

Design optimization of heat exchangers in topside systems for offshore oil and gas processing

Mayukh Bandopadhyay

Natural Gas Technology Submission date: June 2014 Supervisor: Jostein Pettersen, EPT Co-supervisor: Henrik Hem Orskaug, Aker Solutions Einar Landa, Aker Solutions

Norwegian University of Science and Technology Department of Energy and Process Engineering



Norwegian University of Science and Technology

Department of Energy and Process Engineering

EPT-M-2014-08

MASTER THESIS

for

Student Mayukh Bandopadhyay

Spring 2014

Design optimization of heat exchangers in topside systems for offshore oil and gas processing

Optimalisering av varmevekslere i system for offshore prosessering av olje og gass

Background and objective

Mechanical equipment units are integral parts of any process plant. On a typical oil and gas platform, heat exchangers, scrubbers, separators, rotating equipment etc. are critical for the proper operation of the process systems. These equipment units are needed for maintaining the correct process parameters of the fluids be it crude oil, natural gas or any other process stream.

Process systems consists of individual equipment units which are mapped together along with all relevant process and operational parameters like inlet and outlet temperatures and pressure of the fluids, flow rates, composition and liquid/vapour content. Changing the process parameters of any single unit will have an impact on other process and operation parameters, as well as on utility systems (power, heating, cooling). Too much change of process design may lead to off-spec products and avoiding this is a key constraint. For a typical oil and gas platform, heat exchangers and other mechanical equipment units are generally designed based on process datasheets provided by process designers to the equipment engineers. This sometimes leads to a very non ideal or non-economical design of heat exchangers (mainly) with respect to the inlet and outlet temperatures and the heat duty.

The main focus of this Master's thesis is to manipulate the process parameters of the process and the heat exchangers to achieve a more favourable equipment design and then evaluate the impact on other equipment units and on the process streams and products to check for off-spec conditions. Basis for the work in terms of typical process flow diagram with heat and material balances, as well as relevant heat exchanger designs, will be provided by Aker Solutions.

The main objective of the thesis will be to explore the possibilities for more favourable heat exchanger designs within the given constraints for the process.

The following tasks are to be considered:

- 1. Study relevant literature that describes production processes for oil & gas processing with emphasis on the mechanical equipment units especially considering heat exchangers.
- 2. Develop a model of the main production (separation and compression) process in HYSYS. The model should contain the necessary mechanical equipment units with relevant process parameters.
- 3. An analysis of the model by manipulating process parameters of the heat exchanger units and studying the impact on this change on the other mechanical equipment units and process parameters. The analysis needs to consider constraints like off-spec products caused by changes in process parameters of the heat exchangers. Changes in utilities also need to be considered.
- 4. Based on the process parameters of the heat exchanger units, thermal design calculations shall be conducted for relevant heat exchangers, using design software (HTRI/HTFS).
- 5. Develop generic understanding of how the process design and the thermal calculations for the heat exchangers influence the selection of type and the mechanical design of the heat exchangers. Mechanical design of exchanger units will be decided based on time available during the thesis period.
- 6. Conclusions, with recommendations for further work.

-- " --

Within 14 days of receiving the written text on the master thesis, the candidate shall submit a research plan for his project to the department.

When the thesis is evaluated, emphasis is put on processing of the results, and that they are presented in tabular and/or graphic form in a clear manner, and that they are analyzed carefully.

The thesis should be formulated as a research report with summary both in English and Norwegian, conclusion, literature references, table of contents etc. During the preparation of the text, the candidate should make an effort to produce a well-structured and easily readable report. In order to ease the evaluation of the thesis, it is important that the cross-references are correct. In the making of the report, strong emphasis should be placed on both a thorough discussion of the results and an orderly presentation.

The candidate is requested to initiate and keep close contact with his/her academic supervisor(s) throughout the working period. The candidate must follow the rules and regulations of NTNU as well as passive directions given by the Department of Energy and Process Engineering.

Risk assessment of the candidate's work shall be carried out according to the department's procedures. The risk assessment must be documented and included as part of the final report. Events related to the candidate's work adversely affecting the health, safety or security, must be

documented and included as part of the final report. If the documentation on risk assessment represents a large number of pages, the full version is to be submitted electronically to the supervisor and an excerpt is included in the report.

Pursuant to "Regulations concerning the supplementary provisions to the technology study program/Master of Science" at NTNU §20, the Department reserves the permission to utilize all the results and data for teaching and research purposes as well as in future publications.

The final report is to be submitted digitally in DAIM. An executive summary of the thesis including title, student's name, supervisor's name, year, department name, and NTNU's logo and name, shall be submitted to the department as a separate pdf file. Based on an agreement with the supervisor, the final report and other material and documents may be given to the supervisor in digital format.

Work to be done in lab (Water power lab, Fluids engineering lab, Thermal engineering lab) Field work

Department of Energy and Process Engineering, 14 January 2014

Olav Bolland Department Head

- Potti

Jostein Pettersen Academic Supervisor

Research Advisors/Industry contacts:

Henrik Hem Orskaug, Department Head – Mechanical, Aker Solutions Einar Landa, Aker Solutions

Abstract

On a typical oil and gas platform, mechanical equipment units are integral parts of the topside processing system. Heat exchangers, separators, scrubbers, compressors and other equipment units are critical for the proper operation of the processing plant. The hydrocarbon stream received at the first production separator is a mixed stream comprising oil, water and gas phase. This mixed stream is processed in order to separate the oil dominated, water dominated and gas phase.

The processing systems for hydrocarbon separation consists of individual equipment units which are mapped together to form a network along with all the necessary process and operational parameters like inlet and outlet pressure and temperature, flow rates, compositional data and vapour fraction details. Modifying the process parameters on an individual equipment unit, impacts the process and operational parameters of subsequent downstream equipment units. Changing heat exchanger parameters has visible impacts on the operation of downstream equipments and also on the product specifications. Insufficient cooling of the gas stream reduces compressor efficiency, insufficient heating results in lesser quantities of gas bubbling out in the 3 phase separators and also insufficient cooling causes lesser condensate extraction from scrubber units, upstream of the compressor units.

For the varied heating and cooling applications on an oil and gas topside system, shell and tube exchangers, plate frame heat exchangers and printed circuit heat exchangers are the common configurations used in the industry. Shell and tube exchangers have a robust design and can handle most kinds of process fluids across a large pressure and temperature range. Plate frame exchangers are the preferred choice for topside applications compared to shell and tube exchangers considering the cost benefit owing to weight the footprint savings. However, the operating pressure and temperature are a limiting factor for plate frame exchanger applications. Process fluids only within the range of 35 barg and 200°C can be processed in this type of exchanger. Printed circuit heat exchangers are specially designed compact heat exchangers that have a very high heat transfer effective surface area which allows this type of exchanger to handle large heating duty demands. The compact design of printed circuit exchangers gives them a low weight and footprint factor.

While doing thermal design calculations for shell and tube heat exchangers, factors like L/D ratio, RhoV2 factor, vibration factor, shell side and tube side fluid velocity, effective surface area per shell, allowable and actual pressure drop values, heat duty and LMTD need to be analyzed in order to achieve an optimum design of the heat exchanger.

