14.85%	14.63%	12.07%	14.85%
Liquid velocity	m/s	6.40	6.24	5.07	6.14	6.40
Gas fraction	% v/v	91.36%	87.12%	87.58%	93.17%	93.17%
Gas hold-up	% v/v	88.42%	85.15%	85.37%	87.93%	88.42%
Gas velocity	m/s	8.86	7.36	6.12	11.51	11.51
Relative liquid height (height/pipe ID)	-	-	-	-	-	0.000
Film thickness	mm	10.61	13.73	13.52	11.07	13.73
Pressure drop	mbar/m	3.51	3.39	2.31	3.26	3.51



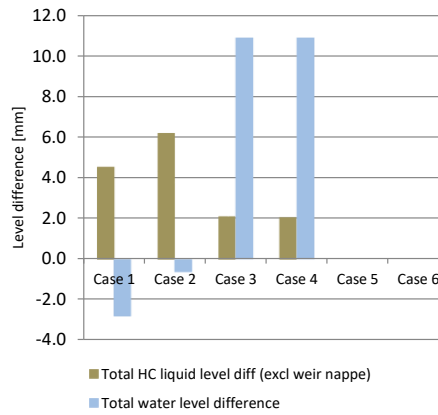
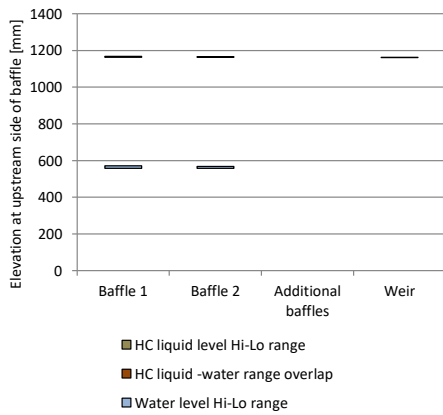
## Appendix 2 - Perforated distribution baffles

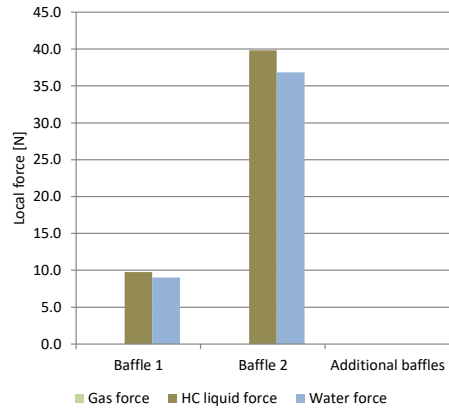
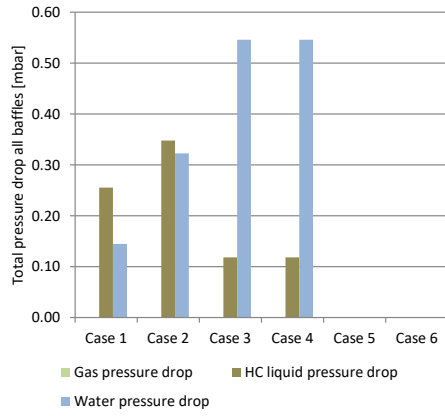
	In phase	NFA	Top El (mm)	Q'ty
Baffle 1	Liquid	0.36	1869	1
Baffle 2	Liquid	0.21	1869	1
Additional baffles	No baffle	0.30	1869	0

Baffle 1			Case 1	Case 2	Case 3	Case 4	Max
Upstream liquid level	mm		1166	1167	1163	1163	1167
Upstream-downstream liquid level	mm		1	1	0	0	1
Upstream water level	mm		557	559	571	571	571
Upstream-downstream water level	mm		-1	0	2	2	2
Gas pressure drop	mbar		0	0	0	0	0
HC Liquid pressure drop	mbar		0	0	0	0	0
Water pressure drop	mbar		0	0	0	0	0
Gas force	N		0.0	0.0	0.0	0.0	0.0
HC Liquid force	N		7.2	9.8	3.3	3.3	9.8
Water force	N		2.3	5.2	9.0	9.0	9.0

