


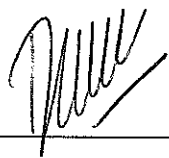

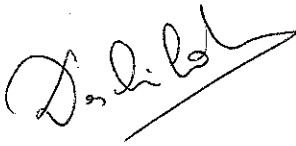


RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428
ALE N° : N/A
RG N° : N/A
DTA N° : C1192-NT-103
Rev : B

RHEA: Liquefier Process Calculations

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RECORD OF CHANGES

VERSION	DATE	NUMBER	DOCUMENT EVOLUTION (Modified Pages)	JUSTIFICATION OF THE MODIFICATION
(A)	07/05/10		First issue	
(B)	08/30/2010		All cases: → min approach HX08 = 0.6 K (min approach HX09 = 0.2 K) → Leaks and bearings updated → dP MP = 155 mbar CXXX – XXXX – KXXX – CKXX – KKXX: → T03 efficiency = 78 %	

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RHEA: Liquefier Process Calculations

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RHEA: Liquefier Process Calculations

1 INTRODUCTION

The purpose of this document is to present the method and results of the process calculations computed for the 20 T / day helium liquefaction system for the Ras Laffan Helium 2 Recovery Project.

2 REFERENCE

- [1] C1192 NT 102 (0) – RHEA process loading sequences
- [2] C1192 NT 103 – Margins
- [3] C1192 NT 107 - Process Optimisation note
- [4] C1192 DS 105 (0) Turbines

3 SIMULATION SOFTWARE AND HE EQUATION OF STATE

The process thermodynamic calculations are computed using the Process simulator ASPEN HYSYS v.2004.2 (Build 13.3.6.6612) copyright ©1995-2006 Aspen Technology, Inc.

This software is running a model of equation of state type MBWR (Modified Benedict/Webb/Rubin), with 32 terms valid for pure components and computed from R.D. McCarty - V. Arp. Equations.

4 SUMMARY OF INPUT DATA

4.1 Performance required

The design of the liquefaction system is achieved according to the “average case” data defined in [R1]. Indeed, the liquefier is meant to:

- liquefy the feed helium
- liquefy the helium which has been pulled from the trucks
- cool down the trucks
- balance the heat loads (loading bays, heat in-leaks to the cold box, adsorbers cool-down, etc...)

The table hereunder shows the loads repartition and margins of the liquefier [2].

	Feed	Pulling	Cool-Down	Adsorbers Eq.	Heat Loads Eq.	Heat Loads	
Source	Ex. 8	Ex. 8	DGR	DTA	DTA	DTA	
Base	231.0 g/s	10.3 g/s	24.5 g/s	1.7 g/s	Eq. 12.0 g/s	1200 W	
Margin	6%	0%	0%	0%	25%	25%	
Margin	13.9 g/s	0.0 g/s	0.0 g/s	0.0 g/s	3.0 g/s	300 W	
Process	244.9 g/s	10.3 g/s	24.5 g/s	1.7 g/s	Eq. 15.0 g/s	1500 W	
Process	21.16 TPD	0.89 TPD	2.12 TPD	0.15 TPD	1.30 TPD		
Overall Marg.							5.7%

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4.2 Performed calculations

4.2.1 Design Calculation

The case called "average" is the design case. The input data are shown in the table hereunder which is extracted of the reference document [1]. We consider a margin of 6 % on the feed.

Case	Feed	Pull	L_To	L_From	C_To	C_Tr	C_From	K_To	K_Tr	K_From
BASE	231.5 g/s	10.3 g/s								
L			246.0 g/s	38.5 g/s						
C					36.7 g/s	0.6 g/s	36.1 g/s			
K								129.4 g/s	104.4 g/s	25.0 g/s
X										

CASE_ALL	Duration	%	%	Feed	Pull	L_To	L_From	C_To	C_Tr	C_From	K_To	K_Tr	K_From
CLXX	33	21%	21%	231.5 g/s	10.3 g/s	246.0 g/s	38.5 g/s	36.7 g/s	0.6 g/s	36.1 g/s	0.0 g/s	0.0 g/s	0.0 g/s
LXXX	24	16%	37%	231.5 g/s	10.3 g/s	246.0 g/s	38.5 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s
KLXX	21	14%	51%	231.5 g/s	10.3 g/s	246.0 g/s	38.5 g/s	0.0 g/s	0.0 g/s	0.0 g/s	129.4 g/s	104.4 g/s	25.0 g/s
CLLX	20	13%	64%	231.5 g/s	10.3 g/s	492.1 g/s	77.0 g/s	36.7 g/s	0.6 g/s	36.1 g/s	0.0 g/s	0.0 g/s	0.0 g/s
LLXX	17	11%	75%	231.5 g/s	10.3 g/s	492.1 g/s	77.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s
KXXX	14	9%	84%	231.5 g/s	10.3 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	129.4 g/s	104.4 g/s	25.0 g/s
KLLX	6	4%	88%	231.5 g/s	10.3 g/s	492.1 g/s	77.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	129.4 g/s	104.4 g/s	25.0 g/s
CXXX	5	3%	91%	231.5 g/s	10.3 g/s	0.0 g/s	0.0 g/s	36.7 g/s	0.6 g/s	36.1 g/s	0.0 g/s	0.0 g/s	0.0 g/s
CKLX	4	3%	94%	231.5 g/s	10.3 g/s	246.0 g/s	38.5 g/s	36.7 g/s	0.6 g/s	36.1 g/s	129.4 g/s	104.4 g/s	25.0 g/s
CKXX	4	3%	96%	231.5 g/s	10.3 g/s	0.0 g/s	0.0 g/s	36.7 g/s	0.6 g/s	36.1 g/s	129.4 g/s	104.4 g/s	25.0 g/s
KKXX	3	2%	98%	231.5 g/s	10.3 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	258.7 g/s	208.7 g/s	50.0 g/s
XXXX	2	1%	99%	231.5 g/s	10.3 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s
LLLX	1	1%	100%	231.5 g/s	10.3 g/s	738.1 g/s	115.5 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s

AVERAGE			100%	231.5 g/s	10.3 g/s	273.2 g/s	42.8 g/s	15.7 g/s	0.2 g/s	15.5 g/s	46.2 g/s	37.3 g/s	8.9 g/s
AVERAGE			100%	20 TPD	0.9 TPD	23.60 TPD	3.70 TPD	1.36 TPD	0.02 TPD	1.34 TPD	3.99 TPD	3.22 TPD	0.77 TPD

CASE_COOL	Duration	%	%	Feed	Pull	L_To	L_From	C_To	C_Tr	C_From	K_To	K_Tr	K_From
CXXX	60	37%	37%	231.5 g/s	10.3 g/s	240.3 g/s	40.1 g/s	36.7 g/s	0.6 g/s	36.1 g/s	0.0 g/s	0.0 g/s	0.0 g/s
XXXX	47	29%	66%	231.5 g/s	10.3 g/s	276.3 g/s	46.1 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s	0.0 g/s
KXXX	44	27%	93%	231.5 g/s	10.3 g/s	261.8 g/s	43.6 g/s	0.0 g/s	0.0 g/s	0.0 g/s	129.4 g/s	104.4 g/s	25.0 g/s
CKXX	9	6%	98%	231.5 g/s	10.3 g/s	226.3 g/s	37.7 g/s	36.7 g/s	0.6 g/s	36.1 g/s	129.4 g/s	104.4 g/s	25.0 g/s
KKXX	3	2%	100%	231.5 g/s	10.3 g/s	247.6 g/s	41.3 g/s	0.0 g/s	0.0 g/s	0.0 g/s	258.7 g/s	208.7 g/s	50.0 g/s

AVERAGE			100%	231.5 g/s	10.3 g/s	255.8 g/s	42.6 g/s	15.5 g/s	0.2 g/s	15.3 g/s	46.8 g/s	37.8 g/s	9.0 g/s
AVERAGE			100%	20 TPD	0.9 TPD	22.1 TPD	3.7 TPD	1 TPD	0 TPD	1 TPD	4 TPD	3 TPD	1 TPD



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RHEA: Liquefier Process Calculations

Refer to PFD in appendix 1.

- Feed = feed flow to be liquefied
- Pull = depressurization flow from container (from initial pressure down to 1,22 bars abs). This flow is processed to the gasbag and through the purification section. It is sent to the liquefier at HP level.
- L_To = Liquid flow from storage tank to the containers (when liquid is being loaded)
- L_from = Return flow from the containers to the liquefier (when liquid is being loaded)
- C_To = Liquid flow from storage tank to the containers (when cool down from 300K to 80K is being performed)
- C_from = Return flow from the containers to the liquefier (when cool down from 300K to 80K is being performed)
- K_To = Liquid flow from storage tank to the containers (when cool down from 80K to 4K is being performed and densification occurs)
- K_from = Return flow from the containers to the liquefier (when cool down from 80K to 4K is being performed and densification occurs)

CKLX means that:

- 1 container is being cooled down from 300K to 80K (C)
- 1 container is being cooled down from 80K to 4K (K)
- 1 container is being loaded (liquid accumulation in container (L)
- 1 bay undergoes other activities (pulling, purging, accumulation of LHe in storage tanks etc...) (X)

4.2.2 Simulation Calculation

Eight simulation calculations are achieved by keeping constant the equipments (heat exchangers, turbines) defined by the design case (average).

- CXXX, XXXX, KXXX, CKXX and KKXX have been calculated by simulation.

The input data are exposed in the previous table. We consider a margin of 6 % on the feed.

In order to minimize the number of simulations, loading and “other activities” have been merged into X (X includes L).

The diagram hereunder shows the cases distribution.

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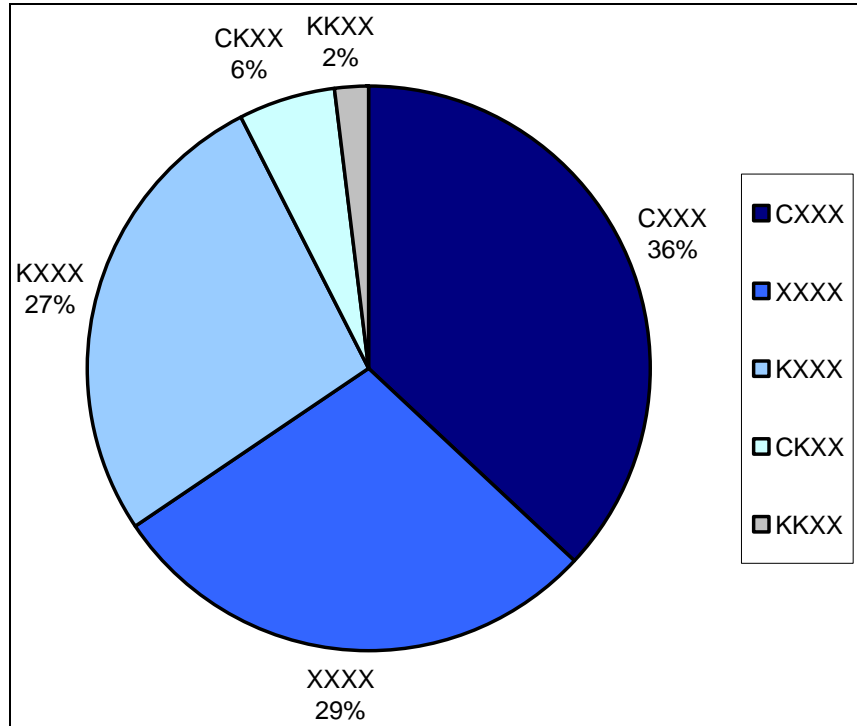


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RHEA: Liquefier Process Calculations



- **LLLX:** in the five previous cases, we consider a global (storage & trucks) rising level always by-passing HX10 and HX11. In fact, it can happen that the storage level decreases while the trucks level increases. This affects the return vapor in HX10 & HX11. To estimate the impact of a high decreasing level in the storage, we consider the case LLLX which causes the minimum vapor return in HX10 & HX11.

The input data are exposed in the previous table. It's signified that 738.1 g/s of LHe have to be supplied to fill trucks. A part of the flow is produced by the liquefier and the rest is provided by the storage that causes a decreasing level.

- **Turbines nominal conditions:** this case has been calculated in the aim to dispose of a nominal case for the turbines design. We consider the same input data than for the average case but the margin on the feed is 3% (instead of 6%) and heat loads on the cold end are decreased by 20%.
- **LN2 option for 80 K adsorber regeneration:** a case has been investigated consisting of an optional use of LN2 to help the liquefier during the regeneration of the 80 K adsorber.

4.2.3 Optimization calculation

Two phases of optimization have been performed.

The first one has consisted in a global approach to quantify the impact of different parameters (temperature upstream T06, architecture of the turbines, number of turbines, value of the medium

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pressure) and to choose an optimal cycle. The details of this study are presented in the reference document [3].

In the second phase, the profit of different turbine architectures at the cold end (liquid turbine, two-phase turbine) was studied. This is exposed in the appendix 10. Should T6 expand down to LP pressure, would the LHe production increase by approx. 3%

4.3 Assumptions

The assumptions described in this paragraph are used for all the calculations performed.

4.3.1 Pressure drops

The values given hereunder are referenced to the maximum pressure drop for piping and equipment.

Pressure drop [mbar]	HP Circuit	Turbines Circuit	MP Circuit	LP Circuit
Oil removal system	500			
Piping	90		20	25
HX01	110	110	60	50
HX02	25		10	10
HX03	130	50	45	40
HX04	30		10	10
HX05	30		5	5
HX06	70		15	15
HX07	25		5	5
HX08	25		5	5
HX09	5			0
HX010	10			0
HX011	10			0
Overall HX	470	160	155	140

Remark: pressure drops on HX have been increased after suppliers quotations.

	Pressure drop [mbar]
80K Adsorber	200
20K Adsorber	200
Valve T01	200
Valve T02	200
Valve T03	200
Valve T04	200
Valve T05	200
Valve T06	200



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4.3.2 Heat Losses

The following thermal losses are valid for all cases.

Equipment	Thermal losses [W]
HX01	370
HX02	70
HX03	350
HX04	150
HX05	400
80K Adsorber	0
HX06	200
HX07	100
HX08	170
20K Adsorber	75
HX09	450
HX10	25
HX11	25
LHe storage	300
Vapor from storage	400
Vapor from trucks	800

4.3.3 Turbines

Turbines	Efficiency [%]	Leaks [g/s]	Bearings [g/s]
T01 [C7]	74	0.54	136.1
T02 [C7]	74	0.52	
T03 [C6]	78	0.49	
T04 [C6]	78	0.74	
T05 [C6]	78	0.63	
T06 [C4]	73	0.74	

The turbine leaks are collected at the turbine outlets. The total gas utility has to be compressed from low to high pressure.

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RHEA: Liquefier Process Calculations

5 PROCESS CALCULATION

5.1 Main results

	Average	CXXX	XXXX	KXXX	CKXX	KKXX
From Buffer	0 g/s	0 g/s	18.6 g/s	5.6 g/s	0 g/s	0 g/s
To Buffer	0 g/s	16.5 g/s	0 g/s	0 g/s	29.5 g/s	8.9 g/s
LHe to trucks and storage	263.1 g/s	287.7 g/s	330.7 g/s	189.2 g/s	146.2 g/s	46.03 g/s
Rising level from trucks and storage	44.83 g/s	49.02 g/s	56.29 g/s	32.21 g/s	24.9 g/s	7.832 g/s
Net to trucks (*)	255.8 g/s	239.3 g/s	274.4 g/s	261.4 g/s	226.3 g/s	246.9 g/s

(*) Net to trucks = (LHe to trucks and storage) + (C_Tr+K_Tr) – (Rising level from trucks and storage)

	CXXX	XXXX	KXXX	CKXX	KKXX
Net to trucks (*)	239.3 g/s	274.4 g/s	261.4 g/s	226.3 g/s	246.9 g/s
%	37 %	29 %	27 %	6 %	1 %
		Balance	Net to trucks (*)		254.75 g/s
		OK WITH AVERAGE CASE (< 0.5%)			

5.2 Average (design)

5.2.1 Helium Liquefaction cycle

The helium (4065 g/s) enters the cold box at 323 K / 20.4 bars to be cooled down and liquefied.

The pre-cooling from warm end to 100 K is ensured within HX01 to HX04 by part of the flow (1195 g/s) expanded through T01 from 234 K, 20.1 bar to 205 K, 12.7 bar, cooled down in HX03 and expanded through T02 from 128 K, 12.5 bar to 99 K, 5 bar. From T02 outlet, the expanded flow rate is mixed in MP circuit of HX04 to HX01, warmed up and sent to the compressor suction of the second stage.

The cooling from 100 K to 19 K is realized within HX05 to HX08 by T03 and T04. The fluid crosses HX05 to be cooled down to 66 K and goes through the “80 K adsorber”. Part of the flow rate is expanded through T03 (from 66 K to 44 K) and other part through T04 (from 29 K to 19 K), both from high pressure to medium pressure. The flow rate from T03 and T04 at medium pressure is used to cool down high pressure helium in counter current heat exchangers HX08 to HX05.

**RHEA: Liquefier Process Calculations**

Downstream of the 20 K adsorber, the helium flow is divided in two parts:

- T05 flow rate is expanded from high pressure to low pressure (from 19 K to 8.9 K) and mixed with the vapors from the LHe storage tanks and the vapors from the trucks filling.
- After being cooled down in HX10, the rest of the high pressure stream is expanded through T06 (from 19.3 bar, 7.4 K to 3 bar, 5.5 K) and cooled down in HX11. The Joule-Thomson expansion allows liquefying part of the fluid. The vapor phase is warmed up along all current counter heat exchangers and sent to the first stage of the compressor through the LP channels.

The compression from LP (1.05 bar) to MP (4.83 bar) provides 887 g/s helium mass flow rate at 323 K which is then combined with the MP cold box flow rate and further compressed in the MP/HP compressors from 4.83 bar to 21 bar. A part of this flow serves the by-pass and the turbine bearings.

5.2.2 Heat exchangers

The values given hereunder are referenced to design mode (average case).

Heat Exchanger	Temperature [K]	Minimum Approach [K]	UA [W/K]
HX 01	323 - 234	2.5	368 000
HX 02	234 - 205	2	91 400
HX 03	205 - 128	2	381 000
HX 04	128 - 100	1	125 000
HX 05	100 - 66	1	207 000
HX 06	66 - 45	0.45	119 000
HX 07	45 - 29	0.45	111 000
HX 08	29 - 20	0.6	30 000
HX 09	20 - 9	0.2	97 000
HX 10	9 - 7.4	0.1	6 200
HX 11	5.5 - 5.4	0.1	3 500

5.2.3 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1195	182
T02	1195	182
T03	886	102
T04	1007	50
T05	434	22
T06	542	5

Rk: the T06 operation is very dependant of the inlet conditions because at this level of temperature, low variations of temperature produce high variations of density. In order to make sure that T06 will not be



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RHEA: Liquefier Process Calculations

limited in term of mass flow in case of higher inlet temperature; it has been decided to slightly over-design T06:

T06 over-design					
	m_in	T_in	Z_in	P_in	Flow coefficient (= $M \cdot \sqrt{(ZT)/P}$)
Nominal conditions	541.8 g/s	7.5 K	0.913	19.35 bar	
Default temperature conditions	541.8 g/s	8 K	0.891	19.35 bar	74.76
Over-design mass flow	552.9 g/s + 2.0%	7.5 K	0.913	19.35 bar	74.76

So, T06 design is based on the nominal conditions with +2% of margin on the mass flow rate.

5.2.4 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	887	1.05	4.83	900
Comp MP/HP	4067	4.83	21	3995

5.2.5 Process Flow Diagram (PFD) and Workbook

The increasing labels from warm end to cold end reference the components (HX, turbines). The table (or workbook) displays, for each point, mass flow, temperature, pressure, vapor fraction, enthalpy and heat flow.

To help the reading of diagram and table, the following rules are used for the numbering of the fluids:

- First item (from 00 to 11): 00 refers to the warm end and 11 to the cold end of the cycle; as a consequence, the fluid table is sorted from warm end to cold end.
- The second item refers to the different fluids (HP = high pressure helium, MP = medium pressure helium, LP = low pressure helium).
- The index is meant to differentiate the fluids at the same temperature and pressure level.

See annex 1.



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RHEA: Liquefier Process Calculations

5.3 CXXX (Simulation)

5.3.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 236
HX 02	236 - 206
HX 03	206 - 130
HX 04	130 - 102
HX 05	102 - 67
HX 06	67 - 45
HX 07	45 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.3.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1186	182
T02	1186	183
T03	874	102
T04	1001	50
T05	431	22
T06	541	5

5.3.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	897.4	1.05	4.83	911
Comp MP/HP	4036	4.83	21	3964

5.3.4 PFD and Workbook

See annex 2.



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RHEA: Liquefier Process Calculations

5.4 XXXX (Simulation)

5.4.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 236
HX 02	236 - 207
HX 03	207 - 130
HX 04	130 - 101
HX 05	101 - 66
HX 06	66 - 45
HX 07	45 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.4.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1188	183
T02	1188	183
T03	876	102
T04	1001	50
T05	431	21
T06	541	5

5.4.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	881	1.05	4.83	894
Comp MP/HP	4023	4.83	21	3951

5.4.4 PFD and Workbook

See annex 3.

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RHEA: Liquefier Process Calculations

5.5 KXXX (Simulation)

5.5.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 231
HX 02	231 - 202
HX 03	202 - 125
HX 04	125 - 98
HX 05	98 - 65
HX 06	65 - 44
HX 07	44 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.5.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1196	184
T02	1196	176
T03	886	101
T04	1011	50
T05	436	22
T06	540	5

5.5.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	885	1.05	4.83	898
Comp MP/HP	4055	4.83	21	3982

5.5.4 PFD and Workbook

See annex 4.



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RHEA: Liquefier Process Calculations

5.6 CKXX (Simulation)

5.6.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 231
HX 02	231 - 202
HX 03	202 - 125
HX 04	125 - 97
HX 05	97 - 65
HX 06	65 - 44
HX 07	44 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.6.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1201	183
T02	1201	178
T03	891	101
T04	1006	50
T05	434	22
T06	538	5

5.6.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	911	1.05	4.83	924
Comp MP/HP	4086	4.83	21	4013

5.6.4 PFD and Workbook

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RHEA: Liquefier Process Calculations

5.7 KKXX (Simulation)

5.7.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 226
HX 02	226 - 197
HX 03	197 - 120
HX 04	120 - 94
HX 05	94 - 63
HX 06	63 - 42
HX 07	42 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.7.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1209	185
T02	1209	170
T03	901	99
T04	1011	49
T05	436	21
T06	534	5

5.7.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	888	1.05	4.88	901
Comp MP/HP	4086	4.88	21	4013

5.7.4 PFD and Workbook

See annex 6.

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RHEA: Liquefier Process Calculations

5.8 LLLX (Simulation)

5.8.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 236
HX 02	236 - 207
HX 03	207 - 130
HX 04	130 - 101
HX 05	101 - 66
HX 06	66 - 45
HX 07	45 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.8.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1191	182
T02	1191	184
T03	880	102
T04	1005	50
T05	434	21
T06	544	5

5.8.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	887	1.05	4.83	900
Comp MP/HP	4040	4.83	21	3968

5.8.4 PFD and Workbook

See annex 7.

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RHEA: Liquefier Process Calculations

5.9 Turbines nominal conditions case (Simulation)

5.9.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 234
HX 02	234 - 205
HX 03	205 - 128
HX 04	128 - 100
HX 05	100 - 66
HX 06	66 - 45
HX 07	45 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.9.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1166	177
T02	1166	178
T03	866	100
T04	986	49
T05	423	21
T06	530	5

5.9.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	869	1.05	4.73	870
Comp MP/HP	3964	4.73	20.5	3885

5.9.4 PFD and Workbook

See annex 8.

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RHEA: Liquefier Process Calculations

5.10 LN2 option for 80 K adsorber regeneration (Simulation)

5.10.1 Heat exchangers

Heat Exchanger	Temperature [K]
HX 01	323 - 234
HX 02	234 - 205
HX 03	205 - 126
HX 04	126 - 98
HX 05	98 - 66
HX 06	66 - 45
HX 07	45 - 29
HX 08	29 - 20
HX 09	20 - 9
HX 10	9 - 7.4
HX 11	5.5 - 5.4

5.10.2 Turbines

Turbines	Mass flow rate [g/s]	Work [kW]
T01	1194	182
T02	1194	180
T03	886	102
T04	1007	50
T05	434	22
T06	542	5

5.10.3 Compressors

Compressors	Mass flow rate [g/s]	Feed pressure [bar]	Product pressure [bar]	Ideal work [kW]
Comp LP/MP	911	1.05	4.83	924
Comp MP/HP	4091	4.83	21	4018

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5.10.4 LN2 consumption

	Mass flow rate [g/s]	Feed pressure [bar]
LN2 consumption	80	1.2

5.10.5 PFD and Workbook

See annex 9.