Keywords: hydrocarbon separation, process parameters, heat exchangers, shell & tube, plate frame, printed circuit heat exchangers, thermal design,

Acknowledgement

This Master thesis has been carried out at the Department of Energy and Process Engineering, Norwegian University of Science and Technology alongwith background information and support from Aker Solutions, Oslo.

First of all, I owe my deepest gratitude to my supervisor Professor Jostein Pettersen for providing me with this opportunity to work on this project. His continuous guidance throughout the course of the thesis work especially his technical input and his comments and suggestions were of immense help in framing the report.

I am also extremely grateful to my co-supervisor Henrik Hem Orskaug, Department Head – Mechanical, Aker Solutions for all his support during the project related to background information and technical clarifications.

A special word of appreciation to Einar Landa, Aker Solutions for training me on thermal design of heat exchangers and for all his guidance during the entire thesis work. Einar introduced me to the ASPEN EDR software which is based on the HTFS technology and taught me the thermal designing of heat exchangers using this software.

I would also like to appreciate the support I received from Odd Nesje and Thomas Kompalla at the Process Department in Aker Solutions regarding the development of the HYSYS simulation model for this thesis work.

Table of Contents

Abstrac	ct	i
Acknow	wledg	ementii
Table of	of Con	tents iii
List of	Figur	esvi
List of	Table	s vii
Nomen	clatur	e viii
1.0	Intro	oduction1
1.1	Bac	kground and Objectives1
1.2	Sco	pe of Work1
1.3	Stru	cture of Report2
2.0	Bac	kground on Hydrocarbon Separation and Equipments used4
2.1	Fun	damentals of Hydrocarbon Separation4
2.2	Mec	hanical equipments required in hydrocarbon separation5
2.3	Fun	damentals of Heat Exchanger Selection6
3.0	Proc	cess Description and Equipment Details7
3.1	Proc	cess Description7
3	.1.1	Inlet Arrangement7
3	.1.2	Oil Stabilization and Export7
3	.1.3	Gas Recompression9
3	.1.4	Gas Dehydration10
3	.1.5	Gas Compression for Injection10
3.2	Deta	ails of Major Equipments11
3	.2.1	Inlet Arrangement and Oil Stabilization Train11
3	.2.2	Gas Recompression Train12
3	.2.3	Field 1 Gas Compression and Dehydration Train12
3	.2.4	Field 2 Gas Compression and Dehydration Train13
3.3	Proc	luct Specifications14
3	.3.1	Oil Product Specifications

3.	.3.2	Gas Product Specifications	.14
4.0	Basi	s for Analysis	.15
4.1	Well	Stream Composition	.15
4.2	Cool	ling Medium System	.16
4.	.2.1	Mitigation of Hydrate Formation	.16
4.3	Heat	ing Medium System	.17
5.0	Deve	elopment of HYSYS Simulation Model	.18
5.1	Desi	gn Basis for Hysys Simulation	.18
5.2	Pseu	do Components	.18
5.3	Bina	ry Interaction Parameters	.19
5.4	Stan	dard Equipment Specifications	.20
5.	.4.1	Pressure Drop	.20
5.	.4.2	Pump Efficiencies	.20
5.	.4.3	Compressor Efficiencies	.20
5.5	Meth	nodology of building Hysys Simulation Model	.21
5.	.5.1	Inlet Arrangement	.21
5.	.5.2	Oil Stabilization & Export Oil Train	.24
5.	.5.3	Gas Compression Train	.26
5.	.5.4	Field 1 Injection Gas Compression and Dehydration Train	.28
5.	.5.5	Field 2 Injection Gas Compression and Dehydration Train	.31
5.	.5.6	Deviation from Process Description	.33
5.	.5.7	Determination of Flowrate for Field 1 & Field 2	.34
6.0	Base	Case Simulation Results & Case Studies	.36
6.1	Intro	duction	.36
6.2	Base	Case Simulation Results	.36
6.	.2.1	Modelled Oil Product Specifications	.36
6.	.2.2	Modelled Injection Gas Specifications	.37
6.3	Case	e Study I – Removal of Stabilization Separator Cross Exchanger (20-HB-004)	.39
6.4		e Study II – Feeding Low Temperature Heating Medium to Injection train erheaters (24-HA-102 & 24-HA-202)	.43
6.5	Case	e Study III – Removal of Superheater and Scrubber unit prior to Gas Dehydration	.47

7.0 Th	ermal Calculations of Heat Exchangers	51
	ermal calculations for Inlet Heaters (20-HA-001 & 20-HA-002) – Base Case	U
	ermal Calculations of Superheaters in the Gas Compression Train	
7.2.1	Thermal Calculations of 24-HA-102 & 24-HA-202 – Base Case Design	58
7.2.2	Thermal Calculations of 24-HA-102 & 24-HA-202 – Case Study II	67
7.3 Th	ermal Calculations of Stabilization Separator Heater (20-HA-003)	76
7.3.1	Thermal Calculation of 20-HA-003 – Base Case Design	76
7.3.2	Thermal Calculation of 20-HA-003 – Case Study I	80
7.4 Th	ermal Calculations of Crude Oil Cooler (21-HB-001)	
7.4.1	Thermal Calculations of 21-HB-001 – Base Case Design	
7.4.2	Thermal Calculations of 21-HB-001 – Case Study I	
	ermal Calculations of Field 1 & 2 Dehydration Inlet Coolers (24-HJ-101 & 24	
	1)	
7.5.1	Thermal Calculations of the 24-HJ-101 & 24-HJ-201 – Base Case Design	
7.5.2	Thermal Calculations of the 24-HJ-101 & 24-HJ-201 – Case Study III	
8.0 Di	scussion and Conclusions	
8.1 Di	scussion on optimum design of heat exchangers	107
8.2 Co	nclusions	
9.0 Re	ferences	
Appendix A	A – Process Datasheets for Heat Exchangers in Base Case Simulation	A-1
Appendix E	B – Process Datasheets for Heat Exchangers in Case Study I	B-1
Appendix C	C – Process Datasheets for Heat Exchangers in Case Study II	C-1
Appendix D	D – Process Datasheets for Heat Exchangers in Case Study III	D-1
Appendix E	E – Thermal Calculations for Heat Exchangers in Base Case Design	E-1
Appendix F	F – Thermal Calculations for Heat Exchangers in Case Study I	F-1
Appendix C	G – Thermal Calculations for Heat Exchangers in Case Study II	G-1
Appendix H	I – Thermal Calculations for Heat Exchangers in Case Study III	H-1