Baffle 2			Case 1	Case 2	Case 3	Case 4	Max
Upstream liquid level	mm		1165	1166	1163	1163	1166
Upstream-downstream liquid level	mm		4	5	2	2	5
Upstream water level	mm		557	559	568	568	568
Upstream-downstream water level	mm		-2	-1	9	9	9
Gas pressure drop	mbar		0	0	0	0	0
HC Liquid pressure drop	mbar		0	0	0	0	0
Water pressure drop	mbar		0	0	0	0	0
Gas force	N		0.0	0.0	0.0	0.0	0.0
HC Liquid force	N		29.3	39.8	13.3	13.3	39.8
Water force	N		9.5	21.2	36.8	36.8	36.8

Weir			Case 1	Case 2	Case 3	Case 4	Max
Upstream liquid level	mm		1161	1161	1161	1161	1161
Nappe height	mm		0	0	0	0	0



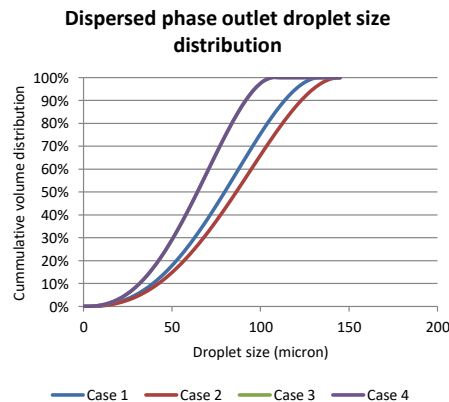
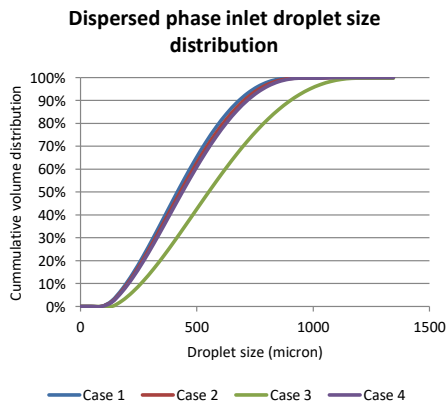
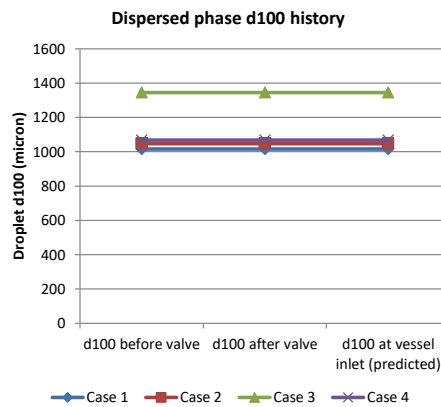
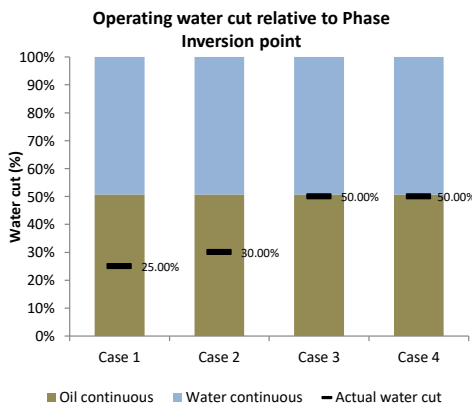


### Appendix 3 - Liquid-liquid separation detailed calculations

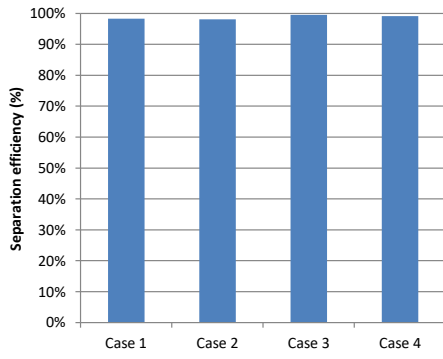
Valve pipe diameter	mm	355.60
Pipe length (valve - vessel inlet)	m	10.0
Pipe roughness	mm	0.0460
Oil-water surface tension basis		Calculated
Override predicted phase inversion point?		no
Override predicted d100 at vessel inlet?		no