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6 ANNEX 1: AVERAGE CASE

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Rhea-Design Ex8_2.1.2-Sans_LN2 Version(12)

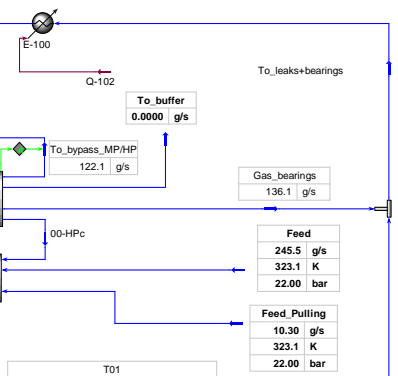
P BP/MP	899.6 kW
P MP/HP	3995 kW
P totale idéale	4894 kW

From_buffer	0.0000 g/s
-------------	------------

From_Leaks+Bearings

Comp LP/MP	
Feed Pressure	1.050 bar
Feed Temperature	320.5 K
Product Pressure	4.825 bar
Mass Flow	886.5 g/s
Capacity	2.024e+004 ACT_m3/h

Comp MP/HP	
Feed Pressure	4.825 bar
Feed Temperature	321.2 K
Product Pressure	21.00 bar
Mass Flow	4067 g/s
Capacity	2.028e+004 ACT_m3/h



Calcul puissance énergétique

Calcul off-design

HX01	1.000
HX02	1.000
HX03	1.000
HX04	1.000
HX05	1.000
HX06	1.000
HX07	1.000
HX08	1.000
HX09	1.000
HX10	1.000
HX11	1.000
T01	1.000
T02	1.000
T03	1.000
T04	1.000
T05	1.000
T06	1.000
Comp BP/MP	1.000
Comp MP/HP	1.000

HX-02	
UA (Calculated)	9.142e+004 W/C
Minimum Approach	2.050 K
Heat Leak	70.00 W*
dP HP	25.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-01	
UA (Calculated)	3.676e+005 W/C
Heat Leak	370.0 W*
Minimum Approach	2.530 K
dP turb	110.0 mbar
dP HP	110.0 mbar
dP MP	60.00 mbar
dP BP	50.00 mbar

HX-03	
UA (Calculated)	3.810e+005 W/C
Heat Leak	350.0 W*
Minimum Approach	2.050 K
dP HP	50.00 mbar
dP MP	130.0 mbar
dP BP	45.00 mbar

HX-04	
UA (Calculated)	1.250e+005 W/C
Minimum Approach	1.059 K
Heat Leak	150.0 W*
dP HP	30.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-05	
UA (Calculated)	2.069e+005 W/C
Heat Leak	400.0 W*
Minimum Approach	1.000 K
dP HP	30.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-06	
UA (Calculated)	1.186e+005 W/C
Minimum Approach	0.4471 K
Exchanger Cold Duty	2.224e+005 W*
Heat Leak	200.0 W*
dP HP	70.00 mbar
dP MP	15.00 mbar
dP BP	15.00 mbar

HX-07	
UA (Calculated)	1.113e+005 W/C
Minimum Approach	0.4471 K
Heat Leak	100.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-08	
UA (Calculated)	2.968e+004 W/C
Minimum Approach	0.6000 K
Heat Leak	170.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-09	
UA (Calculated)	9.729e+004 W/C
Heat Leak	450.0 W*
Minimum Approach	0.2251 K
dP HP	5.000 mbar
dP BP	0.0000 mbar

HX-10	
UA (Calculated)	6184 W/C
Minimum Approach	0.1050 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-09	
UA (Calculated)	9.729e+004 W/C
Heat Leak	450.0 W*
Minimum Approach	0.2251 K
dP HP	5.000 mbar
dP BP	0.0000 mbar

HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

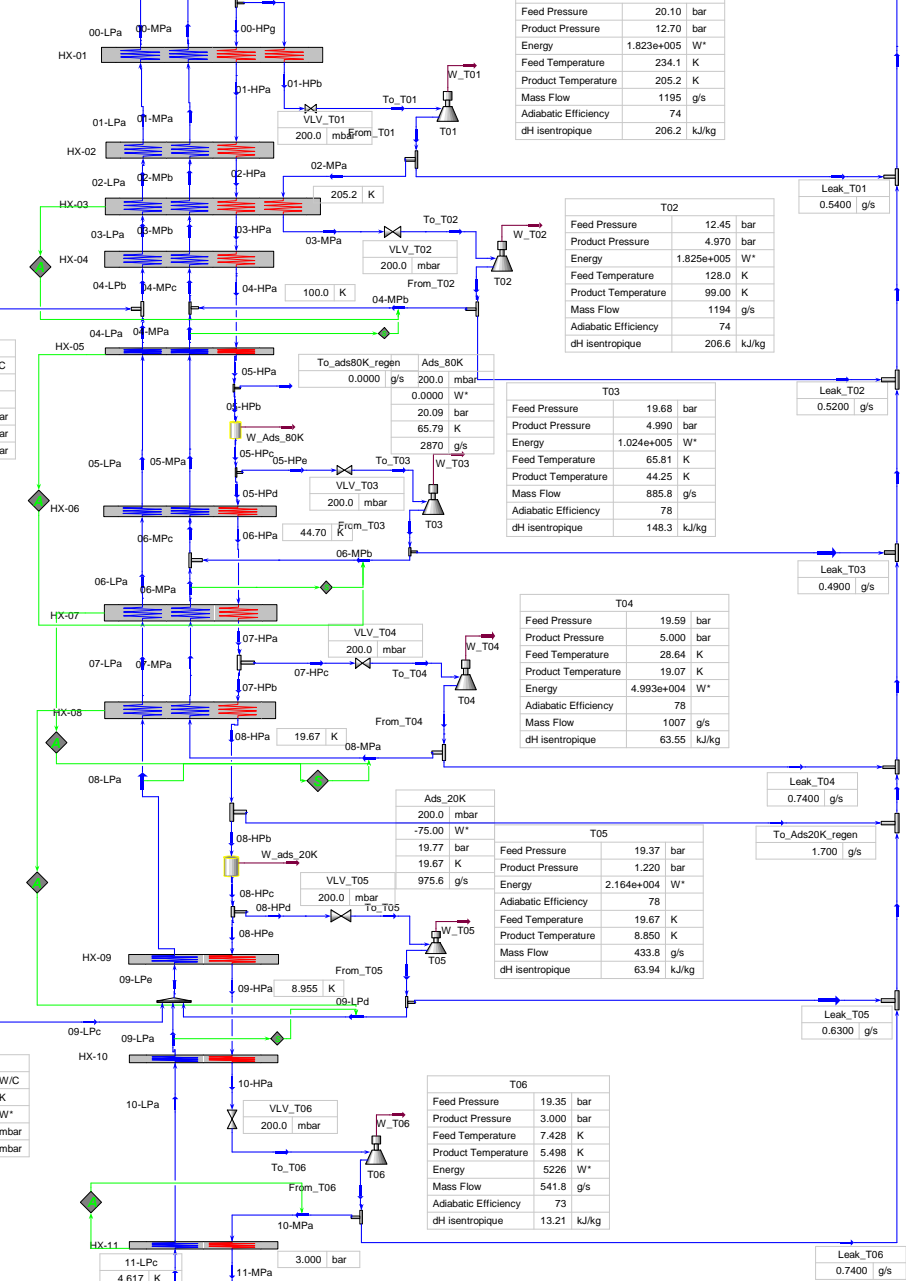
HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar


HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-11	
UA (Calculated)	3519 W/C
Minimum Approach	0.1002 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar




Balance Input/Output	
IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	0.0000 g/s
Rising level	44.83 g/s
OUT	
LHe	263.1 g/s
C_Tr+K_Tr	37.50 g/s
To buffer	0.0000 g/s
Balance	1.705e-013 g/s
Net to trucks	255.8 g/s

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 09:49:30 2010
4			
5			

Workbook: Case (Main)

		Streams				Fluid Pkg:	All
11	Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe	
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (K)	323.1 *	323.2	323.2	323.2	323.2	323.2
14	Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41	20.41
15	Mass Flow (g/s)	4067	4067	3809	4065	4065	4065
16	Mass Enthalpy (J/g)	1685	1685	1685	1685	1685	1685
17	Heat Flow (W*)	6.852e+006	6.852e+006	6.417e+006	6.848e+006	6.848e+006	6.848e+006
18	Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc	
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	Temperature (K)	323.2	323.2	320.7	320.7	320.5	320.5
21	Pressure (bar)	20.41	20.41	1.075	1.050	1.050 *	1.050 *
22	Mass Flow (g/s)	1195	2870	703.0	703.0	886.5	886.5
23	Mass Enthalpy (J/g)	1685	1685	1665	1665	1665	1665
24	Heat Flow (W*)	2.012e+006	4.836e+006	1.171e+006	1.171e+006	1.476e+006	1.476e+006
25	Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe	
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
27	Temperature (K)	320.7	320.7	323.1 *	323.1	321.2	321.2
28	Pressure (bar)	4.845	4.825	4.825	4.825	4.825	4.825
29	Mass Flow (g/s)	3085	3085	886.5	859.9	4067	4067
30	Mass Enthalpy (J/g)	1667	1667	1680	1680	1669	1669
31	Heat Flow (W*)	5.142e+006	5.142e+006	1.489e+006	1.444e+006	6.789e+006	6.789e+006
32	Name	01-HPa	01-HPb	01-LPa	01-MPa	02-HPa	
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
34	Temperature (K)	234.1	234.1	225.1	225.1	205.2	205.2
35	Pressure (bar)	20.30	20.30	1.125	4.905	20.28	20.28
36	Mass Flow (g/s)	2870	1195	703.0	3085	2870	2870
37	Mass Enthalpy (J/g)	1222	1222	1169	1170	1072	1072
38	Heat Flow (W*)	3.508e+006	1.460e+006	8.218e+005	3.610e+006	3.077e+006	3.077e+006
39	Name	02-LPa	02-MPa	02-MPb	03-HPa	03-LPa	
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
41	Temperature (K)	203.2	205.2 *	203.2	128.0	120.2	120.2
42	Pressure (bar)	1.135	12.70 *	4.915	20.15	1.180	1.180
43	Mass Flow (g/s)	703.0	1194	3085	2870	703.0	703.0
44	Mass Enthalpy (J/g)	1055	1070	1056	670.7	624.5	624.5
45	Heat Flow (W*)	7.418e+005	1.277e+006	3.259e+006	1.925e+006	4.390e+005	4.390e+005
46	Name	03-MPa	03-MPb	04-HPa	04-LPa	04-LPb	
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
48	Temperature (K)	128.0	120.2	100.0 *	99.00	98.76	98.76
49	Pressure (bar)	12.65	4.960	20.12	1.190	1.190	1.190
50	Mass Flow (g/s)	1194	3085	2870	694.1	703.0	703.0
51	Mass Enthalpy (J/g)	668.4	625.7	525.0	514.4	513.2	513.2
52	Heat Flow (W*)	7.980e+005	1.930e+006	1.507e+006	3.570e+005	3.607e+005	3.607e+005
53	Name	04-MPa	04-MPb	04-MPc	05-HPa	05-HPb	
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
55	Temperature (K)	99.00	99.00	99.00	65.79	65.79	65.79
56	Pressure (bar)	4.970	4.970	4.970	20.09	20.09	20.09
57	Mass Flow (g/s)	1892	1193 *	3085	2870	2870	2870
58	Mass Enthalpy (J/g)	515.5	515.5	515.5	345.8	345.8	345.8
59	Heat Flow (W*)	9.752e+005	6.152e+005	1.590e+006	9.925e+005	9.925e+005	9.925e+005
60	Name	05-HPc	05-HPd	05-HPe	05-LPa	05-MPa	
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
62	Temperature (K)	65.80	65.80	65.80	60.74	60.74	60.74
63	Pressure (bar)	19.89	19.89	19.89	1.195	4.975	4.975
64	Mass Flow (g/s)	2870	1985	885.8	694.1	1892	1892
65	Mass Enthalpy (J/g)	345.8	345.8	345.8	315.6	316.3	316.3
66	Heat Flow (W*)	9.925e+005	6.862e+005	3.063e+005	2.191e+005	5.984e+005	5.984e+005

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 09:49:30 2010
4			
5			

Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	06-HPa	06-LPa	06-MPa	06-MPb	06-MPc		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (K)	44.70 *	44.25	44.25	44.25	44.25	44.25	44.25
14	Pressure (bar)	19.82	1.210	4.990	4.990	4.990	4.990	4.990
15	Mass Flow (g/s)	1985	694.1	1007	885.3 *	1892		
16	Mass Enthalpy (J/g)	233.7	229.9	230.1	230.1	230.1	230.1	230.1
17	Heat Flow (W*)	4.638e+005	1.595e+005	2.316e+005	2.037e+005	4.353e+005		
18	Name	07-HPa	07-HPb	07-HPc	07-LPa	07-MPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	Temperature (K)	28.65	28.65	28.65	24.72	24.72	24.72	24.72
21	Pressure (bar)	19.79	19.79	19.79	1.215	4.995	4.995	4.995
22	Mass Flow (g/s)	1985	977.3	1007	694.1	1007	1007	1007
23	Mass Enthalpy (J/g)	145.7	145.7	145.7	128.0	126.8	126.8	126.8
24	Heat Flow (W*)	2.892e+005	1.424e+005	1.468e+005	8.881e+004	1.276e+005		
25	Name	08-HPa	08-HPb	08-HPc	08-HPd	08-HPe		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
27	Temperature (K)	19.67	19.67	19.68	19.68	19.68	19.68	19.68
28	Pressure (bar)	19.77	19.77	19.57	19.57	19.57	19.57	19.57
29	Mass Flow (g/s)	977.3	975.6	975.6	433.8	541.8	541.8	541.8
30	Mass Enthalpy (J/g)	93.31	93.31	93.39	93.39	93.39	93.39	93.39
31	Heat Flow (W*)	9.120e+004	9.104e+004	9.111e+004	4.051e+004	5.060e+004		
32	Name	08-LPa	08-MPa	09-HPa	09-LPa	09-LPc		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
34	Temperature (K)	19.07	19.07	8.955	8.850	7.030	7.030	7.030
35	Pressure (bar)	1.220	5.000 *	19.56	1.220	1.220	1.220	1.220
36	Mass Flow (g/s)	694.1	1007 *	541.8	216.1	44.83	44.83	44.83
37	Mass Enthalpy (J/g)	98.32	96.17	23.16	43.51	33.15	33.15	33.15
38	Heat Flow (W*)	6.824e+004	9.679e+004	1.255e+004	9401	1486		
39	Name	09-LPd	09-LPe	10-HPa	10-LPa	10-MPa		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
41	Temperature (K)	8.850 *	8.730	7.415	5.398	5.498 *	5.498 *	5.498 *
42	Pressure (bar)	1.220	1.220	19.55	1.220	3.000 *	3.000 *	3.000 *
43	Mass Flow (g/s)	433.2 *	694.1	541.8	216.1	541.1	541.1	541.1
44	Mass Enthalpy (J/g)	43.51	42.85	15.03	23.02	5.386	5.386	5.386
45	Heat Flow (W*)	1.885e+004	2.974e+004	8144	4974	2914		
46	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
47	Vapour Fraction	0.3700 *	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
48	Temperature (K)	4.425	4.424	4.617	5.386	4.424	4.424	4.424
49	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220	1.220	1.220
50	Mass Flow (g/s)	541.1 *	216.1	216.1	541.1	24.40 *	24.40 *	24.40 *
51	Mass Enthalpy (J/g)	3.084	15.29	17.14	3.084	-4.107	-4.107	-4.107
52	Heat Flow (W*)	1669	3304	3704	1669	-100.2	-100.2	-100.2
53	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
54	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
55	Temperature (K)	4.424	320.0 *	4.424	323.1 *	323.1 *	323.1 *	323.1 *
56	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *	22.00 *	22.00 *
57	Mass Flow (g/s)	15.50 *	15.50	37.50 *	245.5 *	10.30 *	10.30 *	10.30 *
58	Mass Enthalpy (J/g)	-4.107	1662	-4.107	1685	1685	1685	1685
59	Heat Flow (W*)	-63.66	2.576e+004	-154.0	4.137e+005	1.736e+004		
60	Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
62	Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	205.2	205.2	205.2
63	Pressure (bar)	1.050	1.050	4.825	1.050	12.70	12.70	12.70
64	Mass Flow (g/s)	0.0000 *	26.61	122.1	141.5	1195	1195	1195
65	Mass Enthalpy (J/g)	1662	1662	1663	1662	1070	1070	1070
66	Heat Flow (W*)	0.0000	4.422e+004	2.031e+005	2.351e+005	1.278e+006		



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 09:49:30 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	From_T02	From_T03	From_T04	From_T05	From_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	99.00	44.25	19.07	8.850	5.498
Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *
Mass Flow (g/s)	1194	885.8	1007	433.8	541.8
Mass Enthalpy (J/g)	515.5	230.1	96.17	43.51	5.386
Heat Flow (W*)	6.155e+005	2.038e+005	9.686e+004	1.888e+004	2918
Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02
Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	4.424	80.00 *	205.2	99.00
Pressure (bar)	20.50	1.220	1.190	12.70	4.970
Mass Flow (g/s)	136.1 *	8.900	8.900	0.5400 *	0.5200 *
Mass Enthalpy (J/g)	1685	-4.107	415.7	1070	515.5
Heat Flow (W*)	2.293e+005	-36.55	3700	577.6	268.0
Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	LHe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	0.0000
Temperature (K)	44.25	19.07	8.850	5.498	4.424
Pressure (bar)	4.990	5.000	1.220	3.000	1.220
Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	325.0
Mass Enthalpy (J/g)	230.1	96.17	43.51	5.386	-4.107
Heat Flow (W*)	112.8	71.16	27.41	3.986	-1335
Name	LHe to trucks and stor	Rising level from truck	To_Ads20K_regen	To_ads80K_regen	To_buffer
Vapour Fraction	0.0000	1.0000 *	1.0000	1.0000	1.0000
Temperature (K)	4.424	4.425	19.67	65.79	323.2
Pressure (bar)	1.220	1.220	19.77	20.09	20.50
Mass Flow (g/s)	263.1	44.83	1.700 *	0.0000 *	0.0000 *
Mass Enthalpy (J/g)	-4.107	15.31	93.31	345.8	1685
Heat Flow (W*)	-1081	686.4	158.6	0.0000	0.0000
Name	To_bypass_LP/MP	To_bypass_MP/HP	To_leaks+bearings	To_T01	To_T02
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.1	323.2	313.7	234.1	128.0
Pressure (bar)	4.825	20.50	1.220	20.10	12.45
Mass Flow (g/s)	26.61 *	122.1 *	141.5	1195	1194
Mass Enthalpy (J/g)	1680	1685	1630	1222	668.4
Heat Flow (W*)	4.468e+004	2.057e+005	2.305e+005	1.460e+006	7.980e+005
Name	To_T03	To_T04	To_T05	To_T06	Total_leaks
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	65.81	28.64	19.67	7.428	43.81
Pressure (bar)	19.68	19.59	19.37	19.35	1.220
Mass Flow (g/s)	885.8	1007	433.8	541.8	5.360
Mass Enthalpy (J/g)	345.8	145.7	93.39	15.03	227.5
Heat Flow (W*)	3.063e+005	1.468e+005	4.051e+004	8144	1220
Name	W_ads_20K	W_Ads_80K	W_dewar	W_ORs	W_pipeBP
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	0.0000 *	0.0000 *
Name	W_pipeHP	W_pipeMP	W_T01	W_T02	W_T03
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	0.0000 *	0.0000 *	1.823e+005	1.825e+005	1.024e+005



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 09:49:30 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_T04	W_T05	W_T06	W_trucks_300K	W_trucks_80K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	4.993e+004	2.164e+004	5226	2.582e+004	3736
Name	W_vapor_from_storag	W_vapor_from_trucks			
Vapour Fraction	---	---			
Temperature (K)	---	---			
Pressure (bar)	---	---			
Mass Flow (g/s)	---	---			
Mass Enthalpy (J/g)	---	---			
Heat Flow (W*)	400.0 *	800.0 *			



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

RHEA: Liquefier Process Calculations

7 ANNEX 2: CXXX CASE

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(12) Rhea-Simulation CXXX

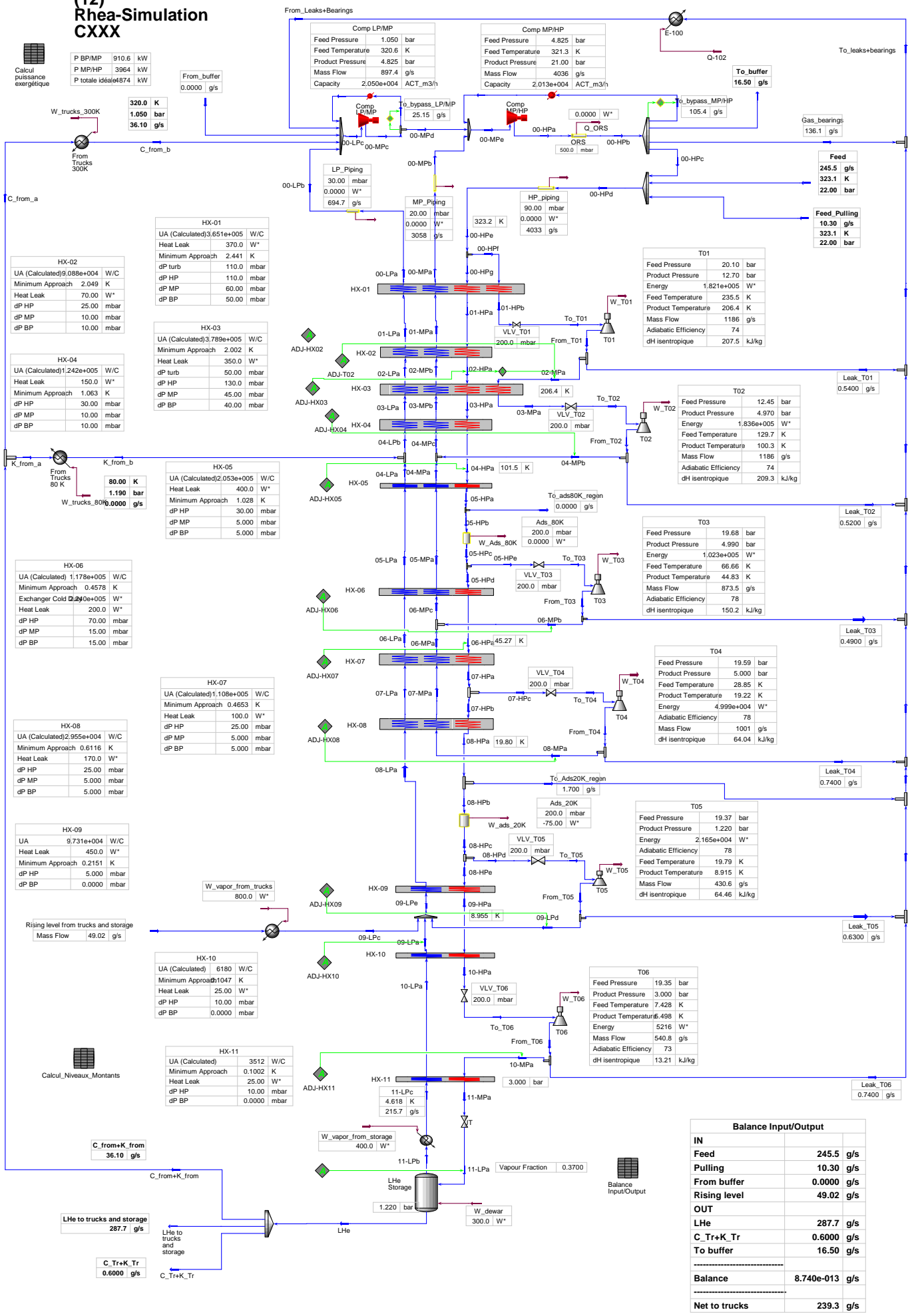
Calcul puissance énergétique

P BP/MP	910.6	kW
P MP/HP	3964	kW
P totale idéale	4874	kW

Calcul off-design

Calcul off-design

HX01	0.9993
HX02	1.000
HX03	1.001
HX04	1.000
HX05	0.9995
HX06	1.000
HX07	1.000
HX08	1.000
Erreur sur HX de 01 à 08	9999
HX09	0.9995
HX10	1.001
HX11	0.9992
T01	0.9958
T02	0.9998
T03	0.9923
T04	0.9972
T05	0.9963
T06	0.9982
Comp BP/MP	1.012
Comp MP/HP	0.9925



HX-01

UA (Calculated)	3.651e+005	W/C
Heat Leak	370.0	W*
Minimum Approach	2.441	K
dP turb	110.0	mbar
dP HP	110.0	mbar
dP MP	60.00	mbar
dP BP	50.00	mbar

HX-02

UA (Calculated)	9.088e+004	W/C
Heat Leak	70.00	W*
Minimum Approach	2.049	K
dP turb	25.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

HX-03

UA (Calculated)	3.789e+005	W/C
Heat Leak	350.0	W*
Minimum Approach	2.002	K
dP turb	50.00	mbar
dP HP	130.0	mbar
dP MP	45.00	mbar
dP BP	40.00	mbar

HX-04

UA (Calculated)	1.242e+005	W/C
Heat Leak	150.0	W*
Minimum Approach	1.063	K
dP turb	30.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

HX-05

UA (Calculated)	2.053e+005	W/C
Heat Leak	400.0	W*
Minimum Approach	1.028	K
dP turb	30.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

HX-06

UA (Calculated)	1.178e+005	W/C
Heat Leak	450.0	W*
Minimum Approach	0.4578	K
Exchanger Cold Duty	4.90e+005	W*
Heat Leak	200.0	W*
dP HP	70.00	mbar
dP MP	15.00	mbar
dP BP	15.00	mbar

HX-07

UA (Calculated)	2.955e+004	W/C
Heat Leak	170.0	W*
Minimum Approach	0.6116	K
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

HX-08

UA (Calculated)	9.731e+004	W/C
Heat Leak	450.0	W*
Minimum Approach	0.2151	K
dP HP	5.000	mbar
dP MP	0.0000	mbar

HX-09

UA (Calculated)	6180	W/C
Heat Leak	25.00	W*
Minimum Approach	0.1047	K
dP HP	10.00	mbar
dP BP	0.0000	mbar

HX-10

UA (Calculated)	3512	W/C
Heat Leak	0.1002	K
Minimum Approach	25.00	W*
dP HP	10.00	mbar
dP BP	0.0000	mbar

HX-11

UA (Calculated)	3512	W/C
Heat Leak	0.1002	K
Minimum Approach	25.00	W*
dP HP	10.00	mbar
dP BP	0.0000	mbar

Balance Input/Output

IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	0.0000 g/s
Rising level	49.02 g/s
OUT	
LHe	287.7 g/s
C.Tr+K.Tr	0.6000 g/s
To buffer	16.50 g/s
Balance	8.740e-013 g/s
Net to trucks	239.3 g/s



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:29:46 2010


Workbook: Case (Main)

Streams

Fluid Pkg:


All

Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.1 *	323.2	323.2	323.2	323.2
Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41
Mass Flow (g/s)	4036	4036	3778	4033	4033
Mass Enthalpy (J/g)	1685	1685	1685	1685	1685
Heat Flow (W*)	6.799e+006	6.799e+006	6.364e+006	6.795e+006	6.795e+006
Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.2	320.7	320.8	320.6
Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *
Mass Flow (g/s)	1186	2847	694.7	694.7	897.4
Mass Enthalpy (J/g)	1685	1685	1666	1666	1665
Heat Flow (W*)	1.998e+006	4.797e+006	1.157e+006	1.157e+006	1.494e+006
Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.7	320.8	323.1 *	323.1	321.3
Pressure (bar)	4.845	4.825	4.825	4.825	4.825
Mass Flow (g/s)	3058	3058	897.4	872.3	4036
Mass Enthalpy (J/g)	1667	1667	1680	1680	1670
Heat Flow (W*)	5.098e+006	5.098e+006	1.507e+006	1.465e+006	6.738e+006
Name	01-HPa	01-HPb	01-LPa	01-MPa	2
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	235.5	235.5	226.5	226.5	12.31
Pressure (bar)	20.30	20.30	1.130	4.905	1.220
Mass Flow (g/s)	2847	1186	694.7	3058	3.070
Mass Enthalpy (J/g)	1229	1229	1176	1178	62.40
Heat Flow (W*)	3.500e+006	1.458e+006	8.172e+005	3.601e+006	191.6
Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	206.6 *	204.5	206.4	204.5	129.7
Pressure (bar)	20.28	1.140	12.70 *	4.915	20.15
Mass Flow (g/s)	2847	694.7	1186	3058	2847
Mass Enthalpy (J/g)	1079	1062	1076	1064	679.6
Heat Flow (W*)	3.073e+006	7.380e+005	1.275e+006	3.253e+006	1.935e+006
Name	03-LPa	03-MPa	03-MPb	4	04-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	121.9	129.7	121.9	5.407	101.5 *
Pressure (bar)	1.180	12.65	4.960	1.220	20.12
Mass Flow (g/s)	694.7	1186	3058	1.370	2847
Mass Enthalpy (J/g)	633.2	677.3	634.4	23.09	532.6
Heat Flow (W*)	4.399e+005	8.029e+005	1.940e+006	31.63	1.516e+006
Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	100.4	100.4	100.4	100.3 *	100.4
Pressure (bar)	1.190	1.190	4.970	4.970	4.970
Mass Flow (g/s)	694.7	694.7	1873	1185 *	3058
Mass Enthalpy (J/g)	521.8	521.8	522.9	522.4	522.7
Heat Flow (W*)	3.625e+005	3.625e+005	9.794e+005	6.191e+005	1.598e+006
Name	5	05-HPa	05-HPb	05-HPc	05-HPd
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	13.56	66.64	66.64	66.65	66.65
Pressure (bar)	1.220	20.09	20.09	19.89	19.89
Mass Flow (g/s)	3.810	2847	2847	2847	1974
Mass Enthalpy (J/g)	69.11	350.3	350.3	350.3	350.3
Heat Flow (W*)	263.3	9.973e+005	9.973e+005	9.973e+005	6.914e+005