List of Figures

- Figure 3.1 : Process Flow Diagram
- Figure 5.1 : HYSYS Simulation Model (Base Case Simulation)
- Figure 5.2 : Inlet Arrangement (Well stream to Inlet Separator) HYSYS model
- Figure 5.3 : Oil Stabilization Train HYSYS model
- Figure 5.4 : Export Oil Train HYSYS model
- Figure 5.5 : Gas Recompression Train (Stage 1) HYSYS model
- Figure 5.6 : Gas Recompression Train (Stage 2) HYSYS model
- Figure 5.7 : Field 1 1st Stage Compression HYSYS model
- Figure 5.8 : Field 1 Dehydration Train HYSYS model
- Figure 5.9 : Field 1 2nd & 3rd Stage Injection Gas Compression HYSYS model
- Figure 5.10 : Field 2 1st Stage Compression HYSYS model
- Figure 5.11 : Field 2 Dehydration Train HYSYS model
- Figure 5.12 : Field 2 2nd & 3rd Stage Injection Gas Compression HYSYS model
- Figure 5.13 : Determination of Field 1 Flowrate
- Figure 5.14 : Determination of Field 2 Flowrate
- Figure 6.1 : Oil Product Specifications from Hysys model
- Figure 6.2 : Field 1 Gas Product Specifications from Hysys model
- Figure 6.3 : Field 2 Gas Product Specifications from Hysys model
- Figure 6.4 : Case Study I Hysys model
- Figure 6.5 : Case Study II Low Temperature Heating Medium to 24-HA-102 Hysys model
- Figure 6.6 : Case Study II Low Temperature Heating Medium to 24-HA-202 Hysys model
- Figure 6.7 : Case Study III Removal of Scrubber and Superheater unit before TEG Contactor 1 Hysys model
- Figure 6.8 : Case Study III Removal of Scrubber and Superheater unit before TEG Contactor 2
- Hysys model

List of Tables

- Table 3.1 : Equipment Details Inlet Arrangement and Oil Stabilization Train
- Table 3.2 : Equipment Details Gas Recompression Train
- Table 3.3 : Equipment Details Field 1 Gas Compression and Dehydration Train
- Table 3.4 : Equipment Details Field 2 Gas Compression and Dehydration Train
- Table 3.5 : Oil Product Specifications
- Table 3.6 : Gas Product Specifications
- Table 4.1 : Wellstream composition for both Field 1 and Field 2 in mole fraction
- Table 5.1 : Properties of Field 1 and Field 2 Pseudo components
- Table 5.2 : Binary Interaction Parameters between components of the wellstream fluid
- Table 5.3 : Equipment pressure drop used in simulations
- Table 5.4 : Compressor Efficiencies
- Table 6.1 : Oil Product Composition from Hysys model
- Table 6.2 : Comparison of exchanger design between Base case & Case study I (20-HA-003)
- Table 6.3 : Comparison of exchanger design between Base case & Case study I (21-HB-001)
- Table 6.4 : Comparison table for 20-HA-003, 21-HB-001 and 20-HB-004 Case Study I
- Table 6.5 : Comparison of exchanger design between Base case & Case study II (24-HA-102)
- Table 6.6 : Comparison of exchanger design between Base case & Case study II (24-HA-102)
- Table 6.7 : Comparison of exchanger design between Base Case & Case study III (24-HJ-101)
- Table 6.8 : Comparison of exchanger design between Base Case & Case study III (24-HJ-201)

Nomenclature

bara	bar absolute
°C	Celcius
TEG	Tri – Ethylene Glycol
BS&W	Basic Sediments and Water
GOR	Gas Oil Ratio
IOR	Increased Oil Recovery
LP	Low Pressure
HP	High Pressure
TVP	True Vapour Pressure
HC	Hydrocarbon
STHE	Shell & Tube Heat Exchanger
CHE	Compact Heat Exchanger
PFHE	Plate & Frame Heat Exchanger
PCHE	Printed Circuit Heat Exchanger
LMTD	Logarithmic Mean Temperature Difference
Sm3/d	Standard cubic meter per day
Sm3/hr	Standard cubic meter per hour
kg/s	Kilograms per second
D	Shell Inner Diameter
L	Tube Length
L/D	Ratio of Tube length to Shell Inner Diameter
TEMA	Tubular Exchanger Manufacturers Association
EDR	Exchanger Design and Rating software
RhoV2	Fluid density (Rho) multiplied by square of Velocity (V^2)

1.0 Introduction

1.1 Background and Objectives

In the offshore oil and gas industry, mechanical equipment units are integral components of all process plants on topside systems. On a typical oil and gas platform, heat exchangers, separators, compressors, pumps, scrubbers etc. are critical components for the proper operation of any hydrocarbon separation process plant. These equipment units are necessary for maintaining the correct process parameters of the different fluid streams flowing through the process system be it crude oil, natural gas, water or any other process stream.

Hydrocarbon separation process systems consist of individual equipment units that are mapped together to form a network alongwith all relevant process and operational parameters like inlet and outlet temperatures of the process streams, inlet pressures of the process streams, pressure drop across the equipments, flow rates, composition and liquid/vapour content of all the process streams. Modifying the process parameters of any particular equipment unit will have any impact on other process and operational parameters downstream of that equipment as well as on the utility systems (power, cooling medium system and heating medium system). Changing the process design by too large an extent can lead to the production of off-spec product. Avoiding the situation wherein we produce off-spec product at the outlet is a major constraint.

For a typical oil and gas platform, heat exchangers, separators and other mechanical equipment units are generally designed based on the process datasheets. These process datasheets are provided by the process designers to the equipment engineers who design these equipment units for the specified process and operatability range. The required process and operation range sometimes leads to a very non-ideal and non-economical design of heat exchangers mainly with respect to inlet and outlet temperatures, heat duty, weight and footprint factor. Eventually nonoptimum design leads to increased cost factors.

The main objective of this thesis work is to explore the possibilities for more favourable design of heat exchangers within the specified constraints on the process parameters.

1.2 Scope of Work

The main focus of this Master's thesis is to manipulate the process parameters of the process and the heat exchangers and then evaluate the impact in order to achieve a more favourable equipment design. Basis for the work in terms of typical process flow diagram with heat and material balances, as well as relevant heat exchanger specifications was provided by Aker Solutions. The following tasks were considered as part of this thesis work:

- 1. Relevant background information on production processes for oil and gas processing was studied with emphasis on the mechanical equipments especially heat exchangers.
- 2. Develop a model of the main production process (separation and compression) in HYSYS. The model will contain all the necessary mechanical equipment units with relevant process parameters.

- 3. An analysis of the model by manipulating the process parameters of the heat exchanger units and then studying the impact of this change on other mechanical equipment units and process parameters. The analysis needs to consider the constraints like off-spec products caused by changes in the process parameters of the heat exchangers.
- 4. Based on the process parameters of the heat exchanger units, thermal design calculations shall be conducted for the relevant heat exchanger using the design software Aspen Exchanger Design and Rating (ASPEN EDR). The thermal design calculations of the relevant heat exchangers with the modified process parameters shall also be conducted using Aspen EDR.
- 5. Develop a generic understanding of how the process design and the thermal calculations for the heat exchangers influence the selection of the type and the mechanical design of the heat exchangers.
- 6. Conclusions, with recommendations for further work.

1.3 Structure of Report

This report begins with an introduction to hydrocarbon separation providing information about the separation process of a mixed stream containing the oil, water and gas phase. This chapter also provides an overview of the major equipments that are part of the process design of a topside hydrocarbon separation system in the offshore oil and gas industry with a special emphasis on the heat exchangers that are part of the processing system.