		Case 1	Case 2	Case 3	Case 4	Max
Valve dP	bar	0.00	0.00	0.00	0.00	0.00
Oil-water interfacial surface tension	dyne/cm	30.14	30.14	30.14	30.14	30.14
Phase inversion critical WC (predicted)	%	50.73%	50.73%	50.73%	50.73%	50.73%
Actual water cut	%	25.00%	30.00%	50.00%	50.00%	50.00%
Continuous phase	-	HC liquid	HC liquid	HC liquid	HC liquid	-
d100 before valve	micron	1016	1047	1345	1068	1345
d100 after valve	micron	1016	1047	1345	1068	1345
d100 at vessel inlet (predicted)	micron	1016	1047	1345	1068	1345
Dispersed phase removal d100 in vessel	micron	134	145	108	108	145
Separation efficiency	%	98.28%	98.06%	99.50%	99.11%	99.50%
Oil outlet - water carryover	m <sup>3</sup> /hr	1.141	1.932	0.660	1.173	1.932
Oil outlet - water concentration	% v/v	0.57%	0.83%	0.50%	0.88%	0.88%
Oil outlet - water concentration	ppm v/v	5707	8264	4959	8774	8774
Water outlet - oil carryover	m <sup>3</sup> /hr	-	-	-	-	-
Water outlet - oil concentration	% v/v	-	-	-	-	-
Water outlet - oil concentration	ppm v/v	-	-	-	-	-

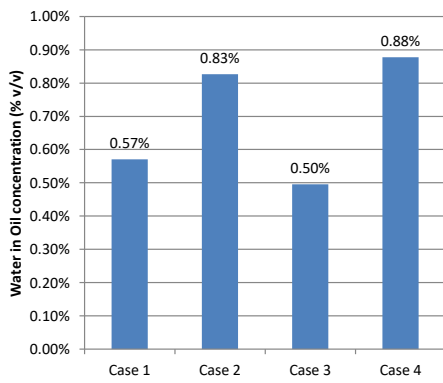
MySep has relatively broad liquid-liquid models in order to achieve applicability in an as wide a range of situations as possible. Therefore, the predictions should be seen as approximations, rather than highly accurate predictions in absolute sense. The carryover of continuous phase through dispersed phase outlet are not calculated and can be expected to be minimal (indicated by: -). This assumes a single incoming dispersion (no secondary / multiple dispersions) and a properly designed liquid-liquid separation section in the vessel (no re-mixing of the bulk phases).



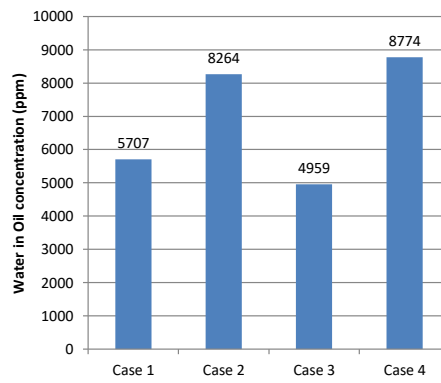
**Vessel separation efficiency for dispersed liquid phase**



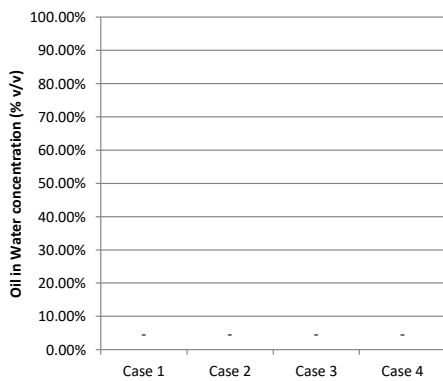
**Oil outlet (WiO)**



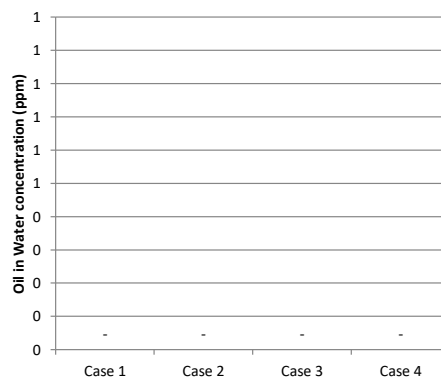
**Oil outlet (WiO)**



**Water outlet (OiW)**



**Water outlet (OiW)**



## Appendix 4 - Weight estimate

DesignCode	ASME VIII Div1		
Material of Construction	Carbon Steel		
Material density (kg/m <sup>3</sup> )	7750.00	Override material density?	no
Design strength (N/mm <sup>2</sup> )	138.00	Override design strength?	no
Corrosion allowance (mm)	0.00	Override corrosion allowance?	no
Radiography (%)	100%		
Vessel under vacuum?	no		
Design pressure (barg)	11.50	Override design pressure?	no
Design temperature (°C)	50.00	Override design temperature?	no
Liquid level	HLLL		
Liquid density (kg/m <sup>3</sup> )	1000.00		
Cylinder thickness (mm)	3	Override cylinder thickness?	no
Head thickness (mm)	3	Override head thickness?	no
Flange rating (#)	150	Override flange rating?	no