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:29:46 2010
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Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	66.65	61.54	61.54	17.08	45.27 *		
14	Pressure (bar)	19.89	1.195	4.975	1.220	19.82		
15	Mass Flow (g/s)	873.5	694.7	1873	4.300	1974		
16	Mass Enthalpy (J/g)	350.3	319.8	320.5	87.80	236.8		
17	Heat Flow (W*)	3.059e+005	2.221e+005	6.003e+005	377.5	4.674e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	44.80	44.80	44.83 *	44.81	28.85		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	694.7	1000	873.0 *	1873	1974		
23	Mass Enthalpy (J/g)	232.7	233.0	233.1	233.1	146.9		
24	Heat Flow (W*)	1.617e+005	2.330e+005	2.035e+005	4.365e+005	2.900e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.85	28.85	24.88	24.88	19.80		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	973.2	1001	694.7	1000	973.2		
30	Mass Enthalpy (J/g)	146.9	146.9	128.8	127.7	94.08		
31	Heat Flow (W*)	1.430e+005	1.470e+005	8.950e+004	1.277e+005	9.155e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.80	19.80	19.80	19.80	19.17		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	971.5	971.5	430.6	540.8	694.7		
37	Mass Enthalpy (J/g)	94.08	94.16	94.16	94.16	98.82		
38	Heat Flow (W*)	9.139e+004	9.147e+004	4.055e+004	5.092e+004	6.865e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	19.22 *	8.955	8.850 *	6.771	8.915 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1000 *	540.8	215.7	49.02	430.0 *		
44	Mass Enthalpy (J/g)	96.95	23.16	43.52	31.63	43.88		
45	Heat Flow (W*)	9.695e+004	1.252e+004	9386	1551	1.887e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	8.740	7.414	5.398	5.498 *	26.00		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	694.7	540.8	215.7	540.1	4.820		
51	Mass Enthalpy (J/g)	42.90	15.03	23.02	5.385	134.7		
52	Heat Flow (W*)	2.980e+004	8129	4966	2908	649.2		
53	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
54	Vapour Fraction	0.3700 *	1.0000	1.0000	1.0000	0.0000		
55	Temperature (K)	4.425	4.424	4.618	5.386	4.424		
56	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220		
57	Mass Flow (g/s)	540.1 *	215.7	215.7	540.1	36.10 *		
58	Mass Enthalpy (J/g)	3.084	15.29	17.15	3.084	-4.107		
59	Heat Flow (W*)	1666	3298	3698	1666	-148.3		
60	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
61	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000		
62	Temperature (K)	4.424	320.0 *	4.424	323.1 *	323.1 *		
63	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *		
64	Mass Flow (g/s)	36.10 *	36.10	0.6000 *	245.5 *	10.30 *		
65	Mass Enthalpy (J/g)	-4.107	1662	-4.107	1685	1685		
66	Heat Flow (W*)	-148.3	6.000e+004	-2.464	4.137e+005	1.736e+004		

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set: Cryogénie - K - bar - g/s1
3		Date/Time: Tue Aug 24 10:29:46 2010
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Workbook: Case (Main) (continued)

Streams (continued)						Fluid Pkg:	All
11	Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01	
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	320.0 *	206.4
14	Pressure (bar)	1.050	1.050	4.825	1.050	1.050	12.70
15	Mass Flow (g/s)	0.0000 *	25.15	105.4	141.5	1186	
16	Mass Enthalpy (J/g)	1662	1662	1663	1662	1076	
17	Heat Flow (W*)	0.0000	4.180e+004	1.753e+005	2.351e+005	1.276e+006	
18	Name	From_T02	From_T03	From_T04	From_T05	From_T06	
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	Temperature (K)	100.3	44.83	19.22	8.915	5.498	
21	Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *	
22	Mass Flow (g/s)	1186	873.5	1001	430.6	540.8	
23	Mass Enthalpy (J/g)	522.4	233.1	96.95	43.88	5.385	
24	Heat Flow (W*)	6.193e+005	2.036e+005	9.703e+004	1.889e+004	2912	
25	Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02	
26	Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
27	Temperature (K)	323.2	4.424	80.00 *	206.4	100.3	
28	Pressure (bar)	20.50	1.220	1.190	12.70	4.970	
29	Mass Flow (g/s)	136.1 *	0.0000	0.0000	0.5400 *	0.5200 *	
30	Mass Enthalpy (J/g)	1685	-4.107	415.7	1076	522.4	
31	Heat Flow (W*)	2.293e+005	0.0000	0.0000	580.9	271.7	
32	Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks	
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
34	Temperature (K)	44.83	19.22	8.915	5.498	44.18	
35	Pressure (bar)	4.990	5.000	1.220	3.000	1.220	
36	Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360	
37	Mass Enthalpy (J/g)	233.1	96.95	43.88	5.385	229.5	
38	Heat Flow (W*)	114.2	71.75	27.64	3.985	1230	
39	Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP	
40	Vapour Fraction	0.0000	0.0000	---	---	---	
41	Temperature (K)	4.424	4.424	---	---	---	
42	Pressure (bar)	1.220	1.220	---	---	---	
43	Mass Flow (g/s)	324.4	287.7	---	---	---	
44	Mass Enthalpy (J/g)	-4.107	-4.107	---	---	---	
45	Heat Flow (W*)	-1332	-1182	4580	0.0000 *	0.0000 *	
46	Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen	
47	Vapour Fraction	---	---	1.0000 *	1.0000	1.0000	
48	Temperature (K)	---	---	4.425	19.80	66.64	
49	Pressure (bar)	---	---	1.220	19.77	20.09	
50	Mass Flow (g/s)	---	---	49.02	1.700 *	0.0000 *	
51	Mass Enthalpy (J/g)	---	---	15.31	94.08	350.3	
52	Heat Flow (W*)	0.0000 *	0.0000 *	750.5	159.9	0.0000	
53	Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_leaks+bearings	To_T01	
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	323.2	323.1	323.2	313.8	235.5	
56	Pressure (bar)	20.50	4.825	20.50	1.220	20.10	
57	Mass Flow (g/s)	16.50 *	25.15 *	105.4 *	141.5	1186	
58	Mass Enthalpy (J/g)	1685	1680	1685	1630	1229	
59	Heat Flow (W*)	2.780e+004	4.224e+004	1.775e+005	2.305e+005	1.458e+006	
60	Name	To_T02	To_T03	To_T04	To_T05	To_T06	
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	129.7	66.66	28.85	19.79	7.428	
63	Pressure (bar)	12.45	19.68	19.59	19.37	19.35	
64	Mass Flow (g/s)	1186	873.5	1001	430.6	540.8	
65	Mass Enthalpy (J/g)	677.3	350.3	146.9	94.16	15.03	
66	Heat Flow (W*)	8.029e+005	3.059e+005	1.470e+005	4.055e+004	8129	



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 10:29:46 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	1.821e+005	1.836e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	1.023e+005	4.999e+004	2.165e+004	5216	6.014e+004
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	0.0000	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

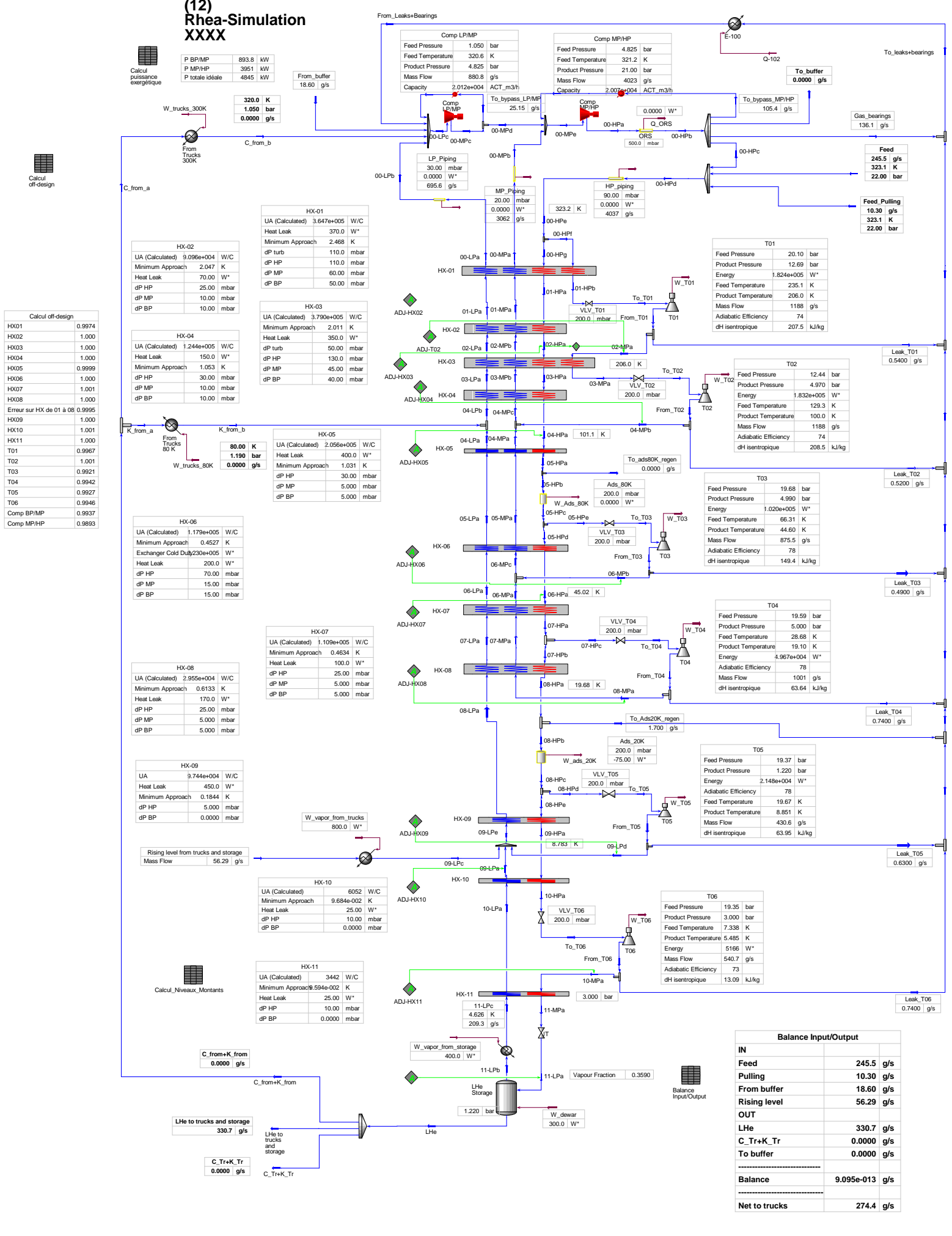
RHEA: Liquefier Process Calculations

8 ANNEX 3: XXXX CASE

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(12) Rhea-Simulation XXXX



P BP/MP	893.8	KW
P MP/HP	3951	KW
P totale idéale	4845	KW

W_trucks_300K	320.0	K
From Trucks	1.050	bar
	0.0000	g/s

UA (Calculated)	9.096e+004	W/C
Minimum Approach	2.047	K
Heat Leak	70.00	W*
dP turb	25.00	mbar
dP HP	10.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

UA (Calculated)	1.244e+005	W/C
Minimum Approach	1.053	K
Heat Leak	30.00	W*
dP HP	30.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

UA (Calculated)	3.790e+005	W/C
Minimum Approach	2.011	K
Heat Leak	350.0	W*
dP turb	50.00	mbar
dP HP	130.0	mbar
dP MP	45.00	mbar
dP BP	40.00	mbar

UA (Calculated)	1.179e+005	W/C
Minimum Approach	0.4527	K
Exchanger Cold Duty	230e+005	W*
Heat Leak	200.0	W*
dP HP	70.00	mbar
dP MP	15.00	mbar
dP BP	15.00	mbar


UA (Calculated)	2.955e+004	W/C
Minimum Approach	0.6133	K
Heat Leak	170.0	W*
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

UA	9.744e+004	W/C
Heat Leak	450.0	W*
Minimum Approach	0.1844	K
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	0.0000	mbar

UA (Calculated)	6052	W/C
Minimum Approach	9.684e-002	K
Heat Leak	25.00	W*
dP HP	10.00	mbar
dP BP	0.0000	mbar


UA (Calculated)	3442	W/C
Minimum Approach	9.594e-002	K
Heat Leak	25.00	W*
dP HP	10.00	mbar
dP BP	0.0000	mbar

Balance Input/Output	
IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	18.60 g/s
Rising level	56.29 g/s
OUT	
LHe	330.7 g/s
C_Tr+K_Tr	0.0000 g/s
To buffer	0.0000 g/s
Balance	9.095e-013 g/s
Net to trucks	274.4 g/s

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:46:43 2010
4			
5			

Workbook: Case (Main)

		Streams					Fluid Pkg:	All
11	Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	323.1 *	323.2	323.2	323.2	323.2	323.2	
14	Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41	20.41	
15	Mass Flow (g/s)	4023	4023	3782	4037	4037	4037	
16	Mass Enthalpy (J/g)	1685	1685	1685	1685	1685	1685	
17	Heat Flow (W*)	6.778e+006	6.778e+006	6.371e+006	6.802e+006	6.802e+006	6.802e+006	
18	Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
20	Temperature (K)	323.2	323.2	320.7	320.7	320.6	320.6	
21	Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *	1.050 *	
22	Mass Flow (g/s)	1188	2849	695.6	695.6	880.8	880.8	
23	Mass Enthalpy (J/g)	1685	1685	1666	1666	1665	1665	
24	Heat Flow (W*)	2.002e+006	4.800e+006	1.159e+006	1.159e+006	1.466e+006	1.466e+006	
25	Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
27	Temperature (K)	320.7	320.7	323.1 *	323.1	321.2	321.2	
28	Pressure (bar)	4.845	4.825	4.825	4.825	4.825	4.825	
29	Mass Flow (g/s)	3062	3062	880.8	855.6	4023	4023	
30	Mass Enthalpy (J/g)	1667	1667	1680	1680	1670	1670	
31	Heat Flow (W*)	5.104e+006	5.104e+006	1.479e+006	1.437e+006	6.716e+006	6.716e+006	
32	Name	01-HPa	01-HPb	01-LPa	01-MPa	2		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
34	Temperature (K)	235.1	235.1	226.1	226.1	12.21	12.21	
35	Pressure (bar)	20.30	20.30	1.130	4.905	1.220	1.220	
36	Mass Flow (g/s)	2849	1188	695.6	3062	3.070	3.070	
37	Mass Enthalpy (J/g)	1228	1228	1174	1176	61.83	61.83	
38	Heat Flow (W*)	3.498e+006	1.458e+006	8.169e+005	3.600e+006	189.8	189.8	
39	Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
41	Temperature (K)	206.2 *	204.1	206.0	204.1	129.3	129.3	
42	Pressure (bar)	20.28	1.140	12.69 *	4.915	20.15	20.15	
43	Mass Flow (g/s)	2849	695.6	1188	3062	2849	2849	
44	Mass Enthalpy (J/g)	1077	1060	1074	1062	677.5	677.5	
45	Heat Flow (W*)	3.070e+006	7.376e+005	1.275e+006	3.251e+006	1.930e+006	1.930e+006	
46	Name	03-LPa	03-MPa	03-MPb	4	04-HPa		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
48	Temperature (K)	121.5	129.3	121.5	5.356	101.1 *	101.1 *	
49	Pressure (bar)	1.180	12.64	4.960	1.220	20.12	20.12	
50	Mass Flow (g/s)	695.6	1188	3062	1.370	2849	2849	
51	Mass Enthalpy (J/g)	631.2	675.2	632.3	22.74	530.8	530.8	
52	Heat Flow (W*)	4.390e+005	8.018e+005	1.936e+006	31.16	1.512e+006	1.512e+006	
53	Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc		
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	100.1	100.1	100.1	100.0 *	100.1	100.1	
56	Pressure (bar)	1.190	1.190	4.970	4.970	4.970	4.970	
57	Mass Flow (g/s)	695.6	695.6	1875	1187 *	3062	3062	
58	Mass Enthalpy (J/g)	520.1	520.1	521.2	520.9	521.0	521.0	
59	Heat Flow (W*)	3.618e+005	3.618e+005	9.772e+005	6.183e+005	1.595e+006	1.595e+006	
60	Name	5	05-HPa	05-HPb	05-HPc	05-HPd		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	13.45	66.30	66.30	66.31	66.31	66.31	
63	Pressure (bar)	1.220	20.09	20.09	19.89	19.89	19.89	
64	Mass Flow (g/s)	3.810	2849	2849	2849	1974	1974	
65	Mass Enthalpy (J/g)	68.52	348.5	348.5	348.5	348.5	348.5	
66	Heat Flow (W*)	261.1	9.928e+005	9.928e+005	9.928e+005	6.878e+005	6.878e+005	

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME	
2		Unit Set:	Cryogénie - K - bar - g/s1	
3		Date/Time:	Tue Aug 24 10:46:43 2010	
4				
5				

Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	66.31	61.21	61.21	16.96	45.02 *		
14	Pressure (bar)	19.89	1.195	4.975	1.220	19.82		
15	Mass Flow (g/s)	875.5	695.6	1875	4.300	1974		
16	Mass Enthalpy (J/g)	348.5	318.0	318.7	87.14	235.5		
17	Heat Flow (W*)	3.051e+005	2.212e+005	5.977e+005	374.7	4.648e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	44.56	44.56	44.60 *	44.58	28.68		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	695.6	1000	875.0 *	1875	1974		
23	Mass Enthalpy (J/g)	231.5	231.7	231.9	231.8	145.9		
24	Heat Flow (W*)	1.610e+005	2.317e+005	2.029e+005	4.347e+005	2.881e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.68	28.68	24.73	24.73	19.68		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	973.1	1001	695.6	1000	973.1		
30	Mass Enthalpy (J/g)	145.9	145.9	128.0	126.9	93.32		
31	Heat Flow (W*)	1.420e+005	1.461e+005	8.906e+004	1.269e+005	9.081e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.68	19.68	19.68	19.68	19.04		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	971.4	971.4	430.6	540.7	695.6		
37	Mass Enthalpy (J/g)	93.32	93.40	93.40	93.40	98.14		
38	Heat Flow (W*)	9.065e+004	9.073e+004	4.022e+004	5.050e+004	6.826e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	19.10 *	8.783	8.686 *	6.420	8.851 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1000 *	540.7	209.3	56.29	430.0 *		
44	Mass Enthalpy (J/g)	96.31	22.16	42.60	29.52	43.52		
45	Heat Flow (W*)	9.631e+004	1.198e+004	8916	1662	1.871e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	8.598	7.323	5.389	5.485 *	25.86		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	695.6	540.7	209.3	540.0	4.820		
51	Mass Enthalpy (J/g)	42.11	14.61	22.97	5.051	133.9		
52	Heat Flow (W*)	2.929e+004	7898	4807	2728	645.6		
53	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
54	Vapour Fraction	0.3590 *	1.0000	1.0000	1.0000	0.0000		
55	Temperature (K)	4.425	4.425	4.626	5.372	4.425		
56	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220		
57	Mass Flow (g/s)	540.0 *	209.3	209.3	540.0	0.0000 *		
58	Mass Enthalpy (J/g)	2.870	15.31	17.22	2.870	-4.096		
59	Heat Flow (W*)	1550	3204	3604	1550	0.0000		
60	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
61	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000		
62	Temperature (K)	4.425	320.0 *	4.425	323.1 *	323.1 *		
63	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *		
64	Mass Flow (g/s)	0.0000 *	0.0000	0.0000 *	245.5 *	10.30 *		
65	Mass Enthalpy (J/g)	-4.096	1662	-4.096	1685	1685		
66	Heat Flow (W*)	0.0000	0.0000	0.0000	4.137e+005	1.736e+004		



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:46:43 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	206.0
Pressure (bar)	1.050	1.050	4.825	1.050	12.69
Mass Flow (g/s)	18.60 *	25.15	105.4	141.5	1188
Mass Enthalpy (J/g)	1662	1662	1663	1662	1074
Heat Flow (W*)	3.091e+004	4.180e+004	1.753e+005	2.351e+005	1.276e+006
Name	From_T02	From_T03	From_T04	From_T05	From_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	100.0	44.60	19.10	8.851	5.485
Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *
Mass Flow (g/s)	1188	875.5	1001	430.6	540.7
Mass Enthalpy (J/g)	520.9	231.9	96.31	43.52	5.051
Heat Flow (W*)	6.185e+005	2.030e+005	9.638e+004	1.874e+004	2731
Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02
Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	4.425	80.00 *	206.0	100.0
Pressure (bar)	20.50	1.220	1.190	12.69	4.970
Mass Flow (g/s)	136.1 *	0.0000	0.0000	0.5400 *	0.5200 *
Mass Enthalpy (J/g)	1685	-4.096	415.7	1074	520.9
Heat Flow (W*)	2.293e+005	0.0000	0.0000	580.0	270.8
Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	44.60	19.10	8.851	5.485	44.02
Pressure (bar)	4.990	5.000	1.220	3.000	1.220
Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360
Mass Enthalpy (J/g)	231.9	96.31	43.52	5.051	228.6
Heat Flow (W*)	113.6	71.27	27.42	3.738	1226
Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP
Vapour Fraction	0.0000	0.0000	---	---	---
Temperature (K)	4.425	4.425	---	---	---
Pressure (bar)	1.220	1.220	---	---	---
Mass Flow (g/s)	330.7	330.7	---	---	---
Mass Enthalpy (J/g)	-4.096	-4.096	---	---	---
Heat Flow (W*)	-1354	-1354	4584	0.0000 *	0.0000 *
Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen
Vapour Fraction	---	---	1.0000 *	1.0000	1.0000
Temperature (K)	---	---	4.425	19.68	66.30
Pressure (bar)	---	---	1.220	19.77	20.09
Mass Flow (g/s)	---	---	56.29	1.700 *	0.0000 *
Mass Enthalpy (J/g)	---	---	15.31	93.32	348.5
Heat Flow (W*)	0.0000 *	0.0000 *	861.9	158.6	0.0000
Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_Leaks+Bearings	To_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.1	323.2	313.7	235.1
Pressure (bar)	20.50	4.825	20.50	1.220	20.10
Mass Flow (g/s)	0.0000 *	25.15 *	105.4 *	141.5	1188
Mass Enthalpy (J/g)	1685	1680	1685	1630	1228
Heat Flow (W*)	0.0000	4.224e+004	1.775e+005	2.305e+005	1.458e+006
Name	To_T02	To_T03	To_T04	To_T05	To_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	129.3	66.31	28.68	19.67	7.338
Pressure (bar)	12.44	19.68	19.59	19.37	19.35
Mass Flow (g/s)	1188	875.5	1001	430.6	540.7
Mass Enthalpy (J/g)	675.2	348.5	145.9	93.40	14.61
Heat Flow (W*)	8.018e+005	3.051e+005	1.461e+005	4.022e+004	7898



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:46:43 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	1.824e+005	1.832e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	1.020e+005	4.967e+004	2.148e+004	5166	0.0000
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	0.0000	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

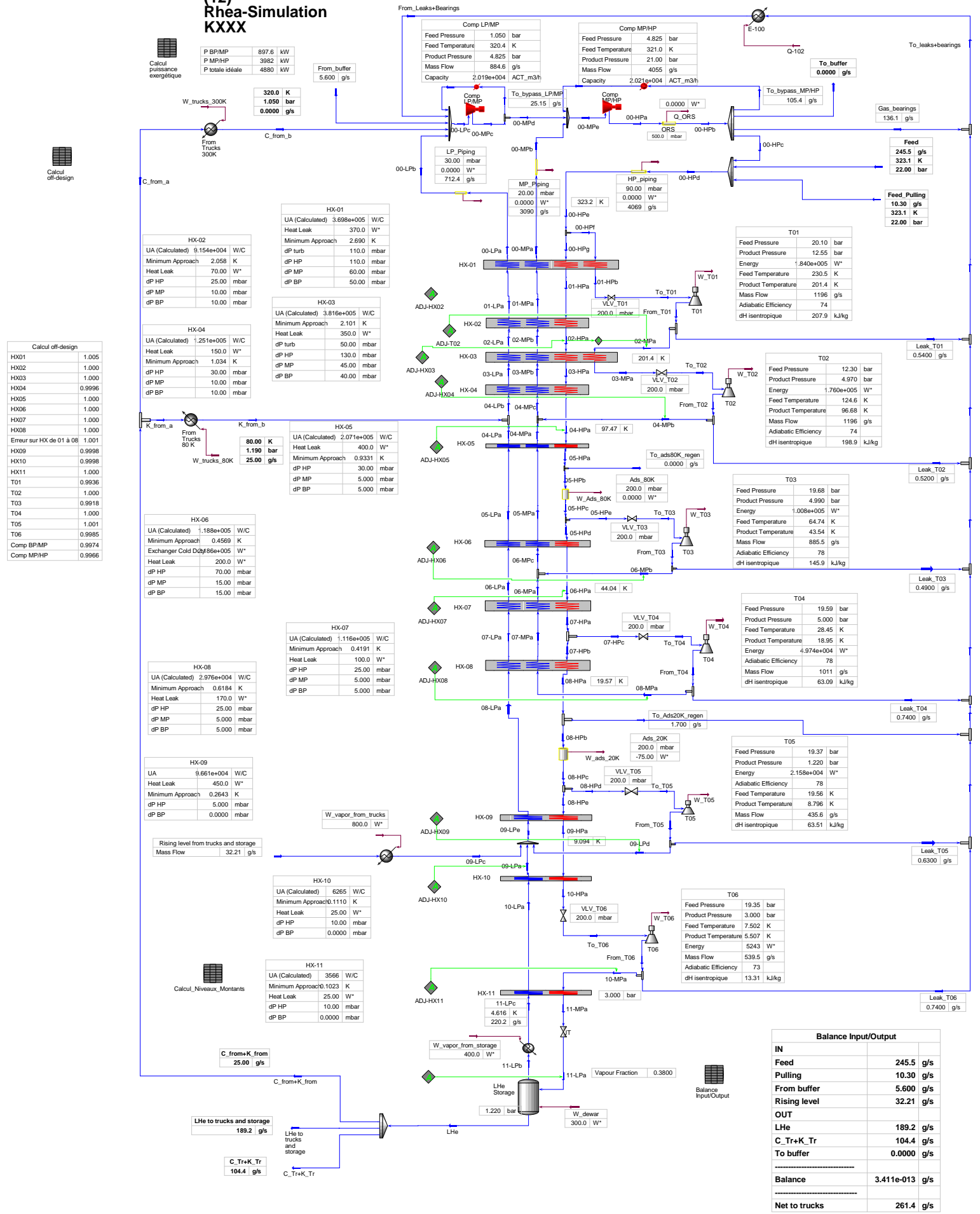
RHEA: Liquefier Process Calculations

9 ANNEX 4: KXXX CASE

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(12) Rhea-Simulation KXXX



Calcul puissance exigétique

P BP/MP	897.6	KW
P MP/HP	3982	KW
P totale idéale	4880	KW

Calcul off-design

HX01	1.005
HX02	1.000
HX03	1.000
HX04	0.9996
HX05	1.000
HX06	1.000
HX07	1.000
HX08	1.000
Erreur sur HX de 01 à 08	1.001
HX09	0.9998
HX10	0.9998
HX11	1.000
T01	0.9936
T02	1.000
T03	0.9918
T04	1.000
T05	1.001
T06	0.9985
Comp BP/MP	0.9974
Comp MP/HP	0.9966

Calcul off-design

HX01	1.005
HX02	1.000
HX03	1.000
HX04	0.9996
HX05	1.000
HX06	1.000
HX07	1.000
HX08	1.000
Erreur sur HX de 01 à 08	1.001
HX09	0.9998
HX10	0.9998
HX11	1.000
T01	0.9936
T02	1.000
T03	0.9918
T04	1.000
T05	1.001
T06	0.9985
Comp BP/MP	0.9974
Comp MP/HP	0.9966

Calcul Niveaux_Montants

HX-01	3.698e+005	W/C
Heat Leak	370.0	W*
Minimum Approach	2.690	K
dP turb	110.0	mbar
dP HP	110.0	mbar
dP MP	60.0	mbar
dP BP	50.0	mbar

Calcul Niveaux_Montants

HX-02	9.154e+004	W/C
Heat Leak	70.00	W*
Minimum Approach	1.034	K
dP HP	25.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

Calcul Niveaux_Montants

HX-03	3.816e+005	W/C
Heat Leak	350.0	W*
Minimum Approach	2.101	K
dP turb	50.00	mbar
dP HP	130.0	mbar
dP MP	45.00	mbar
dP BP	40.00	mbar

Calcul Niveaux_Montants

HX-04	1.251e+005	W/C
Heat Leak	150.0	W*
Minimum Approach	1.034	K
dP HP	30.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

Calcul Niveaux_Montants

HX-05	2.071e+005	W/C
Heat Leak	400.0	W*
Minimum Approach	0.9331	K
dP HP	30.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