Chapter 3 contains the Process Flow Diagram alongwith a detailed description of each of sections in the process design – Inlet Arrangement train; Oil Separation, Stabilization and Export train; Gas Recompression train; Gas Dehydration train and the Gas Compression and Injection train. This chapter also contains a detailed list of all the major equipments in the hydrocarbon separation process design which includes the equipment tag numbers, equipment title and the type of equipment. The oil and gas product specifications are also provided in this chapter.

Chapter 4 provides the basis for the analysis that is conducted as part of this thesis work. The wellstream composition that is used in the Hysys simulation model is given in this chapter. The details of the heating medium and cooling medium systems which are critical the heat exchangers in the process design are also included in this chapter.

In Chapter 5, the development of the Hysys simulation model is explained in detail providing information about the design basis, pseudo components, binary interaction parameters and the standard specifications for all major equipments. In this chapter, the development of the Hysys model of each process train (inlet arrangement, oil separation, gas recompression, gas dehydration and gas compression and injection) is discussed in detail.

Chapter 6 covers the simulation results of the base case design giving details of the oil and gas product specifications. The 3 case studies that are conducted as part of this thesis work are explained in detail in this chapter also.

Chapter 7 contains the thermal design calculations of the relevant exchangers in the base case scenario followed by the thermal calculations of the exchangers that are redesigned owing to changes in the process parameters. In this chapter, as part of the thermal design, the TEMA specification sheet of exchanger alongwith the setting plan and tube layout is provided. The remaining details of the thermal design are given in the Appendix section of this report.

2.0 Background on Hydrocarbon Separation and Equipments used

2.1 Fundamentals of Hydrocarbon Separation

The hydrocarbon stream received at the inlet manifold of most topside oil and gas processing systems comprise oil, gas, water and contaminants that need to be separated and processed (Devold 2006). The hydrocarbon stream received at the first production separator is given a certain retention time for the gas phase to bubble out, the heavier aqueous phase to settle at the bottom of the equipment unit and for the oil dominated phase to stabilize in the middle between the aqueous and gas phase. Certain amount of carry-over occurs during the separation process wherein traces of the other phases are mixed in main oil, water and gas phase.

The oil stream is heated and sent downstream to the subsequent separator units for further separation and stabilization. The heating of this stream is done in order to vapourize the lighter hydrocarbon which are then extracted in the subsequent separators and routed to the gas processing train. The heating up is also done to achieve the required vapour pressure specifications of the product stream at the outlet of the final separator. The oil stream is also routed through filter units and electrostatic coalescers in order to remove the solid and liquid contaminants and to meet the necessary specifications. The final oil product stream after pressurization and cooling to 'export oil specifications' can either be loaded onto tankers or transported through subsea pipelines to terminals or refinery sites onshore.

The main objective of processing the gas stream on a topside system is to make the fluid meet the export or injection specifications. The typical gas processing includes modifying the hydrocarbon dew point, removal of acid gas, dehydration and finally export compression. The only way to modify the hydrocarbon dewpoint of the gas is to either add or remove the heavier hydrocarbon components from the mixture. In the 'Compression-Cooling-Separation' technique, the compressed gas is cooled and the heavier components which have condensed are extracted in scrubber units while the gas stream is routed downstream for further compression. This is repeated till the required dewpoint specification is achieved. The dehydration process is done to meet the water dewpoint specification to ensure that no water condenses out during transportation. Typically a glycol solution like Tri-Ethylene Glycol is used to absorb the water content and then the TEG solution is regenerated to obtain the original purity. The content of acid gas (CO_2 and H_2S) needs to be reduced to the acceptable level since these gases have no heating value and can also be dangerous for the end consumer. An amine based solution in a contactor unit is generally used to control the acid gas content.

The water separated at the first production separator, is routed to the produced water system and depending on the stringency on the produced water specifications, the water is either processed to meet the specifications or else the return flow is routed back to the sea.

2.2 Mechanical equipments required in hydrocarbon separation

A typical offshore oil and gas separation and processing system comprises 3-phase separators, heat exchangers, scrubbers, pumps, compressors, turbines, storage tanks, flare units and a variety of other mechanical equipment units. The quantum of equipment units depend upon the extent of processing that the oil and gas streams need to be subjected to.

The hydrocarbon streams are generally received at the production separators for the initial processing. These three phase separators are typically gravity type wherein the separation process is based on the density of each phase (Devold 2006). The main objective is to achieve maximum liquid recovery alongwith stabilized oil and gas and to separate out the water. Such separator units have a typical retention time of 5 minutes during which the gas phase bubbles out of the hydrocarbon stream, the aqueous phase being heaviest settles at the bottom and oil phase is extracted from the middle section. Certain internals are fitted inside the separator unit which are typically proprietary design and are fitted to ensure maximum phase separation. A large pressure drop across one separator unit is avoided in order to ensure that flash vaporization does not occur.

Downstream of the separator, the oil and gas streams are generally heated or cooled in heat exchangers depending on the process design of the topside system. These heat exchangers can be shell and tube type, plate type or printed circuit type with the first 2 types being most common. In shell and tube exchangers, the process fluid and the heating/cooling medium passes through tubes or around the tubes inside a cylindrical shell. While in plate and frame exchangers, the process fluid and heating/cooling medium flows in opposite directions between alternating plates. The heat exchangers heat or cool down the process fluid either by direct or by indirect heat transfer. In indirect heat transfer the process fluid is heated or cooled against a heating or cooling medium which in turn is heated or cooled in subsequent heat exchangers against hot flue gas or sea water respectively. Indirect cooling is preferred in low temperature ambient conditions in order to prevent freeze out.

The cooled down gas may contain traces of mist and other liquid particles. Before being routed to the compressor unit, the condensed liquid needs to be extracted in order to avoid erosion of the rotary compressor blades. The separation of the liquid and gas phases from the 2-phase process fluid is done in a scrubber unit. The scrubber unit has specially designed trays installed inside the equipment which increases the surface contact of the process fluid with the trays. Large number of gas traps cause the gas to bubble up through the liquid and flow to the top of the vessel while the heavier liquid droplets coalesce and flow downwards. This equipment helps in extracting the heavier hydrocarbons in liquid phase while the gas phase routed downstream comprises lighter hydrocarbons.

The reservoir stream received at the inlet separator has a pressure level depending on the downhole pressure of the reservoir. As the oil dominated phase flows downstream, pressure loss occurs across every equipment unit as well as in the pipelines. After some point in the process flow, the pressure needs to be boosted for the oil stream to continue flowing through the process

train. Centrifugal and screw pumps are used for boosting the pressure of the oil stream upto the required levels so that the hydrocarbon stream can either flow through the remaining process train or the stabilized oil stream can be transported through pipeline to shore.

The gas stream after undergoing multiple processing stages for CO_2 and H_2S removal, dehydration, meeting cricondenbar specifications can either be transported to shore through pipeline or be re-injected into the reservoir for maintaining downhole pressure. In both these cases the gas needs to be pressurized upto a certain point which is done using turbine or motor driven compressors. Depending on the flowrate of either export gas or injection gas and the required pressure levels, reciprocating compressors, screw compressor or centrifugal compressors can be chosen for the necessary application.

2.3 Fundamentals of Heat Exchanger Selection

For handling the variety of process fluids, shell and tube heat exchangers, plate frame heat exchangers and printed circuit heat exchangers are the common configurations that find application on a typical oil and gas processing topside system.