	Weight (kg)
Vessel cylinder	18,355
Vessel heads	2,658
Saddle / Skirt	550
Stiffening rings	0
Boot	0
Nozzles	979
<b>Total empty vessel</b>	<b>22,542</b>

Internals	1,009
<b>Total vessel with internals</b>	<b>23,551</b>

Liquid	33,667
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<b>Total vessel, internals and liquid</b>	<b>57,218</b>
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Vessel weight calculation alerts:

## Appendix 5 - Motion Analysis

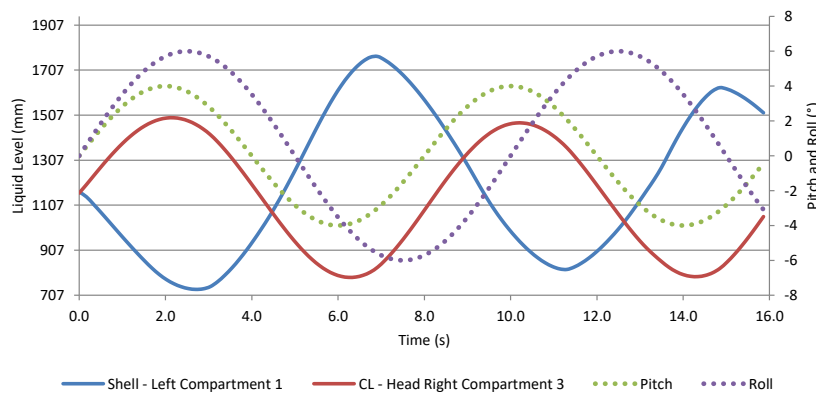
	Max angle (°)	Period (s)
Pitch	4.00	8.00
Roll	6.00	10.00

Separator and facility axes are parallel **TRUE**

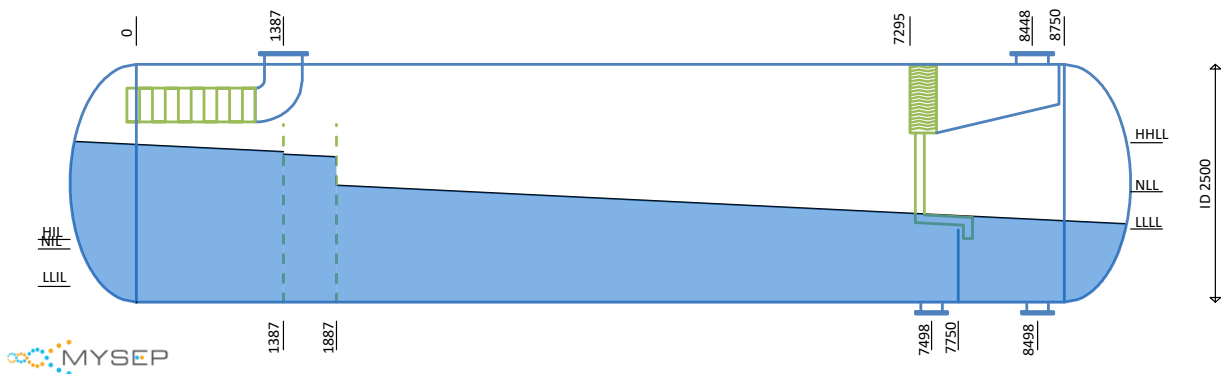
Coordinates		x	y	z
Facility centre of rotation	m	0.0	0.0	0.0
Vessel centre	m	20.0	10.0	-5.0

Calculation settings			
Time step	s	0.018750	
Periods to calculate	-	2.0	
Initial liquid level	mm	NLL	1161
Liquid load	m <sup>3</sup> /hr	Max	331.22
Alarm   Trip nozzles location	mm	4375	4375

### Maximum and minimum liquid levels



Compartment	1	2	3	Overall
Highest liquid level (mm)	1769	1670	1579	1769
Lowest liquid level (mm)	733	880	730	730



#### Critical motion analysis warning:

- No critical warning.