Calcul Niveaux_Montants

HX-06	1.189e+005	W/C
Heat Leak	200.0	W*
Minimum Approach	0.4569	K
dP HP	70.00	mbar
dP MP	15.00	mbar
dP BP	15.00	mbar

Calcul Niveaux_Montants

HX-07	1.116e+005	W/C
Heat Leak	100.0	W*
Minimum Approach	0.4191	K
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

Calcul Niveaux_Montants

HX-08	2.976e+004	W/C
Heat Leak	170.0	W*
Minimum Approach	0.6184	K
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

Calcul Niveaux_Montants

HX-09	9.661e+004	W/C
Heat Leak	450.0	W*
Minimum Approach	0.2643	K
dP HP	5.000	mbar
dP MP	0.0000	mbar

Calcul Niveaux_Montants

HX-10	6265	W/C
Heat Leak	25.00	W*
Minimum Approach	0.1110	K
dP HP	10.00	mbar
dP BP	0.0000	mbar


Calcul Niveaux_Montants

HX-11	3566	W/C
Heat Leak	25.00	W*
Minimum Approach	0.1023	K
dP HP	10.00	mbar
dP BP	0.0000	mbar

Balance Input/Output	
IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	5.600 g/s
Rising level	32.21 g/s
OUT	
LHe	189.2 g/s
C. Tr+K. Tr	104.4 g/s
To buffer	0.0000 g/s

Balance	3.411e-013 g/s

Net to trucks	261.4 g/s

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:44:06 2010
4			
5			

Workbook: Case (Main)

		Streams					Fluid Pkg:	All
11	Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	323.1 *	323.2	323.2	323.2	323.2	323.2	
14	Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41	20.41	
15	Mass Flow (g/s)	4055	4055	3813	4069	4069	4069	
16	Mass Enthalpy (J/g)	1685	1685	1685	1685	1685	1685	
17	Heat Flow (W*)	6.831e+006	6.831e+006	6.424e+006	6.855e+006	6.855e+006	6.855e+006	
18	Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
20	Temperature (K)	323.2	323.2	320.5	320.5	320.4	320.4	
21	Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *	1.050 *	
22	Mass Flow (g/s)	1196	2873	712.4	712.4	884.6	884.6	
23	Mass Enthalpy (J/g)	1685	1685	1665	1665	1664	1664	
24	Heat Flow (W*)	2.015e+006	4.840e+006	1.186e+006	1.186e+006	1.472e+006	1.472e+006	
25	Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
27	Temperature (K)	320.5	320.5	323.1 *	323.1	321.0	321.0	
28	Pressure (bar)	4.845	4.825	4.825	4.825	4.825	4.825	
29	Mass Flow (g/s)	3090	3090	884.6	859.4	4055	4055	
30	Mass Enthalpy (J/g)	1666	1666	1680	1680	1669	1669	
31	Heat Flow (W*)	5.147e+006	5.147e+006	1.486e+006	1.443e+006	6.766e+006	6.766e+006	
32	Name	01-HPa	01-HPb	01-LPa	01-MPa	2		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
34	Temperature (K)	230.5	230.5	221.3	221.3	12.15	12.15	
35	Pressure (bar)	20.30	20.30	1.130	4.905	1.220	1.220	
36	Mass Flow (g/s)	2873	1196	712.4	3090	3.070	3.070	
37	Mass Enthalpy (J/g)	1203	1203	1149	1151	61.55	61.55	
38	Heat Flow (W*)	3.458e+006	1.439e+006	8.188e+005	3.556e+006	189.0	189.0	
39	Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
41	Temperature (K)	201.2 *	199.2	201.4	199.2	124.6	124.6	
42	Pressure (bar)	20.28	1.140	12.55 *	4.915	20.15	20.15	
43	Mass Flow (g/s)	2873	712.4	1196	3090	2873	2873	
44	Mass Enthalpy (J/g)	1051	1035	1050	1036	652.9	652.9	
45	Heat Flow (W*)	3.021e+006	7.370e+005	1.255e+006	3.201e+006	1.876e+006	1.876e+006	
46	Name	03-LPa	03-MPa	03-MPb	4	04-HPa		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
48	Temperature (K)	117.0	124.6	117.0	5.384	97.47 *	97.47 *	
49	Pressure (bar)	1.180	12.50	4.960	1.220	20.12	20.12	
50	Mass Flow (g/s)	712.4	1196	3090	1.370	2873	2873	
51	Mass Enthalpy (J/g)	607.9	650.6	609.1	22.93	511.7	511.7	
52	Heat Flow (W*)	4.331e+005	7.778e+005	1.882e+006	31.41	1.470e+006	1.470e+006	
53	Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc		
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	96.53	95.95	96.53	96.68 *	96.59	96.59	
56	Pressure (bar)	1.190	1.190	4.970	4.970	4.970	4.970	
57	Mass Flow (g/s)	687.4	712.4	1895	1195 *	3090	3090	
58	Mass Enthalpy (J/g)	501.6	498.6	502.6	503.4	502.9	502.9	
59	Heat Flow (W*)	3.448e+005	3.552e+005	9.525e+005	6.016e+005	1.554e+006	1.554e+006	
60	Name	5	05-HPa	05-HPb	05-HPc	05-HPd		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	13.38	64.73	64.73	64.74	64.74	64.74	
63	Pressure (bar)	1.220	20.09	20.09	19.89	19.89	19.89	
64	Mass Flow (g/s)	3.810	2873	2873	2873	1988	1988	
65	Mass Enthalpy (J/g)	68.14	340.2	340.2	340.2	340.2	340.2	
66	Heat Flow (W*)	259.6	9.773e+005	9.773e+005	9.773e+005	6.761e+005	6.761e+005	

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	05-HPe	05-LPa	05-MPa	6	06-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	64.74	59.82	59.82	16.77	44.04 *
Pressure (bar)	19.89	1.195	4.975	1.220	19.82
Mass Flow (g/s)	885.5	687.4	1895	4.300	1988
Mass Enthalpy (J/g)	340.2	310.8	311.5	86.17	230.2
Heat Flow (W*)	3.012e+005	2.137e+005	5.903e+005	370.5	4.575e+005
Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	43.62	43.62	43.54 *	43.58	28.46
Pressure (bar)	1.210	4.990	4.990	4.990	19.79
Mass Flow (g/s)	687.4	1010	885.0 *	1895	1988
Mass Enthalpy (J/g)	226.6	226.8	226.4	226.6	144.7
Heat Flow (W*)	1.558e+005	2.291e+005	2.003e+005	4.294e+005	2.876e+005
Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	28.46	28.46	24.58	24.58	19.57
Pressure (bar)	19.79	19.79	1.215	4.995	19.77
Mass Flow (g/s)	976.8	1011	687.4	1010	976.8
Mass Enthalpy (J/g)	144.7	144.7	127.2	126.1	92.67
Heat Flow (W*)	1.413e+005	1.462e+005	8.746e+004	1.273e+005	9.053e+004
Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	19.57	19.57	19.57	19.57	19.02
Pressure (bar)	19.77	19.57	19.57	19.57	1.220
Mass Flow (g/s)	975.1	975.1	435.6	539.5	687.4
Mass Enthalpy (J/g)	92.67	92.75	92.75	92.75	98.04
Heat Flow (W*)	9.037e+004	9.044e+004	4.040e+004	5.004e+004	6.739e+004
Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	18.95 *	9.094	8.983 *	8.250	8.796 *
Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220
Mass Flow (g/s)	1010 *	539.5	220.2	32.21	435.0 *
Mass Enthalpy (J/g)	95.46	23.98	44.26	40.15	43.21
Heat Flow (W*)	9.642e+004	1.294e+004	9743	1293	1.880e+004
Name	09-LPe	10-HPa	10-LPa	10-MPa	11
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	8.830	7.489	5.405	5.507 *	25.33
Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220
Mass Flow (g/s)	687.4	539.5	220.2	538.8	4.820
Mass Enthalpy (J/g)	43.40	15.38	23.07	5.662	131.2
Heat Flow (W*)	2.983e+004	8298	5080	3051	632.3
Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from
Vapour Fraction	0.3800 *	1.0000	1.0000	1.0000	0.0000
Temperature (K)	4.425	4.426	4.616	5.398	4.426
Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220
Mass Flow (g/s)	538.8 *	220.2	220.2	538.8	25.00 *
Mass Enthalpy (J/g)	3.279	15.31	17.13	3.279	-4.094
Heat Flow (W*)	1767	3371	3771	1767	-102.4
Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling
Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000
Temperature (K)	4.426	320.0 *	4.426	323.1 *	323.1 *
Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *
Mass Flow (g/s)	0.0000 *	0.0000	104.4 *	245.5 *	10.30 *
Mass Enthalpy (J/g)	-4.094	1662	-4.094	1685	1685
Heat Flow (W*)	0.0000	0.0000	-427.4	4.137e+005	1.736e+004



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:44:06 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	201.4
Pressure (bar)	1.050	1.050	4.825	1.050	12.55
Mass Flow (g/s)	5.600 *	25.15	105.4	141.5	1196
Mass Enthalpy (J/g)	1662	1662	1663	1662	1050
Heat Flow (W*)	9307	4.180e+004	1.753e+005	2.351e+005	1.255e+006
Name	From_T02	From_T03	From_T04	From_T05	From_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	96.68	43.54	18.95	8.796	5.507
Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *
Mass Flow (g/s)	1196	885.5	1011	435.6	539.5
Mass Enthalpy (J/g)	503.4	226.4	95.46	43.21	5.662
Heat Flow (W*)	6.018e+005	2.004e+005	9.649e+004	1.882e+004	3055
Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02
Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	4.426	80.00 *	201.4	96.68
Pressure (bar)	20.50	1.220	1.190	12.55	4.970
Mass Flow (g/s)	136.1 *	25.00	25.00	0.5400 *	0.5200 *
Mass Enthalpy (J/g)	1685	-4.094	415.7	1050	503.4
Heat Flow (W*)	2.293e+005	-102.4	1.039e+004	566.8	261.8
Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	43.54	18.95	8.796	5.507	43.07
Pressure (bar)	4.990	5.000	1.220	3.000	1.220
Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360
Mass Enthalpy (J/g)	226.4	95.46	43.21	5.662	223.7
Heat Flow (W*)	110.9	70.64	27.22	4.190	1199
Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP
Vapour Fraction	0.0000	0.0000	---	---	---
Temperature (K)	4.426	4.426	---	---	---
Pressure (bar)	1.220	1.220	---	---	---
Mass Flow (g/s)	318.6	189.2	---	---	---
Mass Enthalpy (J/g)	-4.094	-4.094	---	---	---
Heat Flow (W*)	-1304	-774.7	4611	0.0000 *	0.0000 *
Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen
Vapour Fraction	---	---	1.0000 *	1.0000	1.0000
Temperature (K)	---	---	4.425	19.57	64.73
Pressure (bar)	---	---	1.220	19.77	20.09
Mass Flow (g/s)	---	---	32.21	1.700 *	0.0000 *
Mass Enthalpy (J/g)	---	---	15.31	92.67	340.2
Heat Flow (W*)	0.0000 *	0.0000 *	493.1	157.5	0.0000
Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_Leaks+Bearings	To_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.1	323.2	313.7	230.5
Pressure (bar)	20.50	4.825	20.50	1.220	20.10
Mass Flow (g/s)	0.0000 *	25.15 *	105.4 *	141.5	1196
Mass Enthalpy (J/g)	1685	1680	1685	1629	1203
Heat Flow (W*)	0.0000	4.224e+004	1.775e+005	2.305e+005	1.439e+006
Name	To_T02	To_T03	To_T04	To_T05	To_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	124.6	64.74	28.45	19.56	7.502
Pressure (bar)	12.30	19.68	19.59	19.37	19.35
Mass Flow (g/s)	1196	885.5	1011	435.6	539.5
Mass Enthalpy (J/g)	650.6	340.2	144.7	92.75	15.38
Heat Flow (W*)	7.778e+005	3.012e+005	1.462e+005	4.040e+004	8298



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 10:44:06 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	1.840e+005	1.760e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	1.008e+005	4.974e+004	2.158e+004	5243	0.0000
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	1.049e+004	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

RHEA: Liquefier Process Calculations

10 ANNEX 5: CKXX CASE

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(12) Rhea-Simulation CKXX

Calcul puissance électrique

P BP/MP	924.3 kW
P MP/HP	4013 kW
P totale idéale	4938 kW

From Trucks 300K

320.0 K
1.050 bar
36.10 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
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From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

From Trucks 80K

80.00 K
1.190 bar
25.00 g/s

Calcul off-design

HX01	1.001
HX02	1.000
HX03	1.000
HX04	1.001
HX05	0.9997
HX06	1.000
HX07	0.9996
HX08	1.000
Erreur sur HX de 01 à 08	1.000
HX09	1.001
HX10	1.000
HX11	0.9992
T01	0.9989
T02	0.9997
T03	0.9986
T04	0.9988
T05	0.9978
T06	0.9994
Comp BP/MP	1.027
Comp MP/HP	1.024

Calcul Niveauux_Montants

HX01	1.001
HX02	1.000
HX03	1.000
HX04	1.001
HX05	0.9997
HX06	1.000
HX07	0.9996
HX08	1.000
Erreur sur HX de 01 à 08	1.000
HX09	1.001
HX10	1.000
HX11	0.9992
T01	0.9989
T02	0.9997
T03	0.9986
T04	0.9988
T05	0.9978
T06	0.9994
Comp BP/MP	1.027
Comp MP/HP	1.024

HX-01

UA (Calculated)	3.689e+005 W/C
Heat Leak	370.0 W*
Minimum Approach	2.680 K
dP turb	110.0 mbar
dP HP	110.0 mbar
dP MP	60.00 mbar
dP BP	50.00 mbar

HX-02

UA (Calculated)	9.162e+004 W/C
Heat Leak	2.034 K
Minimum Approach	2.034 K
dP turb	110.0 mbar
dP HP	25.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-03

UA (Calculated)	3.820e+005 W/C
Heat Leak	350.0 W*
Minimum Approach	50.00 mbar
dP turb	30.00 mbar
dP HP	130.0 mbar
dP MP	45.00 mbar
dP BP	40.00 mbar

HX-04

UA (Calculated)	1.254e+005 W/C
Heat Leak	150.0 W*
Minimum Approach	1.027 K
dP turb	30.00 mbar
dP HP	30.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-05

UA (Calculated)	2.071e+005 W/C
Heat Leak	400.0 W*
Minimum Approach	0.9289 K
dP turb	30.00 mbar
dP HP	5.000 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-06

UA (Calculated)	1.188e+005 W/C
Heat Leak	0.4448 K
Minimum Approach	0.4448 K
Exchanger Cold Duty	175e+005 W*
Heat Leak	200.0 W*
dP HP	70.00 mbar
dP MP	15.00 mbar
dP BP	15.00 mbar

HX-07

UA (Calculated)	1.111e+005 W/C
Heat Leak	100.0 W*
Minimum Approach	0.4106 K
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-08

UA (Calculated)	2.965e+004 W/C
Heat Leak	0.6326 K
Minimum Approach	0.6326 K
dP HP	170.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-09

UA (Calculated)	9.627e+004 W/C
Heat Leak	450.0 W*
Minimum Approach	0.2992 K
dP HP	5.000 mbar
dP MP	0.0000 mbar

HX-10

UA (Calculated)	6370 W/C
Heat Leak	25.00 W*
Minimum Approach	0.1181 K
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-11

UA (Calculated)	3621 W/C
Heat Leak	25.00 W*
Minimum Approach	0.1058 K
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-01

UA (Calculated)	3.689e+005 W/C
Heat Leak	370.0 W*
Minimum Approach	2.680 K
dP turb	110.0 mbar
dP HP	110.0 mbar
dP MP	60.00 mbar
dP BP	50.00 mbar

HX-02

UA (Calculated)	9.162e+004 W/C
Heat Leak	2.034 K
Minimum Approach	2.034 K
dP turb	110.0 mbar
dP HP	25.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-03

UA (Calculated)	3.820e+005 W/C
Heat Leak	350.0 W*
Minimum Approach	50.00 mbar
dP turb	30.00 mbar
dP HP	130.0 mbar
dP MP	45.00 mbar
dP BP	40.00 mbar

HX-04

UA (Calculated)	1.254e+005 W/C
Heat Leak	150.0 W*
Minimum Approach	1.027 K
dP turb	30.00 mbar
dP HP	30.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

HX-05

UA (Calculated)	2.071e+005 W/C
Heat Leak	400.0 W*
Minimum Approach	0.9289 K
dP turb	30.00 mbar
dP HP	5.000 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-06

UA (Calculated)	1.188e+005 W/C
Heat Leak	0.4448 K
Minimum Approach	0.4448 K
Exchanger Cold Duty	175e+005 W*
Heat Leak	200.0 W*
dP HP	70.00 mbar
dP MP	15.00 mbar
dP BP	15.00 mbar

HX-07

UA (Calculated)	1.111e+005 W/C
Heat Leak	100.0 W*
Minimum Approach	0.4106 K
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-08

UA (Calculated)	2.965e+004 W/C
Heat Leak	0.6326 K
Minimum Approach	0.6326 K
dP HP	170.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

HX-09

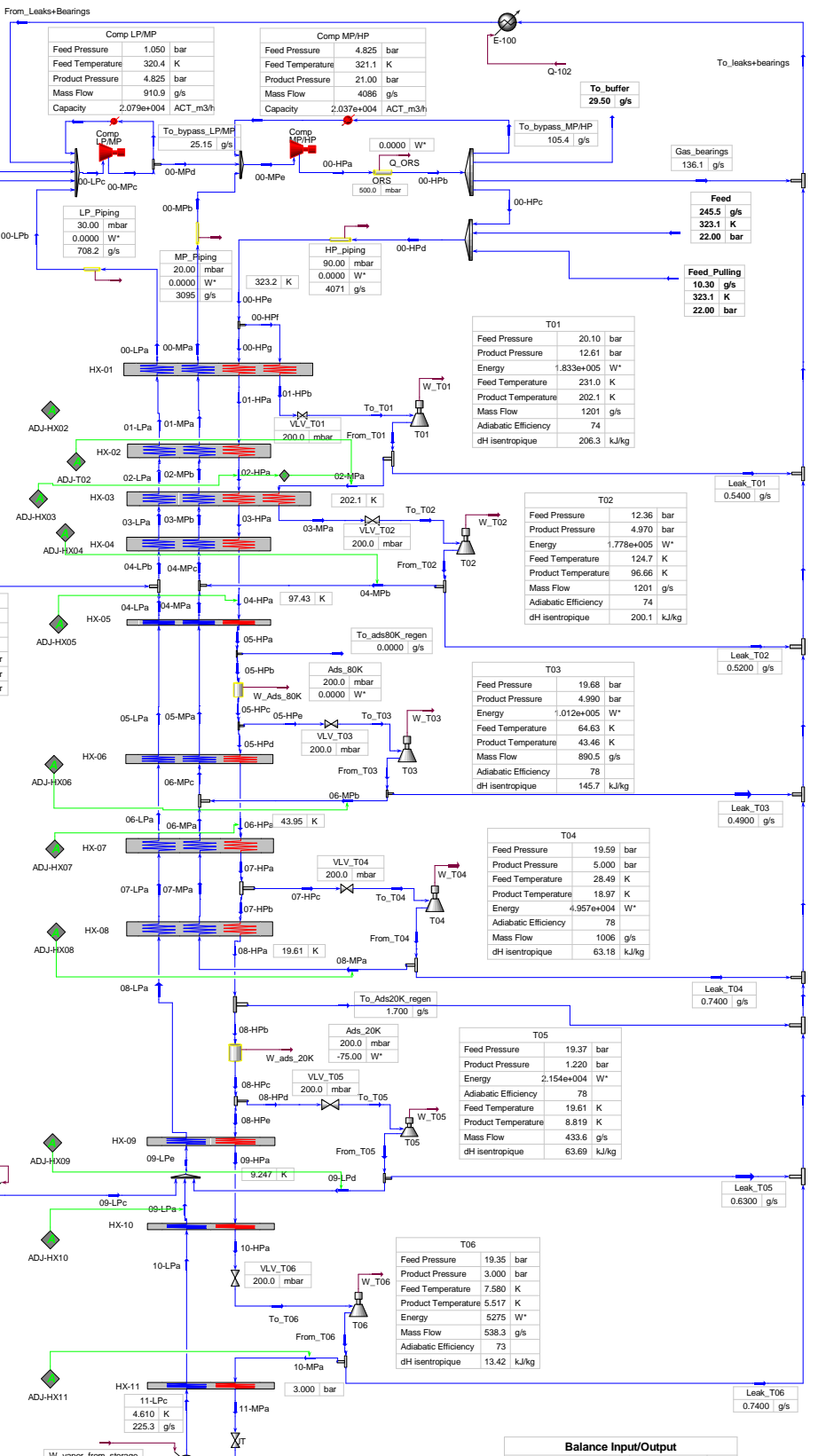
UA (Calculated)	9.627e+004 W/C
Heat Leak	450.0 W*
Minimum Approach	0.2992 K
dP HP	5.000 mbar
dP MP	0.0000 mbar

HX-10

UA (Calculated)	6370 W/C
Heat Leak	25.00 W*
Minimum Approach	0.1181 K
dP HP	10.00 mbar
dP BP	0.0000 mbar

HX-11

UA (Calculated)	3621 W/C
Heat Leak	25.00 W*
Minimum Approach	0.1058 K
dP HP	10.00 mbar
dP BP	0.0000 mbar



Balance Input/Output

IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	0.0000 g/s
Rising level	24.90 g/s
OUT	
LHe	146.2 g/s
C.Tr+K.Tr	105.0 g/s
To buffer	29.50 g/s
Balance	7.674e-013 g/s
Net to trucks	226.3 g/s



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA


Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:26:34 2010

Workbook: Case (Main)

Streams


Fluid Pkg: All

Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.1 *	323.2	323.2	323.2	323.2
Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41
Mass Flow (g/s)	4086	4086	3815	4071	4071
Mass Enthalpy (J/g)	1685	1685	1685	1685	1685
Heat Flow (W*)	6.884e+006	6.884e+006	6.428e+006	6.859e+006	6.859e+006
Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.2	320.5	320.5	320.4
Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *
Mass Flow (g/s)	1201	2870	708.2	708.2	910.9
Mass Enthalpy (J/g)	1685	1685	1665	1665	1664
Heat Flow (W*)	2.023e+006	4.835e+006	1.179e+006	1.179e+006	1.516e+006
Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.5	320.5	323.1 *	323.1	321.1
Pressure (bar)	4.845	4.825	4.825	4.825	4.825
Mass Flow (g/s)	3095	3095	910.9	885.8	4086
Mass Enthalpy (J/g)	1666	1666	1680	1680	1669
Heat Flow (W*)	5.156e+006	5.156e+006	1.530e+006	1.488e+006	6.819e+006
Name	01-HPa	01-HPb	01-LPa	01-MPa	2
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	231.0	231.0	221.8	221.8	12.20
Pressure (bar)	20.30	20.30	1.130	4.905	1.220
Mass Flow (g/s)	2870	1201	708.2	3095	3.070
Mass Enthalpy (J/g)	1206	1206	1152	1154	61.80
Heat Flow (W*)	3.462e+006	1.449e+006	8.161e+005	3.570e+006	189.7
Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	201.9 *	199.8	202.1	199.8	124.7
Pressure (bar)	20.28	1.140	12.61 *	4.915	20.15
Mass Flow (g/s)	2870	708.2	1201	3095	2870
Mass Enthalpy (J/g)	1055	1038	1054	1039	653.7
Heat Flow (W*)	3.027e+006	7.351e+005	1.265e+006	3.217e+006	1.876e+006
Name	03-LPa	03-MPa	03-MPb	4	04-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	117.1	124.7	117.1	5.416	97.43 *
Pressure (bar)	1.180	12.56	4.960	1.220	20.12
Mass Flow (g/s)	708.2	1201	3095	1.370	2870
Mass Enthalpy (J/g)	608.3	651.4	609.5	23.15	511.5
Heat Flow (W*)	4.308e+005	7.820e+005	1.886e+006	31.71	1.468e+006
Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	96.50	95.92	96.50	96.66 *	96.56
Pressure (bar)	1.190	1.190	4.970	4.970	4.970
Mass Flow (g/s)	683.2	708.2	1895	1200 *	3095
Mass Enthalpy (J/g)	501.4	498.4	502.5	503.3	502.8
Heat Flow (W*)	3.426e+005	3.530e+005	9.522e+005	6.039e+005	1.556e+006
Name	5	05-HPa	05-HPb	05-HPc	05-HPd
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	13.42	64.62	64.62	64.63	64.63
Pressure (bar)	1.220	20.09	20.09	19.89	19.89
Mass Flow (g/s)	3.810	2870	2870	2870	1979
Mass Enthalpy (J/g)	68.36	339.6	339.6	339.6	339.6
Heat Flow (W*)	260.5	9.746e+005	9.746e+005	9.746e+005	6.722e+005

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:26:34 2010
4			
5			

Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	64.63	59.69	59.69	16.80	43.95 *		
14	Pressure (bar)	19.89	1.195	4.975	1.220	19.82		
15	Mass Flow (g/s)	890.5	683.2	1895	4.300	1979		
16	Mass Enthalpy (J/g)	339.6	310.1	310.8	86.32	229.7		
17	Heat Flow (W*)	3.024e+005	2.119e+005	5.890e+005	371.2	4.547e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	43.54	43.54	43.46 *	43.50	28.50		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	683.2	1005	890.0 *	1895	1979		
23	Mass Enthalpy (J/g)	226.2	226.4	226.0	226.2	144.9		
24	Heat Flow (W*)	1.545e+005	2.275e+005	2.011e+005	4.286e+005	2.868e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.50	28.50	24.63	24.63	19.61		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	973.7	1006	683.2	1005	973.7		
30	Mass Enthalpy (J/g)	144.9	144.9	127.5	126.3	92.94		
31	Heat Flow (W*)	1.411e+005	1.457e+005	8.711e+004	1.270e+005	9.050e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.61	19.62	19.62	19.62	19.09		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	972.0	972.0	433.6	538.3	683.2		
37	Mass Enthalpy (J/g)	92.94	93.02	93.02	93.02	98.40		
38	Heat Flow (W*)	9.034e+004	9.041e+004	4.034e+004	5.008e+004	6.723e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	18.97 *	9.247	9.129 *	9.559	8.819 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1005 *	538.3	225.3	24.90	433.0 *		
44	Mass Enthalpy (J/g)	95.61	24.89	45.06	47.44	43.34		
45	Heat Flow (W*)	9.609e+004	1.340e+004	1.015e+004	1181	1.877e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	8.948	7.568	5.412	5.517 *	25.36		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	683.2	538.3	225.3	537.6	4.820		
51	Mass Enthalpy (J/g)	44.06	15.76	23.12	5.958	131.3		
52	Heat Flow (W*)	3.010e+004	8482	5209	3203	632.9		
53	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
54	Vapour Fraction	0.3900 *	1.0000	1.0000	1.0000	0.0000		
55	Temperature (K)	4.425	4.424	4.610	5.409	4.424		
56	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220		
57	Mass Flow (g/s)	537.6 *	225.3	225.3	537.6	61.10 *		
58	Mass Enthalpy (J/g)	3.472	15.30	17.08	3.472	-4.101		
59	Heat Flow (W*)	1866	3447	3847	1866	-250.6		
60	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
61	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000		
62	Temperature (K)	4.424	320.0 *	4.424	323.1 *	323.1 *		
63	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *		
64	Mass Flow (g/s)	36.10 *	36.10	105.0 *	245.5 *	10.30 *		
65	Mass Enthalpy (J/g)	-4.101	1662	-4.101	1685	1685		
66	Heat Flow (W*)	-148.1	6.000e+004	-430.6	4.137e+005	1.736e+004		

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:26:34 2010
4			
5			

Workbook: Case (Main) (continued)