Shell and tube exchangers are the most commonly used configuration in the process industry. These exchangers have a highly robust design and can handle most kinds of process fluids. Also shell and tube exchangers can operate in the wide pressure and temperature range (Ludwig 1997). However, for meeting the required heat duty demand, the designed exchanger can sometimes have extreme dimensions resulting in high weight and footprint values which are not preferable for offshore process plants. These exchangers are designed according to the TEMA specifications.

Considering the limitation of weight and footprint on topside systems, plate frame exchangers are definitely the preferred choice provided the operating pressure and temperature range permits. Plate frame exchangers can be designed for pressure ranges upto 35 barg and the temperature limit for these exchangers is 200°C. Even though plate and frame exchangers are more expensive than the conventional shell and tube exchangers, the cost benefit from weight and footprint savings is quite substantial and therefore makes these exchangers the preferred choice.

Printed circuit heat exchangers (PCHE's) are specialized heat exchangers which are chosen when plate frame exchangers are not a feasible option owing to the pressure and temperature constraint and the design of the shell and tube exchangers is non-optimum. These exchangers have a specialized circuit design wherein the effective surface area is very high which accounts for very high heat transfer with a compact equipment design. Even though the cost benefit from weight and footprint saving is substantially high if a shell and tube exchanger is replaced with a printed circuits exchanger, these exchangers are very expensive owing to proprietary design. Each compact unit can handle a high heat transfer between the hot and cold side streams.

3.0 Process Description and Equipment Details

3.1 Process Description

This chapter describes in detail the process design for the hydrocarbon separation. The total process design description is split into sub-sections each explaining one process train.

3.1.1 Inlet Arrangement

The feed flow from Field 1 is received from four flow lines and mixed in the Field 1 manifold before being routed downstream through the Field 1 Inlet Heater (20-HA-002).

The feed flow from Field 2 is received from two flow lines and mixed in the Field 2 manifold before being routed downstream through the Field 2 Inlet Heater (20-HA-001).

3.1.2 Oil Stabilization and Export

The well fluid from the multiple reservoirs received at the Field 1 and Field 2 manifolds is heated in dedicated heaters upstream of the Inlet Separator (20-VA-001). The hydrocarbon from Field 1 and Field 2 is heated in the Field 1 Inlet Heater (20-HA-002) and Field 2 Inlet Heater (20-HA-001) respectively. The fluid from the individual fields are not mixed before heating because the temperature of one wellstream may be lower than the other which may result in lowering the wax appearance temperature of the mixed fluid. Both the inlet heaters heat the hydrocarbon streams to achieve an outlet temperature of 55° C. This outlet temperature is decided based on the wax disappearance temperatures for the hydrocarbon stream.

The data received from Aker Solutions mentions that the presence of wax is observed in the range of 3.7% - 7.9%. The wax appearance temperature is estimated within the range of 25° C and 38° C while wax disappearance temperature is estimated within the range of 48.5° C and 54.7° C. The hydrocarbon stream also flows through 6 to 8 kms of flowlines in a cold water environment of 4° C - 8° C at sea bottom. The low ambient temperature tends to lower the wellstream temperature thereby bringing it closer to the wax appearance temperature. This emphasizes the need for the inlet heaters. The required heating of the well fluid would ensure that the dissolved wax does not hamper the hydrocarbon separation process.

The well fluid is therefore heated to 55°C to avoid any precipitation of wax in the Inlet Separator. The Inlet Separator is a 3-phase separator which is operated at a pressure of 15 bara and a temperature range of 45°C to 55°C. It is specified to have a heavy liquid in light liquid of 5 vol-%. In the HYSYS model, the separator is designed to have a carry-over setup on the product basis of 5 vol% water in oil to meet the required specification. From the inlet separator, the oil is routed downstream for stabilization, the water is directed to the produced water system and the gas is routed to the dehydration and injection compression train.

Downstream of the inlet separator, the oil is directed to the 2^{nd} Stage Separator (20-VA-002) passing through 2 heaters – Stabilization Separator Cross Heat Exchanger (20-HB-004) and Stabilization Separator Heater (20-HA-003).

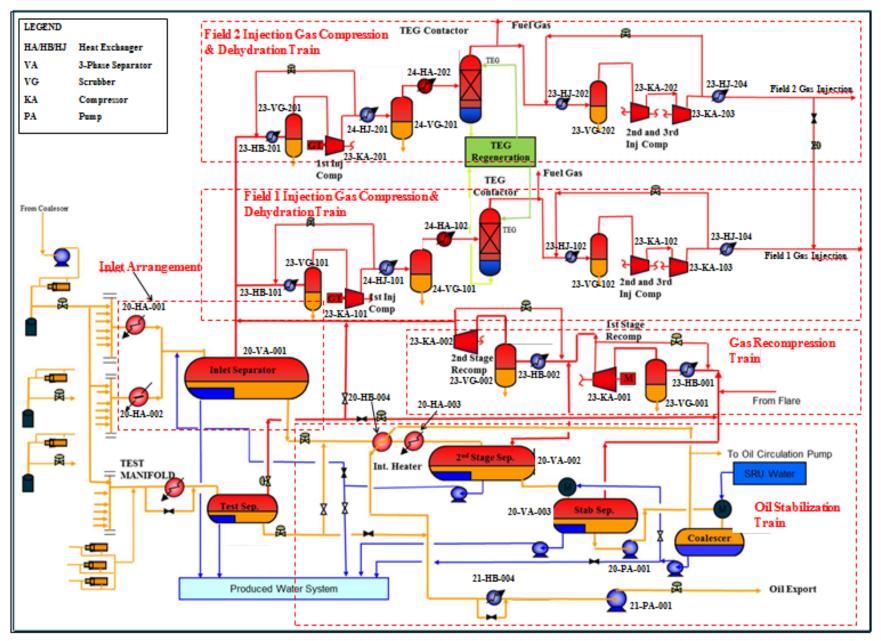


Figure 3.1 : Process Flow Diagram

In the Cross Exchanger, the heat from the stabilized oil is integrated into the stabilization process by heating the oil from the inlet separator against the high temperature stabilized oil. Downstream the cross exchanger, the outlet temperature of the oil from the Stabilization Heater is adjusted to obtain the vapour pressure of the final oil product. Out of the Stabilization Heater, the oil is routed to the 2nd Stage Separator, a 3-phase separator which is operated at an intermediate pressure of 7 bara and at a temperature between 75°C and 80°C to obtain the required vapour pressure. This separator is specified to have a heavy liquid in light liquid of 5 vol-%. Also for this separator, In the HYSYS model, the separator is designed to have a carry-over setup on the product basis of 5 vol% water in oil to meet the required specification. From this separator, the water is again routed to the produced water system while the gas directed towards the recompression train.

Downstream of the 2nd Stage Separator, the pressure of the hydrocarbon is reduced and directed to the Stabilization Separator (20-VA-003). This separator is also a 3-phase separator which is operated at a low pressure of 2 bara. The pressure of this separator is kept as low as possible whilst still maintaining sufficient pressure to route the gas to the inlet of the recompression train. The temperature of this separator is determined by the temperature of liquid hydrocarbon exiting the 2nd stage separator. This separator is specified to have a heavy liquid in light liquid of 2 vol-%. In the HYSYS model, the separator is designed to have a carry-over setup on the product basis of 2 vol% water in oil to meet the required specification. The required vapour pressure specification of the final oil product is reached in the Stabilization Separator. The water from the stabilization separator is also routed to the produced water system. The gas from this separator enters the first compression stage of the recompression train.