Streams (continued)						Fluid Pkg:	All
11	Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01	
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	202.1	202.1
14	Pressure (bar)	1.050	1.050	4.825	1.050	12.61	12.61
15	Mass Flow (g/s)	0.0000 *	25.15	105.4	141.5	1201	1201
16	Mass Enthalpy (J/g)	1662	1662	1663	1662	1054	1054
17	Heat Flow (W*)	0.0000	4.180e+004	1.753e+005	2.351e+005	1.265e+006	1.265e+006
18	Name	From_T02	From_T03	From_T04	From_T05	From_T06	
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	Temperature (K)	96.66	43.46	18.97	8.819	5.517	5.517
21	Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *	3.000 *
22	Mass Flow (g/s)	1201	890.5	1006	433.6	538.3	538.3
23	Mass Enthalpy (J/g)	503.3	226.0	95.61	43.34	5.958	5.958
24	Heat Flow (W*)	6.042e+005	2.012e+005	9.616e+004	1.879e+004	3207	3207
25	Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02	
26	Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
27	Temperature (K)	323.2	4.424	80.00 *	202.1	96.66	96.66
28	Pressure (bar)	20.50	1.220	1.190	12.61	4.970	4.970
29	Mass Flow (g/s)	136.1 *	25.00	25.00	0.5400 *	0.5200 *	0.5200 *
30	Mass Enthalpy (J/g)	1685	-4.101	415.7	1054	503.3	503.3
31	Heat Flow (W*)	2.293e+005	-102.5	1.039e+004	568.9	261.7	261.7
32	Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks	
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
34	Temperature (K)	43.46	18.97	8.819	5.517	43.17	43.17
35	Pressure (bar)	4.990	5.000	1.220	3.000	1.220	1.220
36	Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360	5.360
37	Mass Enthalpy (J/g)	226.0	95.61	43.34	5.958	224.2	224.2
38	Heat Flow (W*)	110.7	70.75	27.30	4.409	1202	1202
39	Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP	
40	Vapour Fraction	0.0000	0.0000	---	---	---	---
41	Temperature (K)	4.424	4.424	---	---	---	---
42	Pressure (bar)	1.220	1.220	---	---	---	---
43	Mass Flow (g/s)	312.3	146.2	---	---	---	---
44	Mass Enthalpy (J/g)	-4.101	-4.101	---	---	---	---
45	Heat Flow (W*)	-1281	-599.6	4608	0.0000 *	0.0000 *	0.0000 *
46	Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen	
47	Vapour Fraction	---	---	1.0000 *	1.0000	1.0000	1.0000
48	Temperature (K)	---	---	4.425	19.61	64.62	64.62
49	Pressure (bar)	---	---	1.220	19.77	20.09	20.09
50	Mass Flow (g/s)	---	---	24.90	1.700 *	0.0000 *	0.0000 *
51	Mass Enthalpy (J/g)	---	---	15.31	92.94	339.6	339.6
52	Heat Flow (W*)	0.0000 *	0.0000 *	381.2	158.0	0.0000	0.0000
53	Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_Leaks+Bearings	To_T01	
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
55	Temperature (K)	323.2	323.1	323.2	313.7	231.0	231.0
56	Pressure (bar)	20.50	4.825	20.50	1.220	20.10	20.10
57	Mass Flow (g/s)	29.50 *	25.15 *	105.4 *	141.5	1201	1201
58	Mass Enthalpy (J/g)	1685	1680	1685	1629	1206	1206
59	Heat Flow (W*)	4.970e+004	4.224e+004	1.775e+005	2.305e+005	1.449e+006	1.449e+006
60	Name	To_T02	To_T03	To_T04	To_T05	To_T06	
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
62	Temperature (K)	124.7	64.63	28.49	19.61	7.580	7.580
63	Pressure (bar)	12.36	19.68	19.59	19.37	19.35	19.35
64	Mass Flow (g/s)	1201	890.5	1006	433.6	538.3	538.3
65	Mass Enthalpy (J/g)	651.4	339.6	144.9	93.02	15.76	15.76
66	Heat Flow (W*)	7.820e+005	3.024e+005	1.457e+005	4.034e+004	8482	8482



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 10:26:34 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	1.833e+005	1.778e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	1.012e+005	4.957e+004	2.154e+004	5275	6.014e+004
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	1.050e+004	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

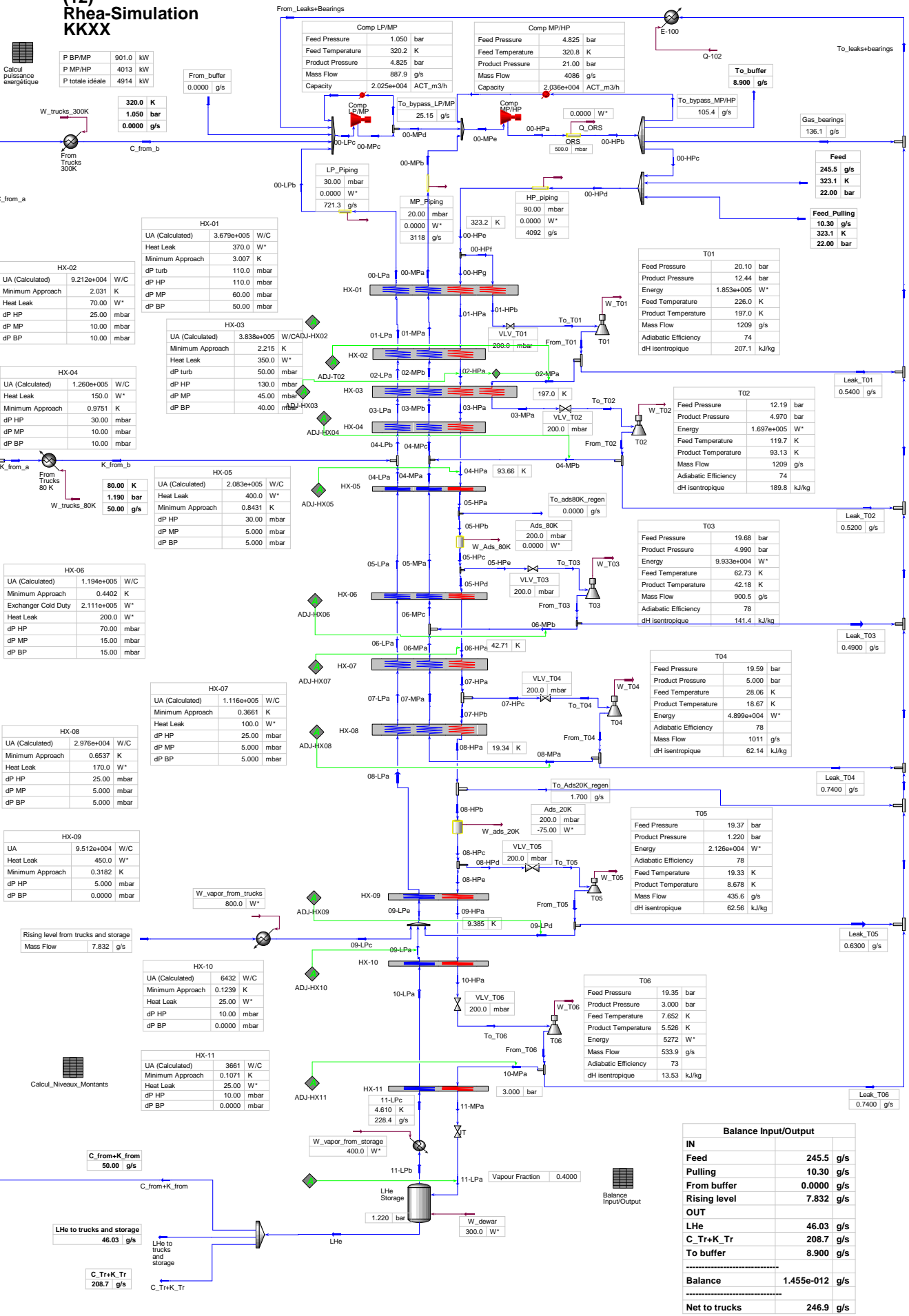
RHEA: Liquefier Process Calculations

11 ANNEX 6: KKXX CASE

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(12) Rhea-Simulation KKXX



Calcul puissance energetique

P BP/MP	901.0 kW
P MP/HP	4013 kW
P totale ideale	4914 kW

Calcul off-design

HX01	0.9934
HX02	1.000
HX03	1.000
HX04	1.001
HX05	1.000
HX06	0.9999
HX07	1.000
HX08	1.000
Erreur sur HX de 01 à 080.9984	
HX09	1.001
HX10	1.000
HX11	1.000
T01	0.9948
T02	0.9999
T03	0.9932
T04	0.9928
T05	0.9944
T06	0.9939
Comp BP/MP	1.000
Comp MP/HP	1.003

Calcul off-design

HX	UA (Calculated)	Minimum Approach	Heat Leak	dP HP	dP MP	dP BP
HX-01	3.679e+005 W/C	370.0 K	3.007 K	110.0 mbar	110.0 mbar	60.0 mbar
HX-02	9.212e+004 W/C	2.031 K	70.00 W*	25.00 mbar	10.00 mbar	10.00 mbar
HX-03	3.838e+005 W/CADJ-HX02	2.215 K	350.0 W*	50.00 mbar	45.00 mbar	40.00 mbar
HX-04	1.260e+005 W/C	150.0 K	70.00 W*	30.00 mbar	10.00 mbar	10.00 mbar
HX-05	2.083e+005 W/C	400.0 K	0.8431 K	30.00 mbar	5.000 mbar	5.000 mbar
HX-06	1.194e+005 W/C	4.402 K	2.111e+005 W*	70.00 mbar	15.00 mbar	15.00 mbar
HX-07	1.116e+005 W/C	0.3661 K	100.0 W*	25.00 mbar	5.000 mbar	5.000 mbar
HX-08	2.976e+004 W/C	0.6537 K	170.0 W*	25.00 mbar	5.000 mbar	5.000 mbar
HX-09	9.512e+004 W/C	450.0 K	0.3182 K	5.000 mbar	0.0000 mbar	
HX-10	6432 W/C	0.1239 K	25.00 W*	10.00 mbar	0.0000 mbar	
HX-11	3661 W/C	0.1071 K	25.00 W*	10.00 mbar	0.0000 mbar	

Calcul Niveaux_Montants

UA (Calculated)	9.212e+004 W/C
Minimum Approach	2.031 K
Heat Leak	70.00 W*
dP HP	25.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

Calcul Niveaux_Montants

UA (Calculated)	1.194e+005 W/C
Minimum Approach	4.402 K
Exchanger Cold Duty	2.111e+005 W*
Heat Leak	200.0 W*
dP HP	70.00 mbar
dP MP	15.00 mbar
dP BP	15.00 mbar

Calcul Niveaux_Montants

UA (Calculated)	1.116e+005 W/C
Minimum Approach	0.3661 K
Heat Leak	100.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

Calcul Niveaux_Montants

UA (Calculated)	2.976e+004 W/C
Minimum Approach	0.6537 K
Heat Leak	170.0 W*
dP HP	25.00 mbar
dP MP	5.000 mbar
dP BP	5.000 mbar

Calcul Niveaux_Montants

UA (Calculated)	9.512e+004 W/C
Minimum Approach	450.0 K
Heat Leak	0.3182 K
dP HP	5.000 mbar
dP MP	0.0000 mbar
dP BP	

Calcul Niveaux_Montants

UA (Calculated)	6432 W/C
Minimum Approach	0.1239 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

Calcul Niveaux_Montants

UA (Calculated)	3661 W/C
Minimum Approach	0.1071 K
Heat Leak	25.00 W*
dP HP	10.00 mbar
dP BP	0.0000 mbar

Calcul Niveaux_Montants

UA (Calculated)	9.212e+004 W/C
Minimum Approach	2.031 K
Heat Leak	70.00 W*
dP HP	25.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar

Calcul Niveaux_Montants

UA (Calculated)	1.260e+005 W/C
Minimum Approach	150.0 K
Heat Leak	70.00 W*
dP HP	30.00 mbar
dP MP	10.00 mbar
dP BP	10.00 mbar



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA


Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 09:44:58 2010

Workbook: Case (Main)

Streams

Fluid Pkg: All

Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.1 *	323.2	323.2	323.2	323.2
Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41
Mass Flow (g/s)	4086	4086	3836	4092	4092
Mass Enthalpy (J/g)	1685	1685	1685	1685	1685
Heat Flow (W*)	6.884e+006	6.884e+006	6.462e+006	6.893e+006	6.893e+006
Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.2	320.2	320.2	320.2
Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *
Mass Flow (g/s)	1209	2882	721.3	721.3	887.9
Mass Enthalpy (J/g)	1685	1685	1663	1663	1663
Heat Flow (W*)	2.037e+006	4.856e+006	1.199e+006	1.199e+006	1.476e+006
Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.2	320.2	323.1 *	323.1	320.8
Pressure (bar)	4.845	4.825	4.825	4.825	4.825
Mass Flow (g/s)	3118	3118	887.9	862.7	4086
Mass Enthalpy (J/g)	1664	1664	1680	1680	1667
Heat Flow (W*)	5.189e+006	5.189e+006	1.491e+006	1.449e+006	6.813e+006
Name	01-HPa	01-HPb	01-LPa	01-MPa	2
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	226.0	226.0	216.6	216.6	12.01
Pressure (bar)	20.30	20.30	1.130	4.905	1.220
Mass Flow (g/s)	2882	1209	721.3	3118	3.070
Mass Enthalpy (J/g)	1180	1180	1125	1126	60.78
Heat Flow (W*)	3.402e+006	1.427e+006	8.116e+005	3.512e+006	186.6
Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	196.4 *	194.4	197.0	194.4	119.7
Pressure (bar)	20.28	1.140	12.44 *	4.915	20.15
Mass Flow (g/s)	2882	721.3	1209	3118	2882
Mass Enthalpy (J/g)	1027	1010	1027	1011	627.7
Heat Flow (W*)	2.959e+006	7.283e+005	1.241e+006	3.152e+006	1.809e+006
Name	03-LPa	03-MPa	03-MPb	4	04-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	112.4	119.7	112.4	5.384	93.66 *
Pressure (bar)	1.180	12.39	4.960	1.220	20.12
Mass Flow (g/s)	721.3	1209	3118	1.370	2882
Mass Enthalpy (J/g)	583.9	625.4	585.0	22.93	491.9
Heat Flow (W*)	4.211e+005	7.558e+005	1.824e+006	31.42	1.418e+006
Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	92.82	91.93	92.82	93.13 *	92.94
Pressure (bar)	1.190	1.190	4.970	4.970	4.970
Mass Flow (g/s)	671.3	721.3	1910	1208 *	3118
Mass Enthalpy (J/g)	482.3	477.7	483.3	484.9	484.0
Heat Flow (W*)	3.238e+005	3.445e+005	9.232e+005	5.858e+005	1.509e+006
Name	5	05-HPa	05-HPb	05-HPc	05-HPd
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	13.21	62.71	62.71	62.72	62.72
Pressure (bar)	1.220	20.09	20.09	19.89	19.89
Mass Flow (g/s)	3.810	2882	2882	2882	1982
Mass Enthalpy (J/g)	67.22	329.5	329.5	329.5	329.5
Heat Flow (W*)	256.1	9.499e+005	9.499e+005	9.499e+005	6.531e+005

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 09:44:58 2010
4			
5			

Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	62.72	57.96	57.96	16.47	42.71 *		
14	Pressure (bar)	19.89	1.195	4.975	1.220	19.82		
15	Mass Flow (g/s)	900.5	671.3	1910	4.300	1982		
16	Mass Enthalpy (J/g)	329.5	301.1	301.8	84.54	223.0		
17	Heat Flow (W*)	2.967e+005	2.021e+005	5.764e+005	363.5	4.420e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	42.34	42.34	42.18 *	42.26	28.06		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	671.3	1010	900.0 *	1910	1982		
23	Mass Enthalpy (J/g)	219.9	220.1	219.2	219.7	142.4		
24	Heat Flow (W*)	1.476e+005	2.223e+005	1.973e+005	4.196e+005	2.823e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.06	28.06	24.29	24.29	19.34		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	971.2	1011	671.3	1010	971.2		
30	Mass Enthalpy (J/g)	142.4	142.4	125.7	124.5	91.27		
31	Heat Flow (W*)	1.383e+005	1.440e+005	8.438e+004	1.257e+005	8.865e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.34	19.34	19.34	19.34	18.90		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	969.5	969.5	435.6	533.9	671.3		
37	Mass Enthalpy (J/g)	91.27	91.35	91.35	91.35	97.39		
38	Heat Flow (W*)	8.849e+004	8.856e+004	3.979e+004	4.877e+004	6.537e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	18.67 *	9.385	9.262 *	22.71	8.678 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1010 *	533.9	228.4	7.832	435.0 *		
44	Mass Enthalpy (J/g)	93.96	25.74	45.80	117.5	42.55		
45	Heat Flow (W*)	9.490e+004	1.374e+004	1.046e+004	919.9	1.851e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	9.033	7.640	5.419	5.526 *	24.68		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	671.3	533.9	228.4	533.2	4.820		
51	Mass Enthalpy (J/g)	44.53	16.10	23.17	6.230	127.7		
52	Heat Flow (W*)	2.989e+004	8598	5292	3321	615.7		
53	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
54	Vapour Fraction	0.4000 *	1.0000	1.0000	1.0000	0.0000		
55	Temperature (K)	4.425	4.427	4.610	5.420	4.427		
56	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220		
57	Mass Flow (g/s)	533.2 *	228.4	228.4	533.2	50.00 *		
58	Mass Enthalpy (J/g)	3.665	15.32	17.07	3.665	-4.088		
59	Heat Flow (W*)	1954	3500	3900	1954	-204.4		
60	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
61	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000		
62	Temperature (K)	4.427	320.0 *	4.427	323.1 *	323.1 *		
63	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *		
64	Mass Flow (g/s)	0.0000 *	0.0000	208.7 *	245.5 *	10.30 *		
65	Mass Enthalpy (J/g)	-4.088	1662	-4.088	1685	1685		
66	Heat Flow (W*)	0.0000	0.0000	-853.2	4.137e+005	1.736e+004		



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 09:44:58 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	197.0
Pressure (bar)	1.050	1.050	4.825	1.050	12.44
Mass Flow (g/s)	0.0000 *	25.15	105.4	141.5	1209
Mass Enthalpy (J/g)	1662	1662	1663	1662	1027
Heat Flow (W*)	0.0000	4.180e+004	1.753e+005	2.351e+005	1.242e+006
Name	From_T02	From_T03	From_T04	From_T05	From_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	93.13	42.18	18.67	8.678	5.526
Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *
Mass Flow (g/s)	1209	900.5	1011	435.6	533.9
Mass Enthalpy (J/g)	484.9	219.2	93.96	42.55	6.230
Heat Flow (W*)	5.861e+005	1.974e+005	9.497e+004	1.854e+004	3326
Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02
Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	4.427	80.00 *	197.0	93.13
Pressure (bar)	20.50	1.220	1.190	12.44	4.970
Mass Flow (g/s)	136.1 *	50.00	50.00	0.5400 *	0.5200 *
Mass Enthalpy (J/g)	1685	-4.088	415.7	1027	484.9
Heat Flow (W*)	2.293e+005	-204.4	2.079e+004	554.6	252.2
Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	42.18	18.67	8.678	5.526	42.04
Pressure (bar)	4.990	5.000	1.220	3.000	1.220
Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360
Mass Enthalpy (J/g)	219.2	93.96	42.55	6.230	218.3
Heat Flow (W*)	107.4	69.53	26.81	4.610	1170
Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP
Vapour Fraction	0.0000	0.0000	---	---	---
Temperature (K)	4.427	4.427	---	---	---
Pressure (bar)	1.220	1.220	---	---	---
Mass Flow (g/s)	304.7	46.03	---	---	---
Mass Enthalpy (J/g)	-4.088	-4.088	---	---	---
Heat Flow (W*)	-1246	-188.2	4639	0.0000 *	0.0000 *
Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen
Vapour Fraction	---	---	1.0000 *	1.0000	1.0000
Temperature (K)	---	---	4.425	19.34	62.71
Pressure (bar)	---	---	1.220	19.77	20.09
Mass Flow (g/s)	---	---	7.832	1.700 *	0.0000 *
Mass Enthalpy (J/g)	---	---	15.31	91.27	329.5
Heat Flow (W*)	0.0000 *	0.0000 *	119.9	155.2	0.0000
Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_leaks+bearings	To_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.1	323.2	313.7	226.0
Pressure (bar)	20.50	4.825	20.50	1.220	20.10
Mass Flow (g/s)	8.900 *	25.15 *	105.4 *	141.5	1209
Mass Enthalpy (J/g)	1685	1680	1685	1629	1180
Heat Flow (W*)	1.499e+004	4.224e+004	1.775e+005	2.305e+005	1.427e+006
Name	To_T02	To_T03	To_T04	To_T05	To_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	119.7	62.73	28.06	19.33	7.652
Pressure (bar)	12.19	19.68	19.59	19.37	19.35
Mass Flow (g/s)	1209	900.5	1011	435.6	533.9
Mass Enthalpy (J/g)	625.4	329.5	142.4	91.35	16.10
Heat Flow (W*)	7.558e+005	2.967e+005	1.440e+005	3.979e+004	8598



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 09:44:58 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	300.0 *	1.853e+005	1.697e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	9.933e+004	4.899e+004	2.126e+004	5272	0.0000
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	2.099e+004	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

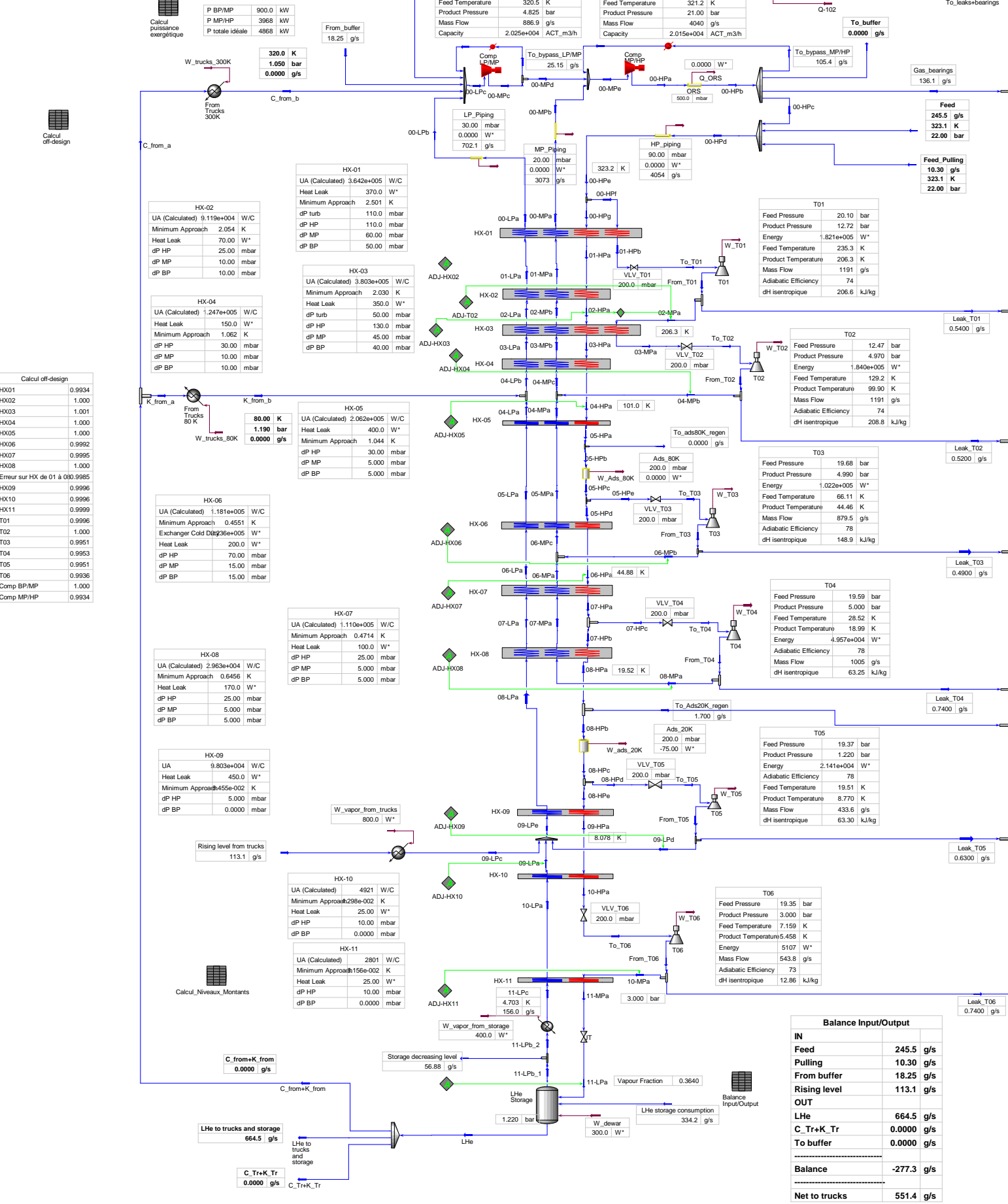
RHEA: Liquefier Process Calculations

12 ANNEX 7: LLLX CASE

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(12) Rhea-Simulation LLLX



Calcul puissance exergétique

P BP/MP	900.0	KW
P MP/HP	3968	KW
P totale idéale	4868	KW

Calcul off-design

HX01	0.9934
HX02	1.000
HX03	1.001
HX04	1.000
HX05	1.000
HX06	0.9992
HX07	0.9995
HX08	1.000
Erreur sur HX de 01 à 08	0.9985
HX09	0.9996
HX10	0.9996
HX11	0.9999
T01	0.9996
T02	1.000
T03	0.9951
T04	0.9953
T05	0.9951
T06	0.9936
Comp BP/MP	1.000
Comp MP/HP	0.9934

Calcul off-design

HX01	0.9934
HX02	1.000
HX03	1.001
HX04	1.000
HX05	1.000
HX06	0.9992
HX07	0.9995
HX08	1.000
Erreur sur HX de 01 à 08	0.9985
HX09	0.9996
HX10	0.9996
HX11	0.9999
T01	0.9996
T02	1.000
T03	0.9951
T04	0.9953
T05	0.9951
T06	0.9936
Comp BP/MP	1.000
Comp MP/HP	0.9934

Calcul Niveaux Montants

UA (Calculated)	9.119e+004	W/C
Minimum Approach	2.054	K
Heat Leak	70.00	W*
dP HP	25.00	mbar
dP MP	10.00	mbar
dP BP	10.00	mbar

Calcul Niveaux Montants

UA (Calculated)	2.062e+005	W/C
Minimum Approach	1.044	K
Heat Leak	400.0	W*
dP HP	30.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

Calcul Niveaux Montants

UA (Calculated)	1.110e+005	W/C
Minimum Approach	0.4714	K
Heat Leak	100.0	W*
dP HP	25.00	mbar
dP MP	5.000	mbar
dP BP	5.000	mbar

Balance Input/Output	
IN	
Feed	245.5 g/s
Pulling	10.30 g/s
From buffer	18.25 g/s
Rising level	113.1 g/s
OUT	
LHe	664.5 g/s
C. Tr+K. Tr	0.0000 g/s
To buffer	0.0000 g/s
Balance	-277.3 g/s
Net to trucks	551.4 g/s



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA


Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 09:48:17 2010

Workbook: Case (Main)

Streams


Fluid Pkg: All

Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.1 *	323.2	323.2	323.2	323.2
Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41
Mass Flow (g/s)	4040	4040	3799	4054	4054
Mass Enthalpy (J/g)	1685	1685	1685	1685	1685
Heat Flow (W*)	6.807e+006	6.807e+006	6.400e+006	6.831e+006	6.831e+006
Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	323.2	320.7	320.7	320.5
Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *
Mass Flow (g/s)	1191	2863	702.1	702.1	886.9
Mass Enthalpy (J/g)	1685	1685	1666	1666	1665
Heat Flow (W*)	2.007e+006	4.824e+006	1.169e+006	1.169e+006	1.477e+006
Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.7	320.7	323.1 *	323.1	321.2
Pressure (bar)	4.845	4.825	4.825	4.825	4.825
Mass Flow (g/s)	3073	3073	886.9	861.8	4040
Mass Enthalpy (J/g)	1667	1667	1680	1680	1669
Heat Flow (W*)	5.122e+006	5.122e+006	1.490e+006	1.447e+006	6.745e+006
Name	01-HPa	01-HPb	01-LPa	01-MPa	2
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	235.3	235.3	226.3	226.3	12.06
Pressure (bar)	20.30	20.30	1.130	4.905	1.220
Mass Flow (g/s)	2863	1191	702.1	3073	3.070
Mass Enthalpy (J/g)	1228	1228	1175	1176	61.05
Heat Flow (W*)	3.517e+006	1.463e+006	8.251e+005	3.615e+006	187.4
Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	206.4 *	204.4	206.3	204.4	129.2
Pressure (bar)	20.28	1.140	12.72 *	4.915	20.15
Mass Flow (g/s)	2863	702.1	1191	3073	2863
Mass Enthalpy (J/g)	1078	1061	1075	1063	677.0
Heat Flow (W*)	3.088e+006	7.452e+005	1.280e+006	3.266e+006	1.938e+006
Name	03-LPa	03-MPa	03-MPb	4	04-HPa
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	121.4	129.2	121.4	5.275	101.0 *
Pressure (bar)	1.180	12.67	4.960	1.220	20.12
Mass Flow (g/s)	702.1	1191	3073	1.370	2863
Mass Enthalpy (J/g)	630.6	674.7	631.7	22.18	530.1
Heat Flow (W*)	4.427e+005	8.032e+005	1.941e+006	30.39	1.518e+006
Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	99.95	99.95	99.95	99.90 *	99.93
Pressure (bar)	1.190	1.190	4.970	4.970	4.970
Mass Flow (g/s)	702.1	702.1	1883	1190 *	3073
Mass Enthalpy (J/g)	519.3	519.3	520.4	520.1	520.3
Heat Flow (W*)	3.646e+005	3.646e+005	9.799e+005	6.190e+005	1.599e+006
Name	5	05-HPa	05-HPb	05-HPc	05-HPd
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	13.31	66.09	66.09	66.10	66.10
Pressure (bar)	1.220	20.09	20.09	19.89	19.89
Mass Flow (g/s)	3.810	2863	2863	2863	1984
Mass Enthalpy (J/g)	67.78	347.4	347.4	347.4	347.4
Heat Flow (W*)	258.2	9.947e+005	9.947e+005	9.947e+005	6.892e+005

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 09:48:17 2010
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Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	66.10	61.01	61.01	61.01	16.82	44.88 *	
14	Pressure (bar)	19.89	1.195	4.975	1.220	19.82		
15	Mass Flow (g/s)	879.5	702.1	1883	4.300	1984		
16	Mass Enthalpy (J/g)	347.4	317.0	317.7	86.40	234.7		
17	Heat Flow (W*)	3.055e+005	2.226e+005	5.982e+005	371.5	4.656e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	44.41	44.41	44.46 *	44.43	28.52		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	702.1	1004	879.0 *	1883	1984		
23	Mass Enthalpy (J/g)	230.7	230.9	231.2	231.0	145.0		
24	Heat Flow (W*)	1.619e+005	2.318e+005	2.032e+005	4.351e+005	2.878e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.52	28.52	24.58	24.58	19.52		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	979.2	1005	702.1	1004	979.2		
30	Mass Enthalpy (J/g)	145.0	145.0	127.2	126.0	92.37		
31	Heat Flow (W*)	1.420e+005	1.457e+005	8.932e+004	1.265e+005	9.044e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.52	19.52	19.52	19.52	18.80		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	977.5	977.5	433.6	543.8	702.1		
37	Mass Enthalpy (J/g)	92.37	92.44	92.44	92.44	96.89		
38	Heat Flow (W*)	9.029e+004	9.036e+004	4.009e+004	5.027e+004	6.802e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	18.99 *	8.078	8.035 *	5.304	8.770 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1004 *	543.8	156.0	113.1	433.0 *		
44	Mass Enthalpy (J/g)	95.71	18.31	38.94	22.38	43.07		
45	Heat Flow (W*)	9.609e+004	9957	6073	2532	1.865e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	8.014	7.144	5.397	5.458 *	25.72		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	702.1	543.8	156.0	543.1	4.820		
51	Mass Enthalpy (J/g)	38.82	13.79	23.02	4.398	133.2		
52	Heat Flow (W*)	2.725e+004	7499	3590	2389	642.0		
53	Name	11-LPa	11-LPb_1	11-LPb_2	11-LPc	11-MPa		
54	Vapour Fraction	0.3640 *	1.0000	1.0000	1.0000	1.0000		
55	Temperature (K)	4.425	4.426	4.426	4.703	5.379		
56	Pressure (bar)	1.220 *	1.220	1.220	1.220	2.990		
57	Mass Flow (g/s)	543.1 *	212.8	156.0	156.0	543.1		
58	Mass Enthalpy (J/g)	2.968	15.31	15.31	17.88	2.968		
59	Heat Flow (W*)	1612	3259	2388	2788	1612		
60	Name	C_from+K_from	C_from_a	C_from_b	C_Tr+K_Tr	Feed		
61	Vapour Fraction	0.0000	0.0000	1.0000	0.0000	1.0000		
62	Temperature (K)	4.426	4.426	320.0 *	4.426	323.1 *		
63	Pressure (bar)	1.220	1.220	1.050	1.220	22.00 *		
64	Mass Flow (g/s)	0.0000 *	0.0000 *	0.0000	0.0000 *	245.5 *		
65	Mass Enthalpy (J/g)	-4.094	-4.094	1662	-4.094	1685		
66	Heat Flow (W*)	0.0000	0.0000	0.0000	0.0000	4.137e+005		

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set: Cryogénie - K - bar - g/s1
3		Date/Time: Tue Aug 24 09:48:17 2010
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Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	Feed_Pulling	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
13	Temperature (K)	323.1 *	320.0 *	320.0 *	320.0 *	320.0 *		
14	Pressure (bar)	22.00 *	1.050	1.050	4.825	1.050		
15	Mass Flow (g/s)	10.30 *	18.25 *	25.15	105.4	141.5		
16	Mass Enthalpy (J/g)	1685	1662	1662	1663	1662		
17	Heat Flow (W*)	1.736e+004	3.033e+004	4.180e+004	1.753e+005	2.351e+005		
18	Name	From_T01	From_T02	From_T03	From_T04	From_T05		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	206.3	99.90	44.46	18.99	8.770		
21	Pressure (bar)	12.72	4.970	4.990	5.000	1.220		
22	Mass Flow (g/s)	1191	1191	879.5	1005	433.6		
23	Mass Enthalpy (J/g)	1075	520.1	231.2	95.71	43.07		
24	Heat Flow (W*)	1.281e+006	6.192e+005	2.033e+005	9.616e+004	1.867e+004		
25	Name	From_T06	Gas_bearings	K_from_a	K_from_b	Leak_T01		
26	Vapour Fraction	1.0000	1.0000	0.0000	1.0000	1.0000		
27	Temperature (K)	5.458	323.2	4.426	80.00 *	206.3		
28	Pressure (bar)	3.000 *	20.50	1.220	1.190	12.72		
29	Mass Flow (g/s)	543.8	136.1 *	0.0000	0.0000	0.5400 *		
30	Mass Enthalpy (J/g)	4.398	1685	-4.094	415.7	1075		
31	Heat Flow (W*)	2392	2.293e+005	0.0000	0.0000	580.7		
32	Name	Leak_T02	Leak_T03	Leak_T04	Leak_T05	Leak_T06		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	99.90	44.46	18.99	8.770	5.458		
35	Pressure (bar)	4.970	4.990	5.000	1.220	3.000		
36	Mass Flow (g/s)	0.5200 *	0.4900 *	0.7400 *	0.6300 *	0.7400 *		
37	Mass Enthalpy (J/g)	520.1	231.2	95.71	43.07	4.398		
38	Heat Flow (W*)	270.5	113.3	70.83	27.13	3.254		
39	Name	Leaks	LHe	LHe storage consump	LHe to trucks and stor	Q-102		
40	Vapour Fraction	1.0000	0.0000	0.0000 *	0.0000	---		
41	Temperature (K)	43.92	4.426	4.423	4.426	---		
42	Pressure (bar)	1.220	1.220	1.220 *	1.220	---		
43	Mass Flow (g/s)	5.360	664.5	334.2 *	664.5	---		
44	Mass Enthalpy (J/g)	228.1	-4.094	-4.109	-4.094	---		
45	Heat Flow (W*)	1223	-2720	-1373	-2720	4587		
46	Name	Q_ORs	Q_pipeBP	Q_pipeHP	Q_pipeMP	Rising level from truck		
47	Vapour Fraction	---	---	---	---	1.0000 *		
48	Temperature (K)	---	---	---	---	4.425		
49	Pressure (bar)	---	---	---	---	1.220		
50	Mass Flow (g/s)	---	---	---	---	113.1		
51	Mass Enthalpy (J/g)	---	---	---	---	15.31		
52	Heat Flow (W*)	0.0000 *	0.0000 *	0.0000 *	0.0000 *	1732		
53	Name	Storage decreasing le	To_Ads20K_regen	To_ads80K_regen	To_buffer	To_bypass_LP/MP		
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
55	Temperature (K)	4.426	19.52	66.09	323.2	323.1		
56	Pressure (bar)	1.220	19.77	20.09	20.50	4.825		
57	Mass Flow (g/s)	56.88	1.700 *	0.0000 *	0.0000 *	25.15 *		
58	Mass Enthalpy (J/g)	15.31	92.37	347.4	1685	1680		
59	Heat Flow (W*)	871.0	157.0	0.0000	0.0000	4.224e+004		
60	Name	To_bypass_MP/HP	To_Leaks+bearings	To_T01	To_T02	To_T03		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
62	Temperature (K)	323.2	313.7	235.3	129.2	66.11		
63	Pressure (bar)	20.50	1.220	20.10	12.47	19.68		
64	Mass Flow (g/s)	105.4 *	141.5	1191	1191	879.5		
65	Mass Enthalpy (J/g)	1685	1630	1228	674.7	347.4		
66	Heat Flow (W*)	1.775e+005	2.305e+005	1.463e+006	8.032e+005	3.055e+005		



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 09:48:17 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	To_T04	To_T05	To_T06	W_ads_20K	W_Ads_80K
Vapour Fraction	1.0000	1.0000	1.0000	---	---
Temperature (K)	28.52	19.51	7.159	---	---
Pressure (bar)	19.59	19.37	19.35	---	---
Mass Flow (g/s)	1005	433.6	543.8	---	---
Mass Enthalpy (J/g)	145.0	92.44	13.79	---	---
Heat Flow (W*)	1.457e+005	4.009e+004	7499	-75.00 *	0.0000 *
Name	W_dewar	W_T01	W_T02	W_T03	W_T04
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	300.0 *	1.821e+005	1.840e+005	1.022e+005	4.957e+004
Name	W_T05	W_T06	W_trucks_300K	W_trucks_80K	W_vapor_from_storag
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	2.141e+004	5107	0.0000	0.0000	400.0 *
Name	W_vapor_from_trucks				
Vapour Fraction	---				
Temperature (K)	---				
Pressure (bar)	---				
Mass Flow (g/s)	---				
Mass Enthalpy (J/g)	---				
Heat Flow (W*)	800.0 *				



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

RHEA: Liquefier Process Calculations

13 ANNEX 8: TURBINES NOMINAL CONDITION CASE

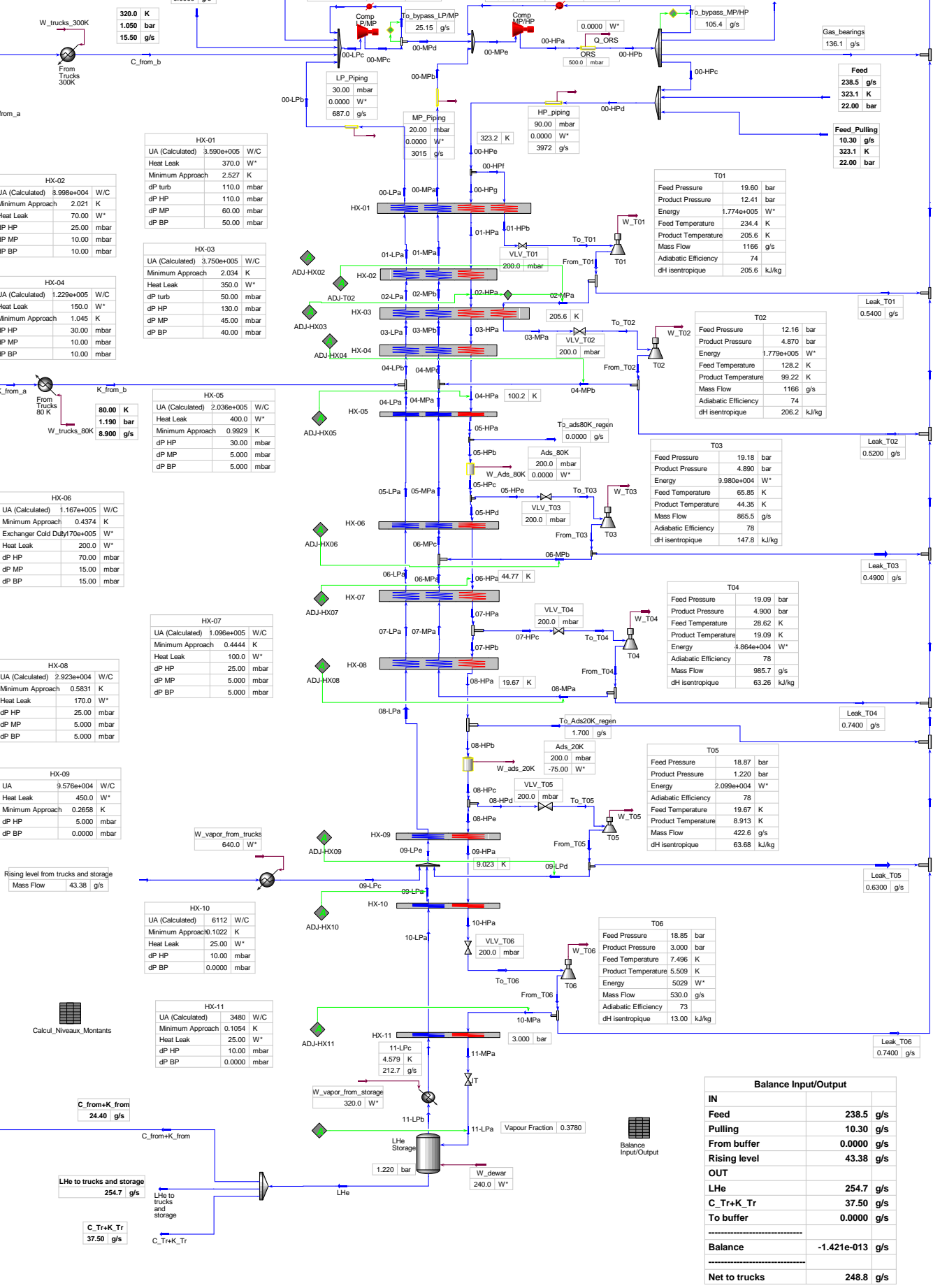
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(12) Rhea-Simulation +3% - 1200 W

Calcul puissance exergetique


P BP/MP	869.8	KW
P MP/HP	3885	KW
P totale ideale	4754	KW



Calcul off-design


HX01	0.9926
HX02	1.000
HX03	1.000
HX04	0.9994
HX05	0.9999
HX06	0.9994
HX07	1.000
HX08	0.9998
Erreur sur HX de 01 à 08 0.9980	
HX09	1.000
HX10	0.9994
HX11	0.9998
T01	1.002
T02	1.000
T03	1.002
T04	1.003
T05	0.9992
T06	0.9974
Comp BP/MP	0.9803
Comp MP/HP	0.9953

Calcul_Niveaux_Montants

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME	
2		Unit Set:	Cryogénie - K - bar - g/s1	
3		Date/Time:	Tue Aug 24 10:03:48 2010	
4				
5				


Workbook: Case (Main)

		Streams					Fluid Pkg:	All
11	Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	323.1 *	323.2	323.2	323.2	323.2	323.2	
14	Pressure (bar)	20.50 *	20.00	20.00	20.00	20.00	19.91	
15	Mass Flow (g/s)	3964	3964	3723	3972	3972	3972	
16	Mass Enthalpy (J/g)	1685	1685	1685	1685	1685	1685	
17	Heat Flow (W*)	6.678e+006	6.678e+006	6.271e+006	6.691e+006	6.691e+006	6.691e+006	
18	Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
20	Temperature (K)	323.2	323.2	320.7	320.7	320.5	320.5	
21	Pressure (bar)	19.91	19.91	1.080	1.050	1.050 *	1.050 *	
22	Mass Flow (g/s)	1166	2806	687.0	687.0	869.1	869.1	
23	Mass Enthalpy (J/g)	1685	1685	1665	1665	1665	1665	
24	Heat Flow (W*)	1.964e+006	4.726e+006	1.144e+006	1.144e+006	1.447e+006	1.447e+006	
25	Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
27	Temperature (K)	320.7	320.7	323.1 *	323.1	321.2	321.2	
28	Pressure (bar)	4.745	4.725	4.725	4.725	4.725	4.725	
29	Mass Flow (g/s)	3015	3015	869.1	843.9	3964	3964	
30	Mass Enthalpy (J/g)	1667	1667	1679	1679	1669	1669	
31	Heat Flow (W*)	5.025e+006	5.025e+006	1.460e+006	1.417e+006	6.617e+006	6.617e+006	
32	Name	01-HPa	01-HPb	01-LPa	01-MPa	2		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
34	Temperature (K)	234.4	234.4	225.4	225.4	12.26	12.26	
35	Pressure (bar)	19.80	19.80	1.130	4.805	1.220	1.220	
36	Mass Flow (g/s)	2806	1166	687.0	3015	3.070	3.070	
37	Mass Enthalpy (J/g)	1224	1224	1171	1172	62.13	62.13	
38	Heat Flow (W*)	3.433e+006	1.427e+006	8.044e+005	3.534e+006	190.7	190.7	
39	Name	02-HPa	02-LPa	02-MPa	02-MPb	03-HPa		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
41	Temperature (K)	205.6 *	203.5	205.6	203.5	128.1	128.1	
42	Pressure (bar)	19.78	1.140	12.41 *	4.815	19.65	19.65	
43	Mass Flow (g/s)	2806	687.0	1166	3015	2806	2806	
44	Mass Enthalpy (J/g)	1074	1057	1072	1058	671.4	671.4	
45	Heat Flow (W*)	3.013e+006	7.263e+005	1.249e+006	3.191e+006	1.884e+006	1.884e+006	
46	Name	03-LPa	03-MPa	03-MPb	4	04-HPa		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
48	Temperature (K)	120.4	128.1	120.4	5.432	100.2 *	100.2 *	
49	Pressure (bar)	1.180	12.36	4.860	1.220	19.62	19.62	
50	Mass Flow (g/s)	687.0	1166	3015	1.370	2806	2806	
51	Mass Enthalpy (J/g)	625.6	669.2	626.7	23.26	525.8	525.8	
52	Heat Flow (W*)	4.297e+005	7.799e+005	1.889e+006	31.86	1.475e+006	1.475e+006	
53	Name	04-LPa	04-LPb	04-MPa	04-MPb	04-MPc		
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	99.19	98.94	99.19	99.22 *	99.20	99.20	
56	Pressure (bar)	1.190	1.190	4.870	4.870	4.870	4.870	
57	Mass Flow (g/s)	678.1	687.0	1850	1165 *	3015	3015	
58	Mass Enthalpy (J/g)	515.4	514.1	516.4	516.6	516.5	516.5	
59	Heat Flow (W*)	3.495e+005	3.532e+005	9.554e+005	6.018e+005	1.557e+006	1.557e+006	
60	Name	5	05-HPa	05-HPb	05-HPc	05-HPd		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	13.50	65.84	65.84	65.84	65.84	65.84	
63	Pressure (bar)	1.220	19.59	19.59	19.39	19.39	19.39	
64	Mass Flow (g/s)	3.810	2806	2806	2806	1940	1940	
65	Mass Enthalpy (J/g)	68.77	345.9	345.9	345.9	345.9	345.9	
66	Heat Flow (W*)	262.0	9.705e+005	9.705e+005	9.705e+005	6.711e+005	6.711e+005	

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:03:48 2010
4			
5			

Workbook: Case (Main) (continued)

Streams (continued)							Fluid Pkg:	All
11	Name	05-HPe	05-LPa	05-MPa	6	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	65.84	60.79	60.79	16.97	44.77 *		
14	Pressure (bar)	19.39	1.195	4.875	1.220	19.32		
15	Mass Flow (g/s)	865.5	678.1	1850	4.300	1940		
16	Mass Enthalpy (J/g)	345.9	315.9	316.6	87.21	234.0		
17	Heat Flow (W*)	2.994e+005	2.142e+005	5.856e+005	375.0	4.540e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	44.32	44.32	44.35 *	44.33	28.63		
21	Pressure (bar)	1.210	4.890	4.890	4.890	19.29		
22	Mass Flow (g/s)	678.1	985.0	865.0 *	1850	1940		
23	Mass Enthalpy (J/g)	230.2	230.5	230.6	230.5	145.7		
24	Heat Flow (W*)	1.561e+005	2.270e+005	1.995e+005	4.265e+005	2.826e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.63	28.63	24.71	24.71	19.67		
28	Pressure (bar)	19.29	19.29	1.215	4.895	19.27		
29	Mass Flow (g/s)	954.3	985.7	678.1	985.0	954.3		
30	Mass Enthalpy (J/g)	145.7	145.7	127.9	126.8	93.46		
31	Heat Flow (W*)	1.390e+005	1.436e+005	8.673e+004	1.249e+005	8.919e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.67	19.68	19.68	19.68	19.09		
35	Pressure (bar)	19.27	19.07	19.07	19.07	1.220		
36	Mass Flow (g/s)	952.6	952.6	422.6	530.0	678.1		
37	Mass Enthalpy (J/g)	93.46	93.54	93.54	93.54	98.39		
38	Heat Flow (W*)	8.903e+004	8.911e+004	3.953e+004	4.957e+004	6.672e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	19.09 *	9.023	8.921 *	6.509	8.913 *		
42	Pressure (bar)	4.900 *	19.06	1.220	1.220	1.220		
43	Mass Flow (g/s)	985.0 *	530.0	212.7	43.38	422.0 *		
44	Mass Enthalpy (J/g)	96.33	23.51	43.91	30.06	43.87		
45	Heat Flow (W*)	9.489e+004	1.246e+004	9338	1304	1.851e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
48	Temperature (K)	8.757	7.483	5.404	5.509 *	25.78		
49	Pressure (bar)	1.220	19.05	1.220	3.000 *	1.220		
50	Mass Flow (g/s)	678.1	530.0	212.7	529.3	4.820		
51	Mass Enthalpy (J/g)	43.00	15.20	23.06	5.708	133.5		
52	Heat Flow (W*)	2.915e+004	8054	4905	3021	643.6		
53	Name	11-LPa	11-LPb	11-LPc	11-MPa	C_from+K_from		
54	Vapour Fraction	0.3780 *	1.0000	1.0000	1.0000	0.0000		
55	Temperature (K)	4.425	4.424	4.579	5.396	4.424		
56	Pressure (bar)	1.220 *	1.220	1.220	2.990	1.220		
57	Mass Flow (g/s)	529.3 *	212.7	212.7	529.3	24.40 *		
58	Mass Enthalpy (J/g)	3.239	15.30	16.80	3.239	-4.104		
59	Heat Flow (W*)	1714	3253	3573	1714	-100.1		
60	Name	C_from_a	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling		
61	Vapour Fraction	0.0000	1.0000	0.0000	1.0000	1.0000		
62	Temperature (K)	4.424	320.0 *	4.424	323.1 *	323.1 *		
63	Pressure (bar)	1.220	1.050	1.220	22.00 *	22.00 *		
64	Mass Flow (g/s)	15.50 *	15.50	37.50 *	238.5 *	10.30 *		
65	Mass Enthalpy (J/g)	-4.104	1662	-4.104	1685	1685		
66	Heat Flow (W*)	-63.60	2.576e+004	-153.9	4.019e+005	1.736e+004		

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set: Cryogénie - K - bar - g/s1
3		Date/Time: Tue Aug 24 10:03:48 2010
4		
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Workbook: Case (Main) (continued)

Streams (continued)						Fluid Pkg:	All
11	Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01	
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	320.0 *	205.6
14	Pressure (bar)	1.050	1.050	4.725	1.050	12.41	
15	Mass Flow (g/s)	0.0000 *	25.15	105.4	141.5	1166	
16	Mass Enthalpy (J/g)	1662	1662	1663	1662	1072	
17	Heat Flow (W*)	0.0000	4.180e+004	1.753e+005	2.351e+005	1.250e+006	
18	Name	From_T02	From_T03	From_T04	From_T05	From_T06	
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
20	Temperature (K)	99.22	44.35	19.09	8.913	5.509	
21	Pressure (bar)	4.870	4.890	4.900	1.220	3.000 *	
22	Mass Flow (g/s)	1166	865.5	985.7	422.6	530.0	
23	Mass Enthalpy (J/g)	516.6	230.6	96.33	43.87	5.708	
24	Heat Flow (W*)	6.021e+005	1.996e+005	9.496e+004	1.854e+004	3025	
25	Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02	
26	Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
27	Temperature (K)	323.2	4.424	80.00 *	205.6	99.22	
28	Pressure (bar)	20.00	1.220	1.190	12.41	4.870	
29	Mass Flow (g/s)	136.1 *	8.900	8.900	0.5400 *	0.5200 *	
30	Mass Enthalpy (J/g)	1685	-4.104	415.7	1072	516.6	
31	Heat Flow (W*)	2.293e+005	-36.52	3700	578.7	268.6	
32	Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	Leaks	
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
34	Temperature (K)	44.35	19.09	8.913	5.509	43.90	
35	Pressure (bar)	4.890	4.900	1.220	3.000	1.220	
36	Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	5.360	
37	Mass Enthalpy (J/g)	230.6	96.33	43.87	5.708	228.0	
38	Heat Flow (W*)	113.0	71.29	27.64	4.224	1222	
39	Name	LHe	LHe to trucks and stor	Q-102	Q_ORs	Q_pipeBP	
40	Vapour Fraction	0.0000	0.0000	---	---	---	
41	Temperature (K)	4.424	4.424	---	---	---	
42	Pressure (bar)	1.220	1.220	---	---	---	
43	Mass Flow (g/s)	316.6	254.7	---	---	---	
44	Mass Enthalpy (J/g)	-4.104	-4.104	---	---	---	
45	Heat Flow (W*)	-1299	-1045	4609	0.0000 *	0.0000 *	
46	Name	Q_pipeHP	Q_pipeMP	Rising level from truck	To_Ads20K_regen	To_ads80K_regen	
47	Vapour Fraction	---	---	1.0000 *	1.0000	1.0000	
48	Temperature (K)	---	---	4.425	19.67	65.84	
49	Pressure (bar)	---	---	1.220	19.27	19.59	
50	Mass Flow (g/s)	---	---	43.38	1.700 *	0.0000 *	
51	Mass Enthalpy (J/g)	---	---	15.31	93.46	345.9	
52	Heat Flow (W*)	0.0000 *	0.0000 *	664.2	158.9	0.0000	
53	Name	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_leaks+bearings	To_T01	
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	323.2	323.1	323.2	313.7	234.4	
56	Pressure (bar)	20.00	4.725	20.00	1.220	19.60	
57	Mass Flow (g/s)	0.0000 *	25.15 *	105.4 *	141.5	1166	
58	Mass Enthalpy (J/g)	1685	1679	1685	1629	1224	
59	Heat Flow (W*)	0.0000	4.224e+004	1.775e+005	2.305e+005	1.427e+006	
60	Name	To_T02	To_T03	To_T04	To_T05	To_T06	
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	128.2	65.85	28.62	19.67	7.496	
63	Pressure (bar)	12.16	19.18	19.09	18.87	18.85	
64	Mass Flow (g/s)	1166	865.5	985.7	422.6	530.0	
65	Mass Enthalpy (J/g)	669.2	345.9	145.7	93.54	15.20	
66	Heat Flow (W*)	7.799e+005	2.994e+005	1.436e+005	3.953e+004	8054	