The high temperature stabilized oil is pumped from the outlet of the stabilization separator to an Electrostatic Coalescer where the final water removal is done to meet the oil product specifications. This equipment though a part of the process flow diagram, is not included in the simulation model since it does not affect the process parameters for the heat exchangers or the total heat and mass transfer of the entire system. Downstream of the coalescer, the stabilized oil is routed through the cross exchanger for heating the oil stream from the inlet separator. After the cross exchanger, the stabilized oil stream enters the Crude Oil Cooler (21-HB-001) where it is cooled to a temperature in the range of 55° C to 60° C. Downstream of the crude oil cooler, the final oil product is pumped by the Export Oil Pumps (21-PA-001A/B/C) to the export pressure of 187 bara. The outlet temperature of the Crude Oil Cooler is adjusted so as to achieve an Export Oil temperature of 60° C.

3.1.3 Gas Recompression

The gas that is extracted from the stabilization system $(2^{nd}$ Stage Separator and Stabilization Separator) is routed to the gas recompression train for recompression to 15 bara through 2 stages before it is merged with the gas from the Inlet Separator.

The gas from the Stabilization Separator enters the recompression train at the pressure and temperature of that separator. It is cooled in the 1st Stage Recompression Suction Cooler (23-HB-001) to 28°C before being scrubbed in the 1st Stage Recompression Suction Scrubber (23-VG-001). The gas is routed to the 1st Stage Recompressor (23-KA-001) where it is compressed to an intermediate pressure of 6 bara. The compressed gas is mixed with the gas extracted from the 2nd Stage Separator and then routed to the 2nd Stage Recompression Suction Cooler (23-HB-002). The mixed gas is cooled down to 28°C before being scrubbed in the 2nd Stage Recompression Suction Cooler (23-HB-002). The mixed gas is cooled down to 28°C before being scrubbed in the 2nd Stage Recompression Scrubber (23-VG-002). The gas from the scrubber is sent downstream to the 2nd Stage Recompressor (23-KA-002) where it is compressed to 15 bara and then mixed with the gas from the inlet separator.

The liquid from the 1st and 2nd Stage Recompression Scrubbers are routed to the Stabilization Separator to integrate the extracted heavy hydrocarbons back into the process.

3.1.4 Gas Dehydration

The gas from Field 1 & 2 is dehydrated using Tri-Ethylene Glycol (TEG) by the Absorption process. Field 1 and Field 2 gas compression trains have individual dehydration towers (TEG contactors) but a common TEG Regeneration unit. The dehydration section of both trains is located in between the 1^{st} and 2^{nd} gas compression stages.

The compressed gas from the Field 1 1st Stage Injection Compressor (23-KA-101) is cooled to 25°C in the Field 1 Dehydration Inlet Cooler (24-HJ-101). Any condensed liquid is removed in the Field 1 Dehydration Scrubber (24-VG-101) downstream of the cooler. The gas extracted from the scrubber is superheated by 3°C in the Field 1 Dehydrator Inlet Superheater (24-HA-102) before routing it to the Field 1 TEG Contactor.

The compressed gas from the Field 2 1st Stage Injection Compressor (23-KA-201) is cooled to 25°C in the Field 2 Dehydration Inlet Cooler (24-HJ-201). Any condensed liquid is removed in the Field 2 Dehydration Scrubber (24-VG-201) downstream of the cooler. The gas extracted from the scrubber is superheated by 3°C in the Field 2 Dehydrator Inlet Superheater (24-HA-202) before routing it to the Field 2 TEG Contactor.

The superheating is done to avoid the gas being at dew point condition at the inlet of the contactor which could result in some condensation of hydrocarbon inside the contactor. The contactor is operated in the temperature range of approximately $30^{\circ}C - 33^{\circ}C$ since the efficiency of the absorption process is quite high at that temperature range.

Liquid extracted from the scrubbers in the dehydration section of both the trains is routed to the inlet separator.

3.1.5 Gas Compression for Injection

The gas extracted from the well fluid in the Inlet Separator alongwith the gas extracted from the oil stabilization train is compressed in two compression trains before being injected back into the field reservoir. Gas compression for both the fields consists of three compression stages with

suction cooling, scrubbing and after-cooling in each train. The 2^{nd} and 3^{rd} stage injection compressors are configured into a back-to-back arrangement on a single shaft assembly in the same casing.

The gas from the Inlet Separator entering the Field 1 compression train is cooled to 28° C in the Field 1 1st Stage Injection Suction Cooler (23-HB-101). The condensed liquid is removed in the 1st Stage Injection Scrubber (23-VG-101) and the gas is sent downstream to the Field 1 1st Stage Injection Compressor (23-KA-101) to be compressed to 50.3 bara. The gas is then routed to the dehydration section for water removal depending on the product specifications for the injection gas. Downstream of the dehydration section, the gas exiting the TEG contactor is cooled in the Field 1 2nd Stage Gas Injection Suction Cooler (23-HJ-102) to 25°C. The condensed liquids are extracted in the Field 1 2nd Stage Injection Scrubber (23-VG-102) and the gas is routed to the Field 1 2nd Stage Injection Compressor (23-KA-102). The discharge pressure of 23-KA-102 is set to 83 bara and the gas is then routed to the Field 1 3rd Stage Injection Compressor (23-KA-103) where it is compressed to the gas injection pressure of 161 bara. Downstream the 3rd stage compressor, the gas is cooled in the Field 1 3rd Stage Gas Injection After Cooler (23-HJ-104) to the gas injection temperature of 60°C.

The gas from the Inlet Separator entering the Field 2 compression train is cooled to 28° C in the Field 2 1st Stage Injection Suction Cooler (23-HB-201). The condensed liquid is removed in the 1st Stage Injection Scrubber (23-VG-201) and the gas is sent downstream to the Field 2 1st Stage Injection Compressor (23-KA-201) to be compressed to 52.3 bara. The gas is then routed to the dehydration section for water removal depending on the product specifications for the injection gas. Downstream of the dehydration section, the gas exiting the TEG contactor is cooled in the Field 2 2nd Stage Gas Injection Suction Cooler (23-HJ-202) to 25°C. The condensed liquids are extracted in the Field 2 2nd Stage Injection Scrubber (23-VG-202) and the gas is routed to the Field 2 2nd Stage Injection Compressor (23-KA-202). The discharge pressure of 23-KA-202 is set to 94 bara and the gas is then routed to the Field 2 3rd Stage Injection Compressor (23-KA-203) where it is compressed to the gas injection pressure of 207 bara. Downstream the 3rd stage compressor, the gas is cooled in the Field 2 3rd Stage Gas Injection After Cooler (23-HJ-204) to the gas injection temperature of 60°C.