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 10:03:48 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_ads_20K	W_Ads_80K	W_dewar	W_T01	W_T02
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	-75.00 *	0.0000 *	240.0 *	1.774e+005	1.779e+005
Name	W_T03	W_T04	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	9.980e+004	4.864e+004	2.099e+004	5029	2.582e+004
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	3736	320.0 *	640.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

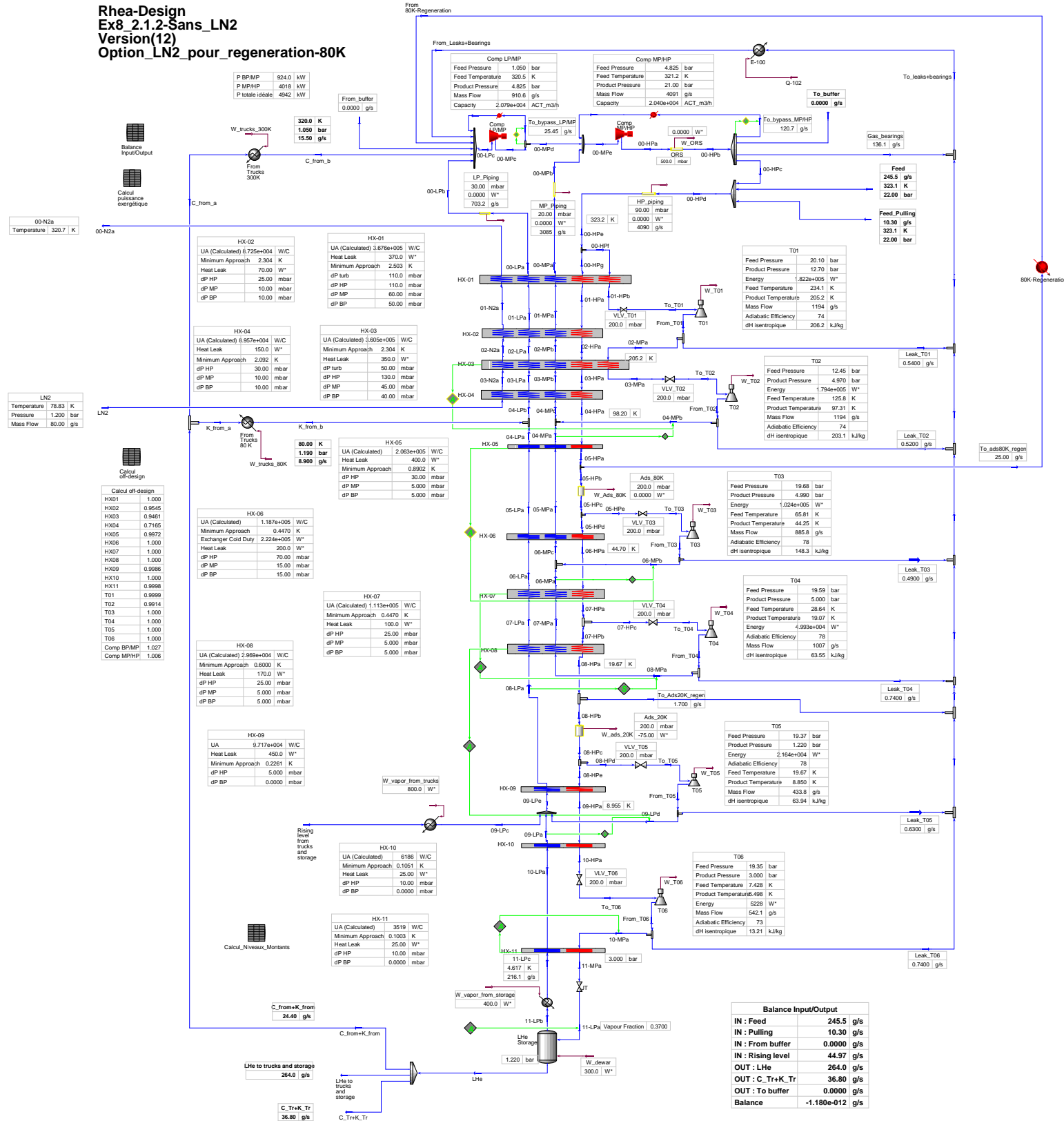
RHEA: Liquefier Process Calculations

14 ANNEX 9: LN2 OPTION FOR 80 K ADSORBER REGENERATION

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Rhea-Design Ex8_2.1.2-Sans_LN2 Version(12) Option_LN2_pour_regeneration-80K



00-N2a
Temperature 320.7 K

LN2
Temperature 78.83 K
Pressure 1.200 bar
Mass Flow 80.00 g/s

Calcul off-design

HX01	1.000
HX02	0.9545
HX03	0.9461
HX04	0.7165
HX05	0.9872
HX06	1.000
HX07	1.000
HX08	1.000
HX09	0.9998
HX10	1.000
HX11	0.9998
T01	0.9999
T02	0.9914
T03	1.000
T04	1.000
T05	1.000
T06	1.000
Comp BPMP	1.027
Comp MPHP	1.006

Calcul Niveau_Montants

HX-01	UA (Calculated) 6.725e+004 W/C
HX-01	Minimum Approach 2.304 K
HX-01	Heat Leak 70.00 W*
HX-01	dP HP 25.00 mbar
HX-01	dP MP 10.00 mbar
HX-01	dP BP 10.00 mbar

Calcul Niveau_Montants

HX-02	UA (Calculated) 1.187e+005 W/C
HX-02	Minimum Approach 0.4470 K
HX-02	Exchanger Cold Duty 2.224e+005 W*
HX-02	Heat Leak 200.0 W*
HX-02	dP HP 70.00 mbar
HX-02	dP MP 15.00 mbar
HX-02	dP BP 15.00 mbar

Calcul Niveau_Montants

HX-03	UA (Calculated) 3.605e+005 W/C
HX-03	Minimum Approach 2.304 K
HX-03	Heat Leak 350.0 W*
HX-03	dP HP 50.00 mbar
HX-03	dP MP 130.00 mbar
HX-03	dP BP 45.00 mbar
HX-03	dP BP 40.00 mbar

Calcul Niveau_Montants

HX-04	UA (Calculated) 8.957e+004 W/C
HX-04	Minimum Approach 2.092 K
HX-04	Heat Leak 150.0 W*
HX-04	dP HP 30.00 mbar
HX-04	dP MP 10.00 mbar
HX-04	dP BP 10.00 mbar

Calcul Niveau_Montants

HX-05	UA (Calculated) 2.063e+005 W/C
HX-05	Minimum Approach 0.8902 K
HX-05	Heat Leak 400.0 W*
HX-05	dP HP 30.00 mbar
HX-05	dP MP 5.000 mbar
HX-05	dP BP 5.000 mbar

Calcul Niveau_Montants

HX-06	UA (Calculated) 1.187e+005 W/C
HX-06	Minimum Approach 0.4470 K
HX-06	Heat Leak 200.0 W*
HX-06	dP HP 70.00 mbar
HX-06	dP MP 15.00 mbar
HX-06	dP BP 15.00 mbar

Calcul Niveau_Montants

HX-07	UA (Calculated) 1.113e+005 W/C
HX-07	Minimum Approach 0.4470 K
HX-07	Heat Leak 100.0 W*
HX-07	dP HP 25.00 mbar
HX-07	dP MP 5.000 mbar
HX-07	dP BP 5.000 mbar

Calcul Niveau_Montants

HX-08	UA (Calculated) 2.060e+004 W/C
HX-08	Minimum Approach 0.6000 K
HX-08	Heat Leak 170.0 W*
HX-08	dP HP 25.00 mbar
HX-08	dP MP 5.000 mbar
HX-08	dP BP 5.000 mbar

Calcul Niveau_Montants

HX-09	UA (Calculated) 6.717e+004 W/C
HX-09	Minimum Approach 0.2261 K
HX-09	Heat Leak 450.0 W*
HX-09	dP HP 5.000 mbar
HX-09	dP BP 0.0000 mbar

Calcul Niveau_Montants


HX-10	UA (Calculated) 6186 W/C
HX-10	Minimum Approach 0.1051 K
HX-10	Heat Leak 25.00 W*
HX-10	dP HP 10.00 mbar
HX-10	dP BP 0.0000 mbar

Calcul Niveau_Montants

HX-11	UA (Calculated) 3519 W/C
HX-11	Minimum Approach 0.1003 K
HX-11	Heat Leak 25.00 W*
HX-11	dP HP 10.00 mbar
HX-11	dP BP 0.0000 mbar


Balance Input/Output

IN : Feed	245.5 g/s
IN : Pulling	10.30 g/s
IN : From buffer	0.0000 g/s
IN : Rising level	44.97 g/s
OUT : LHe	264.0 g/s
OUT : C_Tr+K_Tr	36.80 g/s
OUT : To buffer	0.0000 g/s
Balance	-1.180e-012 g/s

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:50:07 2010
4			
5			

Workbook: Case (Main)

		Streams					Fluid Pkg:	All
11	Name	00-HPa	00-HPb	00-HPc	00-HPd	00-HPe		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	323.1 *	323.2	323.2	323.2	323.2	323.2	
14	Pressure (bar)	21.00 *	20.50	20.50	20.50	20.41	20.41	
15	Mass Flow (g/s)	4091	4091	3834	4090	4090	4090	
16	Mass Enthalpy (J/g)	1685	1685	1685	1685	1685	1685	
17	Heat Flow (W*)	6.892e+006	6.892e+006	6.460e+006	6.891e+006	6.891e+006	6.891e+006	
18	Name	00-HPf	00-HPg	00-LPa	00-LPb	00-LPc		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
20	Temperature (K)	323.2	323.2	320.7	320.7	320.5	320.5	
21	Pressure (bar)	20.41	20.41	1.080	1.050	1.050 *	1.050 *	
22	Mass Flow (g/s)	1194	2896	703.2	703.2	910.6	910.6	
23	Mass Enthalpy (J/g)	1685	1685	1666	1666	1665	1665	
24	Heat Flow (W*)	2.012e+006	4.878e+006	1.171e+006	1.171e+006	1.516e+006	1.516e+006	
25	Name	00-MPa	00-MPb	00-MPc	00-MPd	00-MPe		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
27	Temperature (K)	320.7	320.7	323.1 *	323.1	321.2	321.2	
28	Pressure (bar)	4.845	4.825	4.825	4.825	4.825	4.825	
29	Mass Flow (g/s)	3085	3085	910.6	885.2	4091	4091	
30	Mass Enthalpy (J/g)	1667	1667	1680	1680	1669	1669	
31	Heat Flow (W*)	5.142e+006	5.142e+006	1.529e+006	1.487e+006	6.829e+006	6.829e+006	
32	Name	00-N2a	01-HPa	01-HPb	01-LPa	01-MPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
34	Temperature (K)	320.7	234.1	234.1	224.9	224.9	224.9	
35	Pressure (bar)	1.135	20.30	20.30	1.130	4.905	4.905	
36	Mass Flow (g/s)	80.00	2896	1194	703.2	3085	3085	
37	Mass Enthalpy (J/g)	332.7	1222	1222	1168	1169	1169	
38	Heat Flow (W*)	2.661e+004	3.539e+006	1.460e+006	8.215e+005	3.608e+006	3.608e+006	
39	Name	01-N2a	02-HPa	02-LPa	02-MPa	02-MPb		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
41	Temperature (K)	224.9	205.2	202.9	205.2 *	202.9	202.9	
42	Pressure (bar)	1.160	20.28	1.140	12.70 *	4.915	4.915	
43	Mass Flow (g/s)	80.00	2896	703.2	1194	3085	3085	
44	Mass Enthalpy (J/g)	232.9	1072	1054	1070	1055	1055	
45	Heat Flow (W*)	1.863e+004	3.104e+006	7.411e+005	1.277e+006	3.255e+006	3.255e+006	
46	Name	02-N2a	03-HPa	03-LPa	03-MPa	03-MPb		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
48	Temperature (K)	202.9	125.8	117.4	125.8	117.4	117.4	
49	Pressure (bar)	1.165	20.15	1.180	12.65	4.960	4.960	
50	Mass Flow (g/s)	80.00	2896	703.2	1194	3085	3085	
51	Mass Enthalpy (J/g)	210.0	659.3	610.2	657.0	611.3	611.3	
52	Heat Flow (W*)	1.680e+004	1.909e+006	4.291e+005	7.843e+005	1.886e+006	1.886e+006	
53	Name	03-N2a	04-HPa	04-LPa	04-LPb	04-MPa		
54	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
55	Temperature (K)	117.4	98.20 *	97.31	97.09	97.31	97.31	
56	Pressure (bar)	1.195	20.12	1.190	1.190	4.970	4.970	
57	Mass Flow (g/s)	80.00	2896	694.3	703.2	1892	1892	
58	Mass Enthalpy (J/g)	120.3	515.6	505.6	504.5	506.7	506.7	
59	Heat Flow (W*)	9623	1.493e+006	3.510e+005	3.547e+005	9.586e+005	9.586e+005	
60	Name	04-MPb	04-MPc	05-HPa	05-HPb	05-HPc		
61	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
62	Temperature (K)	97.31	97.31	65.79	65.79	65.80	65.80	
63	Pressure (bar)	4.970	4.970	20.09	20.09	19.89	19.89	
64	Mass Flow (g/s)	1193 *	3085	2896	2871	2871	2871	
65	Mass Enthalpy (J/g)	506.7	506.7	345.8	345.8	345.8	345.8	
66	Heat Flow (W*)	6.046e+005	1.563e+006	1.001e+006	9.926e+005	9.926e+005	9.926e+005	

1	 AIR LIQUIDE ENGINEERING Calgary, Alberta CANADA	Case Name:	D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
2		Unit Set:	Cryogénie - K - bar - g/s1
3		Date/Time:	Tue Aug 24 10:50:07 2010
4			
5			

Workbook: Case (Main) (continued)

		Streams (continued)					Fluid Pkg:	All
11	Name	05-HPd	05-HPe	05-LPa	05-MPa	06-HPa		
12	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
13	Temperature (K)	65.80	65.80	60.74	60.74	44.70 *		
14	Pressure (bar)	19.89	19.89	1.195	4.975	19.82		
15	Mass Flow (g/s)	1985	885.8	694.3	1892	1985		
16	Mass Enthalpy (J/g)	345.8	345.8	315.6	316.3	233.7		
17	Heat Flow (W*)	6.863e+005	3.063e+005	2.191e+005	5.984e+005	4.639e+005		
18	Name	06-LPa	06-MPa	06-MPb	06-MPc	07-HPa		
19	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
20	Temperature (K)	44.25	44.25	44.25	44.25	28.65		
21	Pressure (bar)	1.210	4.990	4.990	4.990	19.79		
22	Mass Flow (g/s)	694.3	1007	885.3 *	1892	1985		
23	Mass Enthalpy (J/g)	229.9	230.1	230.1	230.1	145.7		
24	Heat Flow (W*)	1.596e+005	2.316e+005	2.037e+005	4.353e+005	2.893e+005		
25	Name	07-HPb	07-HPc	07-LPa	07-MPa	08-HPa		
26	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
27	Temperature (K)	28.65	28.65	24.72	24.72	19.67		
28	Pressure (bar)	19.79	19.79	1.215	4.995	19.77		
29	Mass Flow (g/s)	977.6	1007	694.3	1007	977.6		
30	Mass Enthalpy (J/g)	145.7	145.7	128.0	126.8	93.31		
31	Heat Flow (W*)	1.425e+005	1.468e+005	8.884e+004	1.276e+005	9.122e+004		
32	Name	08-HPb	08-HPc	08-HPd	08-HPe	08-LPa		
33	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
34	Temperature (K)	19.67	19.68	19.68	19.68	19.07		
35	Pressure (bar)	19.77	19.57	19.57	19.57	1.220		
36	Mass Flow (g/s)	975.9	975.9	433.8	542.1	694.3		
37	Mass Enthalpy (J/g)	93.31	93.39	93.39	93.39	98.32		
38	Heat Flow (W*)	9.106e+004	9.113e+004	4.051e+004	5.062e+004	6.826e+004		
39	Name	08-MPa	09-HPa	09-LPa	09-LPc	09-LPd		
40	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000		
41	Temperature (K)	19.07	8.955	8.850	7.020	8.850 *		
42	Pressure (bar)	5.000 *	19.56	1.220	1.220	1.220		
43	Mass Flow (g/s)	1007 *	542.1	216.1	44.97	433.2 *		
44	Mass Enthalpy (J/g)	96.17	23.16	43.51	33.10	43.51		
45	Heat Flow (W*)	9.680e+004	1.255e+004	9405	1489	1.885e+004		
46	Name	09-LPe	10-HPa	10-LPa	10-MPa	11-LPa		
47	Vapour Fraction	1.0000	1.0000	1.0000	1.0000	0.3700 *		
48	Temperature (K)	8.729	7.415	5.397	5.498 *	4.425		
49	Pressure (bar)	1.220	19.55	1.220	3.000 *	1.220 *		
50	Mass Flow (g/s)	694.3	542.1	216.1	541.3	541.3 *		
51	Mass Enthalpy (J/g)	42.84	15.03	23.02	5.386	3.084		
52	Heat Flow (W*)	2.974e+004	8147	4976	2916	1669		
53	Name	11-LPb	11-LPc	11-MPa	C_from+K_from	C_from_a		
54	Vapour Fraction	1.0000	1.0000	1.0000	0.0000	0.0000		
55	Temperature (K)	4.424	4.617	5.386	4.424	4.424		
56	Pressure (bar)	1.220	1.220	2.990	1.220	1.220		
57	Mass Flow (g/s)	216.1	216.1	541.3	24.40 *	15.50 *		
58	Mass Enthalpy (J/g)	15.29	17.14	3.084	-4.107	-4.107		
59	Heat Flow (W*)	3305	3705	1669	-100.2	-63.66		
60	Name	C_from_b	C_Tr+K_Tr	Feed	Feed_Pulling	From 80K-Regenerati		
61	Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000		
62	Temperature (K)	320.0 *	4.424	323.1 *	323.1 *	320.0 *		
63	Pressure (bar)	1.050	1.220	22.00 *	22.00 *	1.050		
64	Mass Flow (g/s)	15.50	36.80 *	245.5 *	10.30 *	25.00		
65	Mass Enthalpy (J/g)	1662	-4.107	1685	1685	1662		
66	Heat Flow (W*)	2.576e+004	-151.1	4.137e+005	1.736e+004	4.155e+004		



AIR LIQUIDE ENGINEERING
Calgary, Alberta
CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
Unit Set: Cryogénie - K - bar - g/s1
Date/Time: Tue Aug 24 10:50:07 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	From_buffer	From_bypass_LP/MP	From_bypass_MP/HP	From_Leaks+Bearings	From_T01
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	320.0 *	320.0 *	320.0 *	320.0 *	205.2
Pressure (bar)	1.050	1.050	4.825	1.050	12.70
Mass Flow (g/s)	0.0000 *	25.45	120.7	141.5	1194
Mass Enthalpy (J/g)	1662	1662	1663	1662	1070
Heat Flow (W*)	0.0000	4.229e+004	2.007e+005	2.351e+005	1.278e+006
Name	From_T02	From_T03	From_T04	From_T05	From_T06
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	97.31	44.25	19.07	8.850	5.498
Pressure (bar)	4.970	4.990	5.000	1.220	3.000 *
Mass Flow (g/s)	1194	885.8	1007	433.8	542.1
Mass Enthalpy (J/g)	506.7	230.1	96.17	43.51	5.386
Heat Flow (W*)	6.049e+005	2.038e+005	9.687e+004	1.888e+004	2920
Name	Gas_bearings	K_from_a	K_from_b	Leak_T01	Leak_T02
Vapour Fraction	1.0000	0.0000	1.0000	1.0000	1.0000
Temperature (K)	323.2	4.424	80.00 *	205.2	97.31
Pressure (bar)	20.50	1.220	1.190	12.70	4.970
Mass Flow (g/s)	136.1 *	8.900	8.900	0.5400 *	0.5200 *
Mass Enthalpy (J/g)	1685	-4.107	415.7	1070	506.7
Heat Flow (W*)	2.293e+005	-36.55	3700	577.6	263.5
Name	Leak_T03	Leak_T04	Leak_T05	Leak_T06	LHe
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	0.0000
Temperature (K)	44.25	19.07	8.850	5.498	4.424
Pressure (bar)	4.990	5.000	1.220	3.000	1.220
Mass Flow (g/s)	0.4900 *	0.7400 *	0.6300 *	0.7400 *	325.2
Mass Enthalpy (J/g)	230.1	96.17	43.51	5.386	-4.107
Heat Flow (W*)	112.8	71.16	27.41	3.986	-1335
Name	LHe to trucks and stor	LN2	Q-102	Rising level from truck	To_Ads20K_regen
Vapour Fraction	0.0000	0.0000 *	---	1.0000 *	1.0000
Temperature (K)	4.424	78.83	---	4.425	19.67
Pressure (bar)	1.220	1.200 *	---	1.220	19.77
Mass Flow (g/s)	264.0	80.00 *	---	44.97	1.700 *
Mass Enthalpy (J/g)	-4.107	-118.4	---	15.31	93.31
Heat Flow (W*)	-1084	-9469	4595	688.6	158.6
Name	To_ads80K_regen	To_buffer	To_bypass_LP/MP	To_bypass_MP/HP	To_Leaks+bearings
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	65.79	323.2	323.1	323.2	313.7
Pressure (bar)	20.09	20.50	4.825	20.50	1.220
Mass Flow (g/s)	25.00 *	0.0000 *	25.45 *	120.7 *	141.5
Mass Enthalpy (J/g)	345.8	1685	1680	1685	1629
Heat Flow (W*)	8644	0.0000	4.274e+004	2.033e+005	2.305e+005
Name	To_T01	To_T02	To_T03	To_T04	To_T05
Vapour Fraction	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature (K)	234.1	125.8	65.81	28.64	19.67
Pressure (bar)	20.10	12.45	19.68	19.59	19.37
Mass Flow (g/s)	1194	1194	885.8	1007	433.8
Mass Enthalpy (J/g)	1222	657.0	345.8	145.7	93.39
Heat Flow (W*)	1.460e+006	7.843e+005	3.063e+005	1.468e+005	4.051e+004
Name	To_T06	Total_leaks	W_ads_20K	W_Ads_80K	W_dewar
Vapour Fraction	1.0000	1.0000	---	---	---
Temperature (K)	7.428	43.64	---	---	---
Pressure (bar)	19.35	1.220	---	---	---
Mass Flow (g/s)	542.1	5.360	---	---	---
Mass Enthalpy (J/g)	15.03	226.7	---	---	---
Heat Flow (W*)	8147	1215	-75.00 *	0.0000 *	300.0 *



AIR LIQUIDE ENGINEERING
 Calgary, Alberta
 CANADA

Case Name: D:\DOCUMENTS AND SETTINGS\CINDY.DESCHILDREMY DOCUME
 Unit Set: Cryogénie - K - bar - g/s1
 Date/Time: Tue Aug 24 10:50:07 2010

Workbook: Case (Main) (continued)

Streams (continued)

Fluid Pkg: All

Name	W_OR3	W_pipeBP	W_pipeHP	W_pipeMP	W_T01
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	0.0000 *	0.0000 *	0.0000 *	0.0000 *	1.822e+005
Name	W_T02	W_T03	W_T05	W_T06	W_trucks_300K
Vapour Fraction	---	---	---	---	---
Temperature (K)	---	---	---	---	---
Pressure (bar)	---	---	---	---	---
Mass Flow (g/s)	---	---	---	---	---
Mass Enthalpy (J/g)	---	---	---	---	---
Heat Flow (W*)	1.794e+005	1.024e+005	2.164e+004	5228	2.582e+004
Name	W_trucks_80K	W_vapor_from_storag	W_vapor_from_trucks		
Vapour Fraction	---	---	---		
Temperature (K)	---	---	---		
Pressure (bar)	---	---	---		
Mass Flow (g/s)	---	---	---		
Mass Enthalpy (J/g)	---	---	---		
Heat Flow (W*)	3736	400.0 *	800.0 *		



RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu)