3.2 Details of Major Equipments

This section gives a detailed list of all major equipments in the process design including tag numbers, equipment names and type of each equipment. The process flow diagram given in the previous section is divided into 4 main trains depending on the process occurring in each train. The equipment tag numbers are listed based on the type of equipments in each process train.

3.2.1 Inlet Arrangement and Oil Stabilization Train

Equipment details for the inlet arrangement and oil stabilization and separation train is given in Table 3.1.

Sl.	Tag	Equipment Name	Equipment Type			
No.	Number					
1	20-HA-001	Field 2 Inlet Heater	Shell & Tube Exchanger			
2	20-HA-002	Field 1 Inlet Heater	Shell & Tube Exchanger			
3	20-HA-003	Stabilization Separator Heater	Shell & Tube Exchanger			
4	20-HB-004	Stabilization Separator Cross Heat Exchanger	Shell & Tube Exchanger			
5	21-HB-001	Crude Oil Cooler	Shell & Tube Exchanger			
6	20-PA-001	Oil Booster Pump	Screw Pump			
7	21-PA-001	Oil Export Pump	Screw Pump			
8	20-VA-001	Inlet Separator	3-Phase Separator			
9	20-VA-002	2 nd Stage Separator	3-Phase Separator			
10	20-VA-003	Stabilization Separator	3-Phase Separator			

 Table 3.1 : Equipment Details – Inlet Arrangement and Oil Stabilization Train

3.2.2 Gas Recompression Train

Equipment details for the gas recompression train is given in Table 3.2.

Sl. No.	Tag Number	Equipment Name	Equipment Type
1	23-HB-001	1 st Stage Recompressor Inlet Cooler	Shell & Tube Exchanger
2	23-HB-002	2 nd Stage Recompressor Inlet Cooler	Shell & Tube Exchanger
3	23-KA-001	1 st Stage Recompressor	Centrifugal Compressor
4	23-KA-002	2 nd Stage Recompressor	Centrifugal Compressor
5	23-VG-001	1 st Stage Recompressor Scrubber	Scrubber
6	23-VG-002	2 nd Stage Recompressor Scrubber	Scrubber

3.2.3 Field 1 Gas Compression and Dehydration Train

Equipment details for the Field 1 Gas Compression and Dehydration train is given in Table 3.3.

Sl. No.	Tag Number	Equipment Name	Equipment Type
1	23-HB-101	Field 1 1 st Stage Injection Suction Cooler	Compact Heat Exchanger
2	24-HJ-101	Field 1 Dehydration Inlet Cooler	Compact Heat Exchanger
3	24-HA-102	Field 1 Dehydrator Inlet Superheater	Shell & Tube Exchanger
4	24-HJ-102	Field 1 2 nd Stage Gas Injection Suction Cooler	Compact Heat Exchanger
5	23-HJ-104	Field 1 3 rd Stage Gas Injection After Cooler	Compact Heat Exchanger
6	23-KA-101	Field 1 1 st Stage Injection Compressor	Centrifugal Compressor
7	23-KA-102	Field 1 2 nd Stage Injection Compressor	Centrifugal Compressor
8	23-KA-103	Field 1 3 rd Stage Injection Compressor	Centrifugal Compressor
9	23-VG-101	Field 1 1 st Stage Injection Scrubber	Scrubber
10	24-VG-101	Field 1 Dehydration Scrubber	Scrubber
11	23-VG-102	Field 1 2 nd Stage Injection Scrubber	Scrubber

 Table 3.3 : Equipment Details – Field 1 Gas Compression and Dehydration Train

3.2.4 Field 2 Gas Compression and Dehydration Train

Equipment details for the Field 2 Gas Compression and Dehydration train is given in Table 3.4.

Table 3.4 : Equipment Details – Field 2 Gas Compression and D	Dehydration Train
---	--------------------------

Sl. No.	Tag Number	Equipment Name	Equipment Type
1	23-HB-201	Field 2 1 st Stage Injection Suction Cooler	Compact Heat Exchanger
2	24-HJ-201	Field 2 Dehydration Inlet Cooler	Compact Heat Exchanger
3	24-HA-202	Field 2 Dehydrator Inlet Superheater	Shell & Tube Exchanger
4	24-HJ-202	Field 2 2 nd Stage Gas Injection Suction Cooler	Compact Heat Exchanger
5	23-HJ-204	Field 2 3 rd Stage Gas Injection After Cooler	Compact Heat Exchanger
6	23-KA-201	Field 2 1 st Stage Injection Compressor	Centrifugal Compressor
7	23-KA-202	Field 2 2 nd Stage Injection Compressor	Centrifugal Compressor
8	23-KA-203	Field 2 3 rd Stage Injection Compressor	Centrifugal Compressor
9	23-VG-201	Field 2 1 st Stage Injection Scrubber	Scrubber
10	24-VG-201	Field 2 Dehydration Scrubber	Scrubber
11	23-VG-202	Field 2 2 nd Stage Injection Scrubber	Scrubber

3.3 Product Specifications

The product specifications for both the oil product and the gas product are listed in this section.

3.3.1 Oil Product Specifications

Oil product specifications are given in Table 3.5.

	-	
Specification	Unit	
Field 1 Oil Production	Sm ³ /d	15000
Field 2 Oil Production	Sm ³ /d	17000
Export Oil Pressure	bara	187.5
Export Oil Temperature	°C	60.0
True Vapour Pressure (TVP) @ 30 °C	Bara	0.965
Basic Sediment and Water (BS&W)	%	< 0.5

Table 3.5 : Oil Product Specifications

3.3.2 Gas Product Specifications

Gas product specifications are given in Table 3.6.

Table 3.6 : Gas Product Specifications

Specification	Unit	
Field 1 Injection Gas Production	kg/hr	956500
Field 1 Gas Injection Pressure	bara	160
Field 1 Gas Injection Temperature	°C	60
Field 2 Injection Gas Production	kg/hr	1084000
Field 2 Gas Injection Pressure	bara	206
Field 2 Gas Injection Temperature	°C	60

Since the gas is only meant for re-injection into the Field 1 and Field 2 reservoirs, there is no cricondenbar specification for the gas product.

4.0 Basis for Analysis

This chapter gives details of the wellstream composition that has been used as the basis for developing the Hysys simulation model. It also contains information on the heating medium and the cooling medium systems that is critical for the designing of the heat exchanger units on the topside system.

4.1 Well Stream Composition

This section gives the composition of the well fluid entering the inlet separator from both the fields. The well stream compositions received from Aker Solutions vide email dated 11-Feb-2014 is given in Table 4.1.

Component	FIELD 1	FIELD 2	
	Mole Fraction	Mole Fraction	
H ₂ 0	0.8633	0.8291	
Nitrogen	0.0016	0.0019	
Carbon Dioxide (CO ₂)	0.0020	0.0027	
Methane	0.1102	0.1380	
Ethane	0.0091	0.0117	
Propane	0.0046	0.0059	
i-Butane	0.0007	0.0010	
n-Butane	0.0013	0.0018	
i-Pentane	0.0004	0.0005	
n-Pentane	0.0004	0.0005	
n-Hexane	0.0003	0.0004	
C7*	0.0003	0.0005	
C8*	0.0003	0.0007	
C9*	0.0002	0.0005	
C10 – C20*	0.0034	0.0032	
C21 – C28*	0.0010	0.0009	
C29*+	0.0009	0.0009	
Total Mole Fraction	1.0000	1.0000	

 Table 4.1 : Wellstream composition for both Field 1 and Field 2 in mole fraction

4.2 Cooling Medium System

The cooling medium system is designed to provide cooling duty by supplying low temperature cooling medium to all the process coolers. The cooling medium used for the designed system is a mixture of 45% TEG and 55% Water with the intention of avoiding any freezing of the cooling medium at the minimum ambient temperature of -16° C.