ALE Project : RHEA / 51-3428

ALE N°: N/A

RG N°: N/A

DTA N°: C1192-NT-103

Rev : B

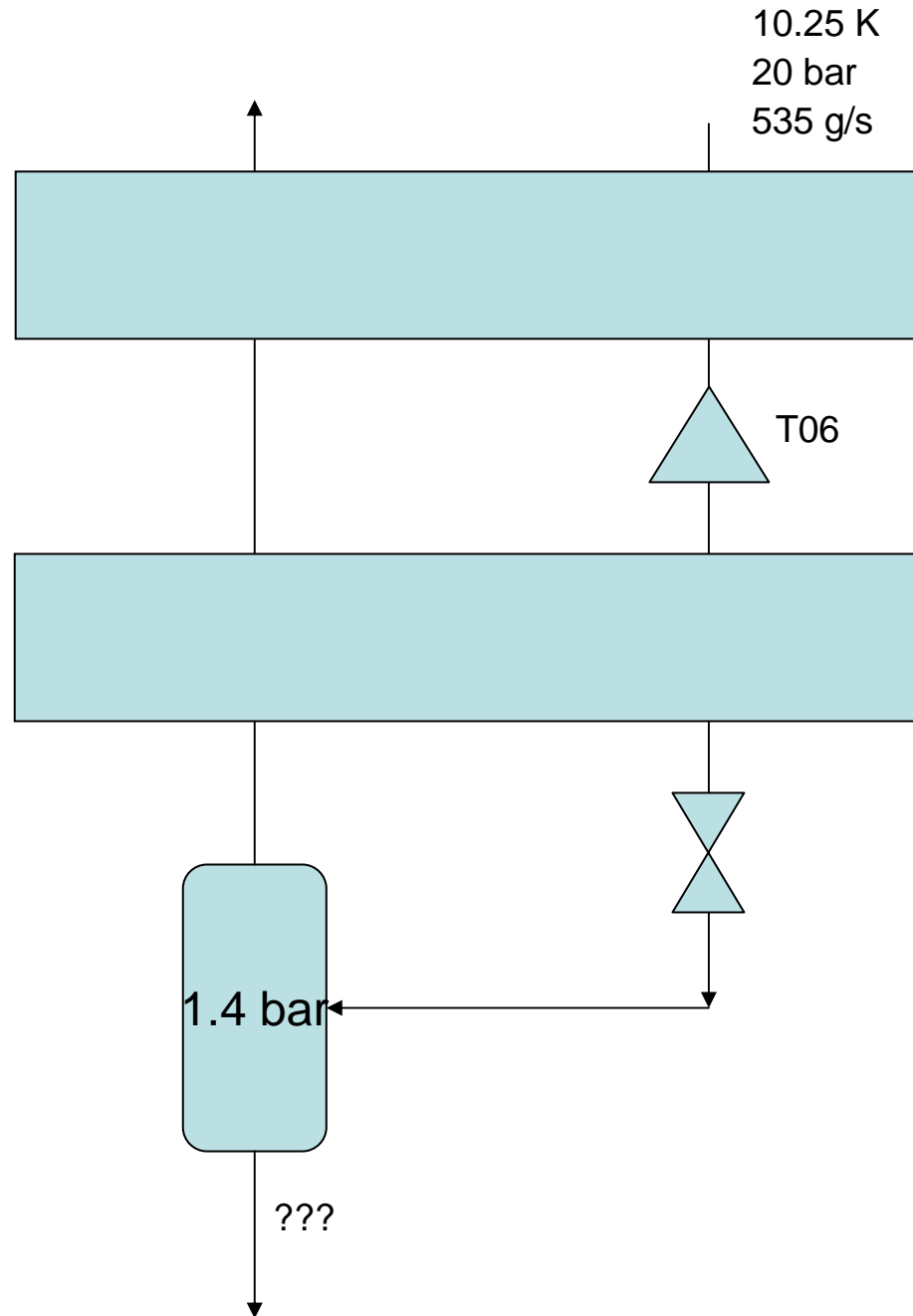
RHEA: Liquefier Process Calculations

15 ANNEX 10: STUDY OF THE COLD END

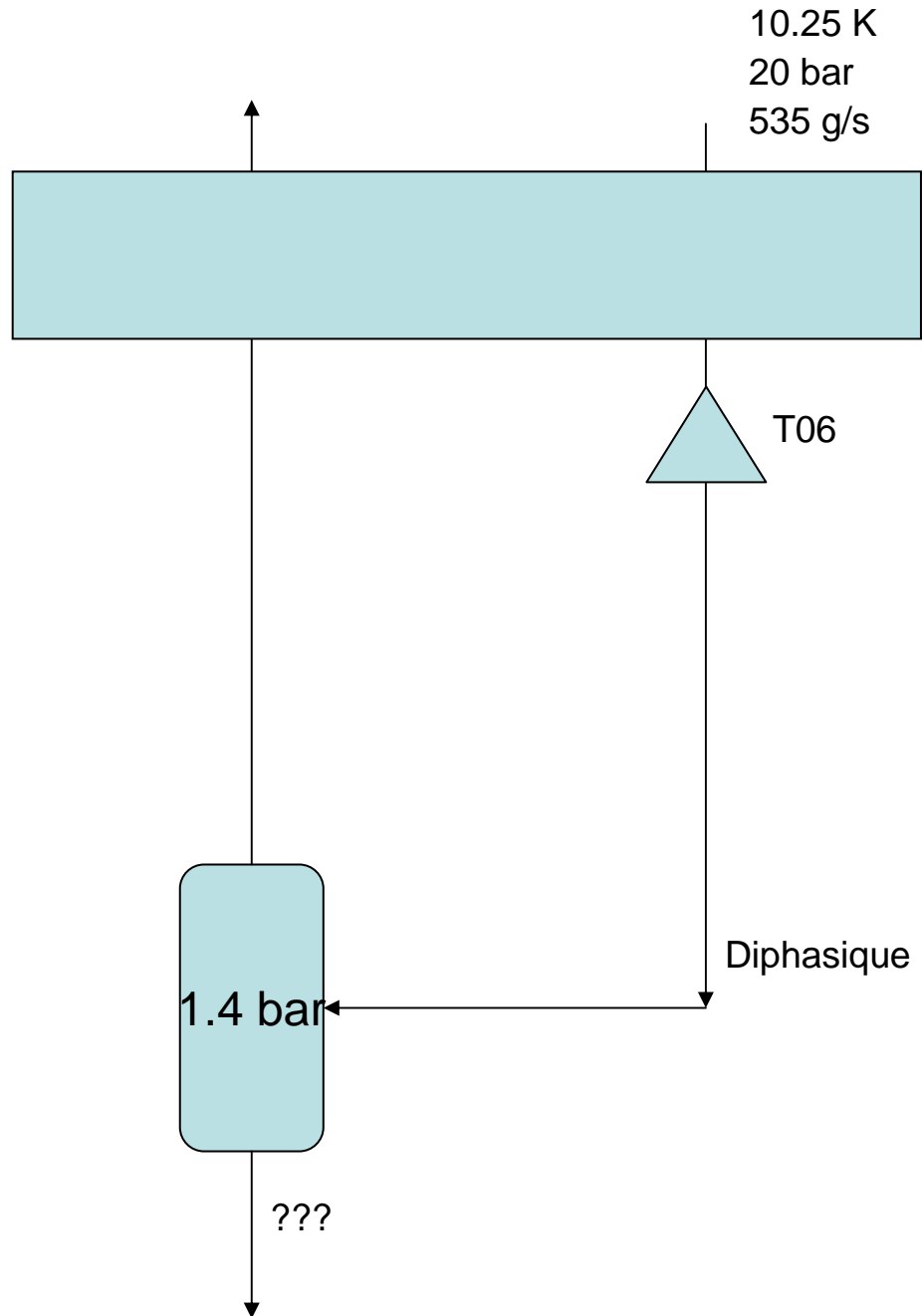
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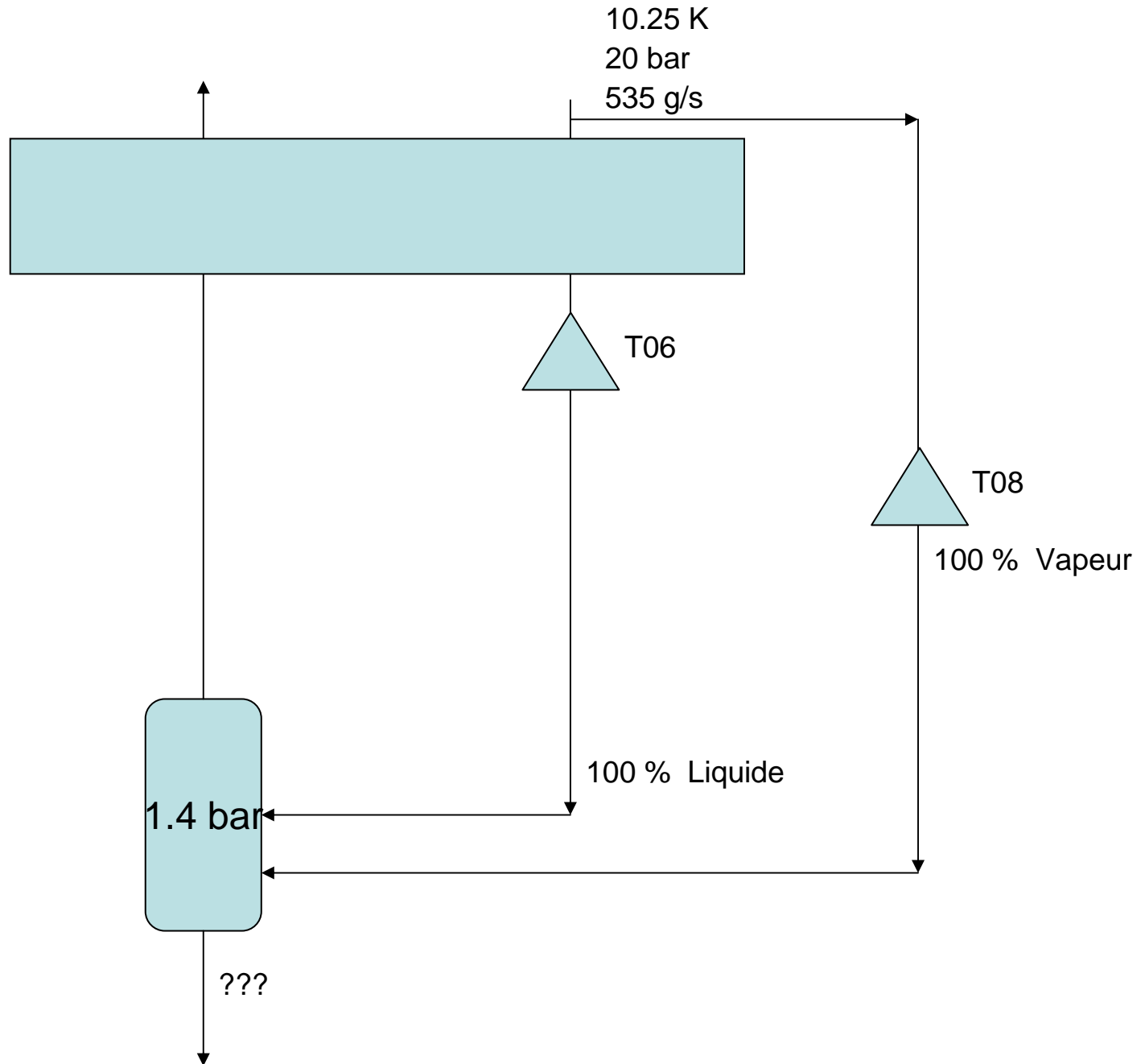
Solution A: 1 Turb S/C Turb. Liq. Non Autorisée



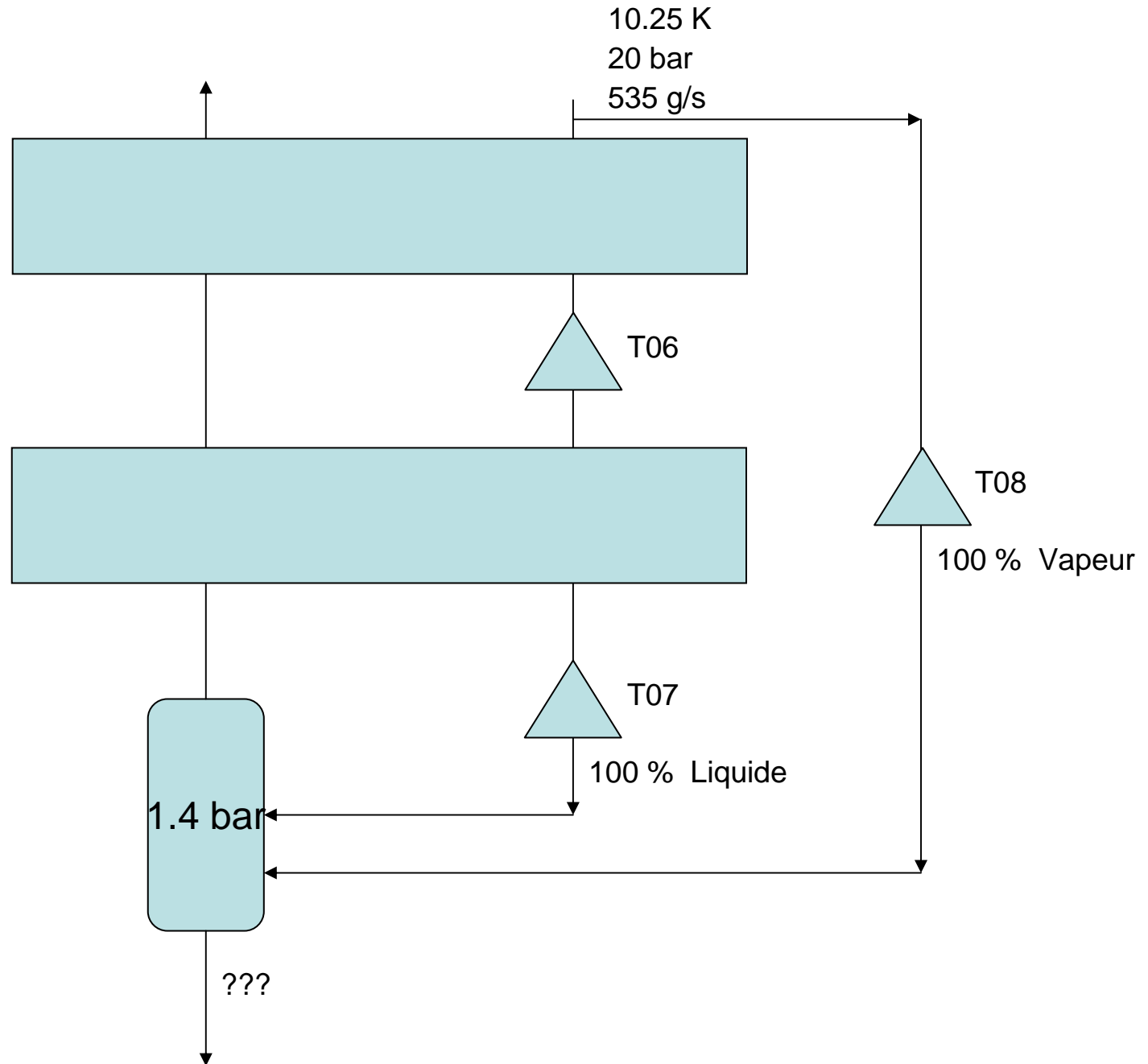
Solution B: 1 Turb [Turb. Liq. Autorisée]



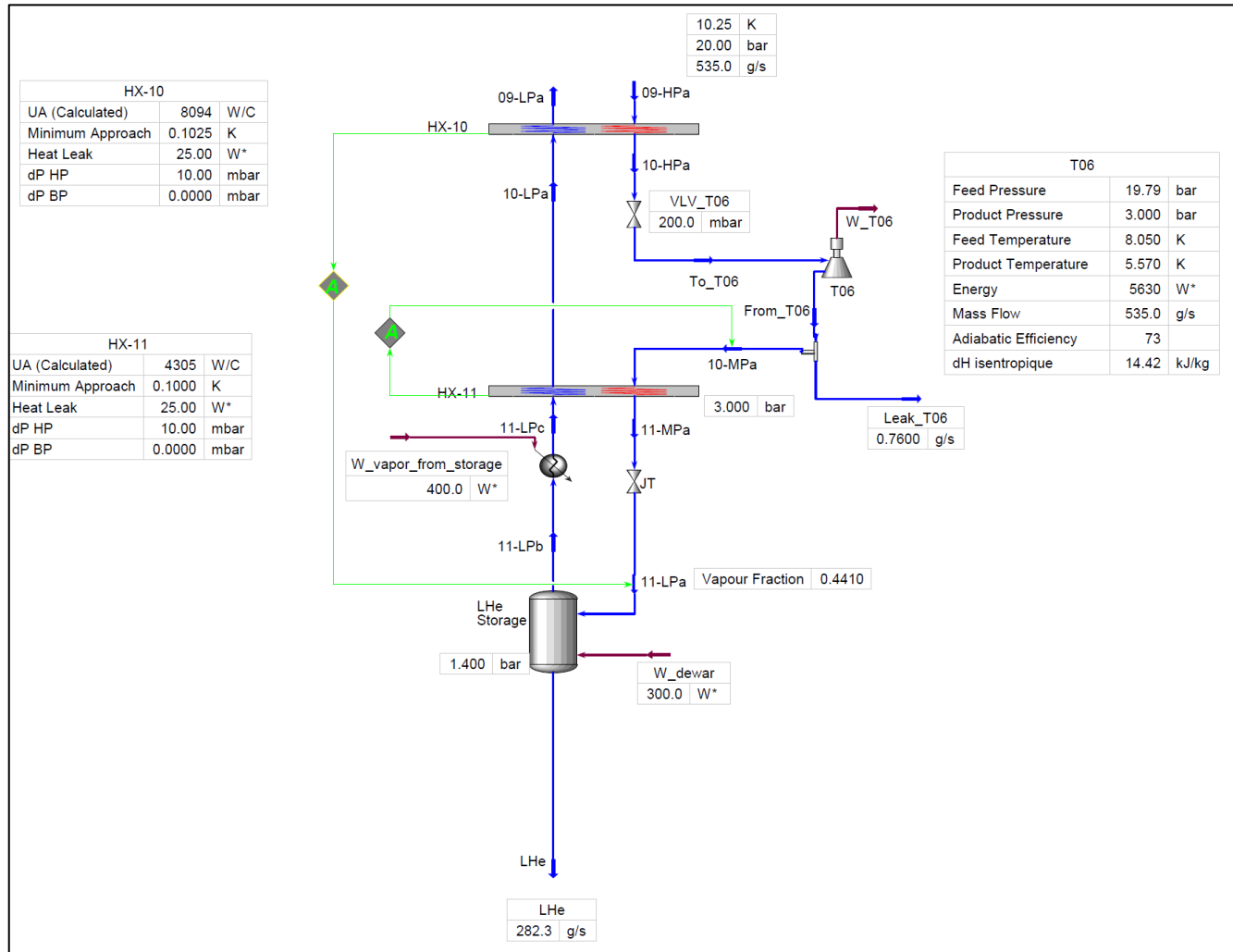
Solution C: 2 Turb [Turb. Liq. Autorisée]



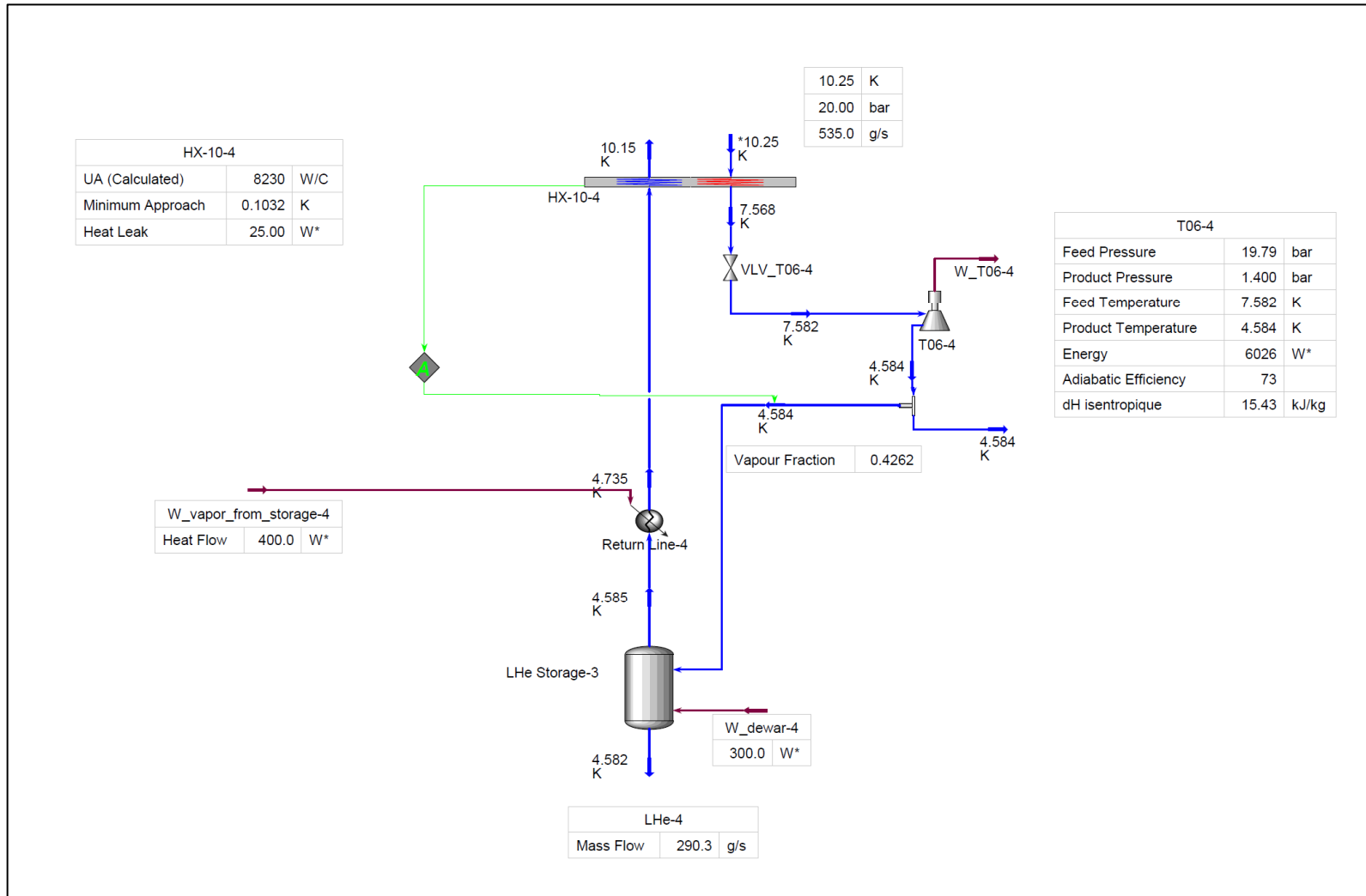
Solution D: 3 Turb [Turb. Liq. Autorisée]



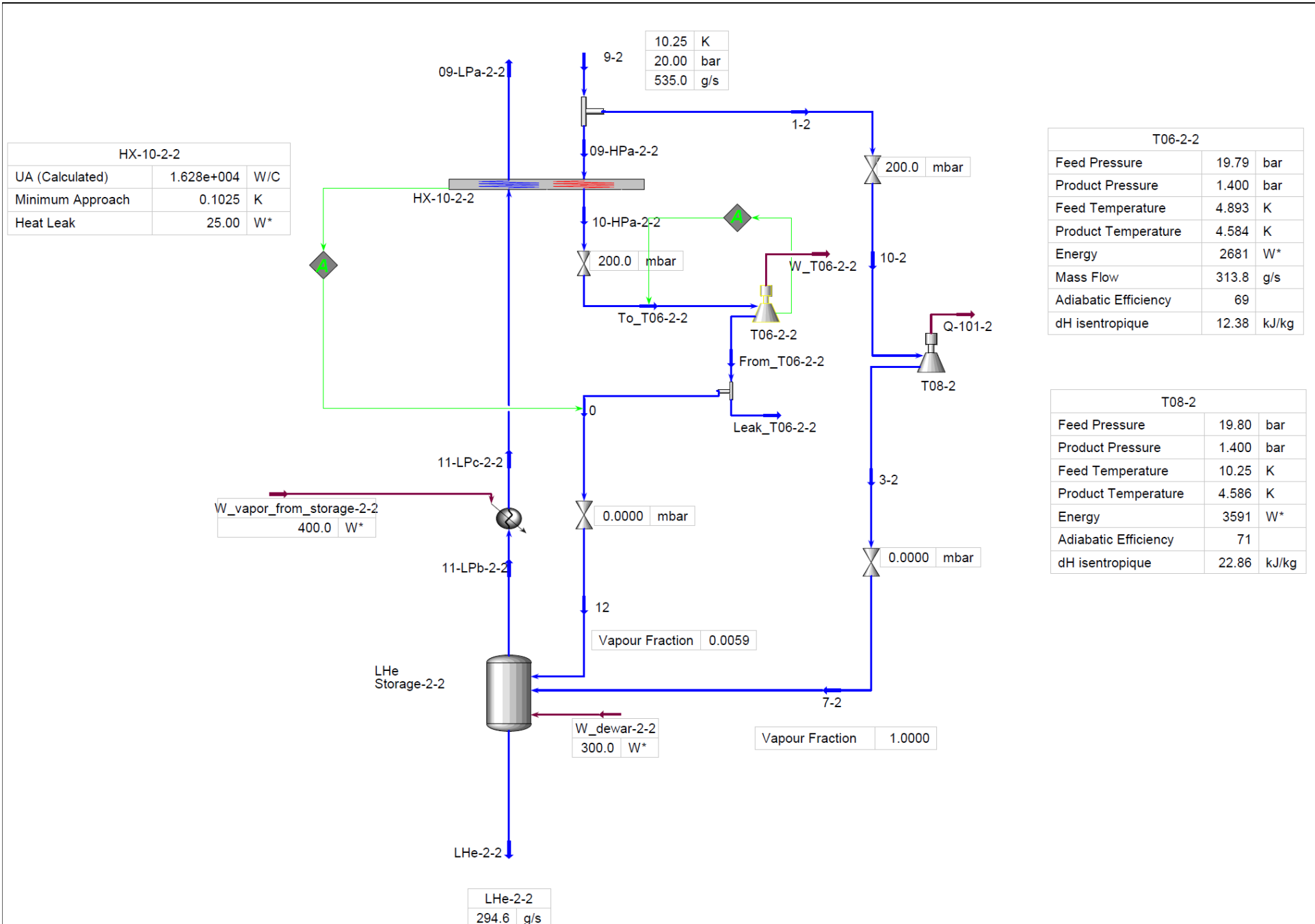
Solution A: 1 Turb S/C [Turb. Liq. Non Autorisée]



Solution B: 1 Turb [Turb. Liq. Autorisée]



Solution C: 2 Turb [Turb. Liq. Autorisée]



Solution D: 3 Turb [Turb. Liq. Autorisée]

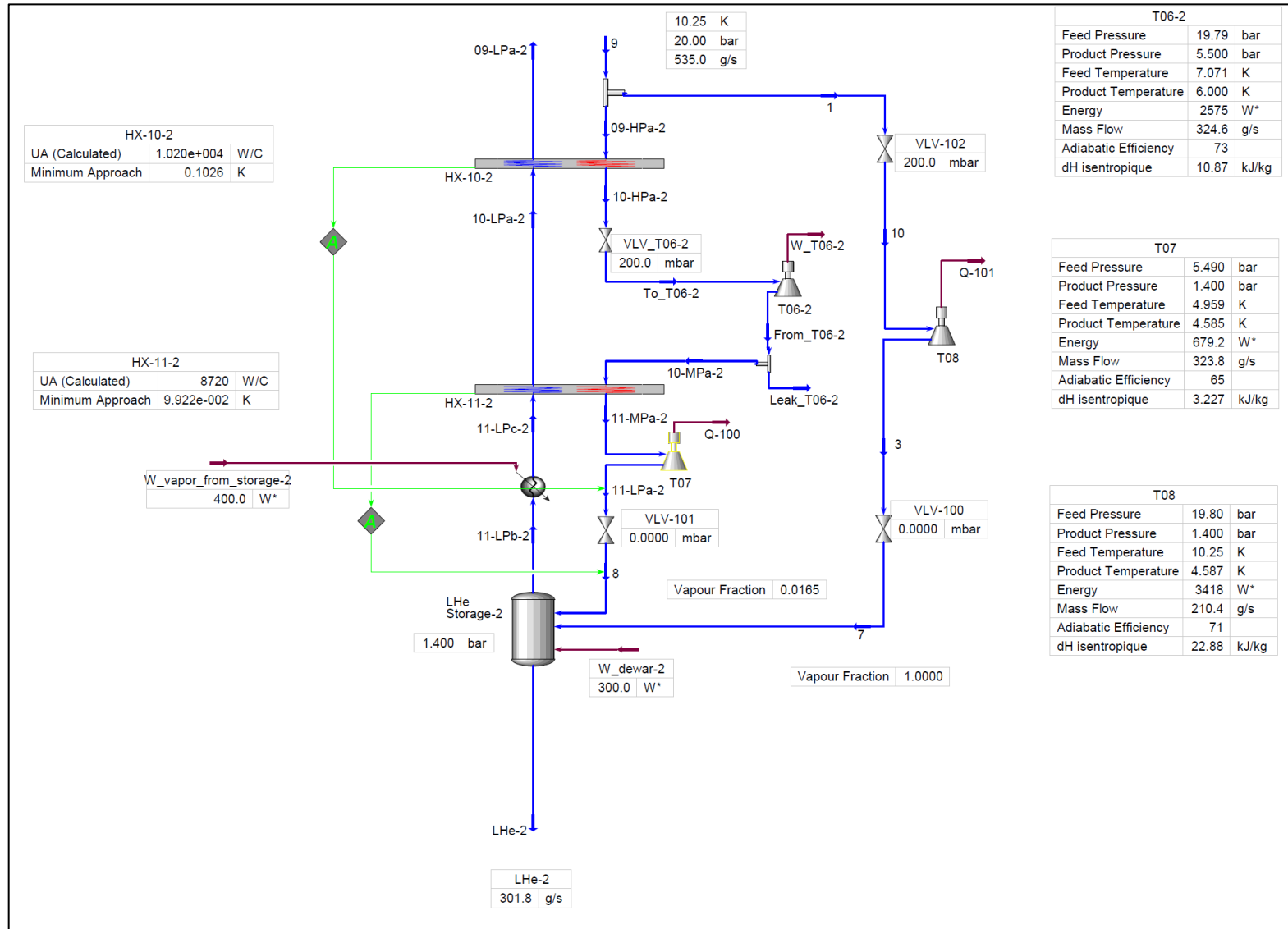


Tableau comparatif

Solution A 1 Turb	Solution B 1 Turb *	Solution C 2 Turb *	Solution D 3 Turb *
282.3 g/s	290.3 g/s	294.6 g/s	301.8 g/s
100 %	102.8 %	104.4 %	106.9 %

* Turbines Liquides Autorisées dans les cas B, C, D.

Note:

Rendements des turbines pris en compte mais à confirmer

Fuites des turbines et débits paliers non pris en compte donc résultats à nuancer