The cooling medium system is a closed loop system wherein the low temperature cooling medium is circulated to the process coolers at a temperature of 15° C. The cooling medium is circulated by three Cooling Medium Circulation Pumps (40-PA-001 A/B/C). The pumps operate in a 2+1 configuration where 2 pumps are working pumps and 1 pump is a stand-by pump.

The warm cooling medium from all the process coolers returns at about 60° C. This return flow is cooled down in two stages.

- In the first stage, part heat from the cooling medium is extracted in the Winterization Heaters. This heat is used for heating purposes on a typical oil and gas platform.
- In the second stage, the remaining heat is extracted in the Cooling Medium Coolers (40-HB-001 A/B/C/D) where sea water is used to cool down the cooling medium to the temperature of 15°C to be recirculated to the process coolers.

The system also includes a Cooling medium Expansion Tank (40-VL-001) which allows for the changes in the volume of the cooling medium. This is required to account for the liquid expansion and contraction resulting for the changes in temperature of the cooling medium.

The Cooling Medium Circulation Pumps, Winterization Heaters and Cooling Medium Coolers are not mentioned in the equipment list since the cooling medium system is not included in the simulation model.

4.2.1 Mitigation of Hydrate Formation

Hydrates are ice like structures which are formed when free water exists and the wellstream condition are within the hydrate formation area (TEP 4185, 2012). Owing to drop in the wellstream temperature, water tends to condense out from the gas and this free water phase causes the hydrates to form.

In both the gas compression and dehydration trains, since we have wet gas in the process stream it is important to check that we are above the hydrate formation temperature at all the wet gas locations. In the Dehydration Inlet Coolers (24-HJ101 & 24-HJ-201) the hydrate formation temperature is noted to be close to 18° C. For all the other exchangers in the compression and dehydration trains where wet gas is a process fluid, the hydrate formation temperature is lower than inlet temperature of the cooling medium (15° C).

To ensure hydrate mitigation, the inlet temperature of the cooling medium to the dehydration coolers is set to 20°C. This is achieved by blending the cooling medium inlet to the dehydrators with a certain proportion of the warm cooling medium from the return line. The mixing operation

is controlled based on the feedback from the temperature indicators on the cooling medium inlet line upstream the dehydrators.

4.3 Heating Medium System

Similar to the cooling medium system, the heating medium system is designed to provide heating duty by supplying high temperature heating medium to all the process heaters. The heating medium used for the designed system is a mixture of 45% TEG and 55% Water with the intention of avoiding any freezing of the cooling medium at the minimum ambient temperature of -16° C.

The heating medium system is a closed loop system wherein the high temperature heating medium is circulated to the process heaters at a temperature of 150° C. The heating medium is circulated by three Heating Medium Circulation Pumps (41-PA-001 A/B/C). The pumps operate in a 2+1 configuration where 2 pumps are working pumps and 1 pump is a stand-by pump.

The cold heating medium from all the process coolers returns at about 100°C. This return flow is heated up in two stages.

- In the first stage, the return flow is heated in the Waste Heat Recovery Units on the Power Generator Turbine Exhaust
- In the second stage, the remaining heating up process is done in the Waste Heat Recovery Units of the Field 1 and Field 2 Gas Injection Compressor Turbine Exhausts (41-HW-101 & 41-HW-201) where the temperature of the heating medium is increased to 150°C before being recirculated to the process heaters.

The system also includes a Heating Medium Expansion Tank (41-VL-001) which allows for the changes in the volume of the heating medium. This is required to account for the liquid expansion and contraction resulting for the changes in temperature of the heating medium.

The Heating Medium Circulation Pump and Waste Heat recovery Units are not mentioned in the equipment list since the heating medium system is not included in the simulation model.

5.0 Development of HYSYS Simulation Model

The Hysys simulation model of the process is developed based on the process description given in Section 3.1. The simulation model also comprises four main sections – oil stabilization, gas compression, gas dehydration and finally injection gas compression. This chapter gives in detail the design basis and the development of the simulation model.

5.1 Design Basis for Hysys Simulation

The simulation model for the process is developed as a 'steady state' simulation model using Hysys version 8.3.

The fluid package used for the simulation model is the Soave – Redlich – Kwong (SRK) equation of state alongwith a 'Costald' density option.

5.2 Pseudo Components

Certain pseudo components are created based on the compositional data of the well fluid from both Field 1 and Field 2. The characterization of these pseudo components has been done using PVTsim and the properties of the pseudo components are given in Table 5.1.

Component	Normal	Molecular	Liquid	Critical	Critical	Ac Factor
Name	Boiling	Weight	Density	Temperature	Pressure	
	Point	(MW)	-	(Tc)	(Pc)	
	(NBP)					
	°C		Kg/m ³	°C	bar	
C7*	91,95	96,00	738,0	262,18	31,95	0,4679
C8*	116,75	107,00	765,0	271,27	31,39	0,4999
C9*	142,25	121,00	781,0	293,30	29,89	0,5399
C10 – C12*	187,12	146,49	802,8	330,78	26,64	0,6130
C13 – C15*	246,36	189,37	829,6	382,38	22,23	0,7272
C16 – C17*	291,23	229,15	848,0	422,16	19,37	0,8255
C18 - C20*	324,78	262,25	863,4	449,21	17,64	0,9035
C21 – C24*	367,86	309,70	881,9	483,73	15,83	1,0069
C25 – C28*	412,38	364,82	900,0	518,59	14,36	1,1124
C29 – C34*	456,91	433,20	918,7	556,98	13,11	1,2206
C35 – C43*	510,80	533,39	941,5	605,55	11,90	1,3267
C44 - C80*	606,40	738,25	977,9	691,06	10,79	1,2841

 Table 5.1 : Properties of Field 1 and Field 2 Pseudo components

5.3 Binary Interaction Parameters

In the various equations of state (EOS), the Binary Interaction Parameter (BIP) is used to analyze the extent of non-ideality in a binary mixture (Jaubert and Privat 2010).

The BIP values of Nitrogen and CO_2 towards the pseudo components are not the standard Hysys values and are given in Table 5.2. All remaining BIP's used for the simulation are the standard Hysys values. For all HC – HC binary mixtures, the BIP values are assumed to be zero.

	H ₂ 0	Nitrogen	CO ₂	H ₂ S
	1120	-		_
H ₂ 0	—	-0,4907	0,0392	0,0829
Nitrogen	-0,4907	_	0,0171	0,1588
Carbon Dioxide (CO ₂)	0,0392	-0,0171	_	0,115
H ₂ S	0,0829	0,1588	0,115	_
Methane	0,5	0,03119	0,0956	0,08879
Ethane	0,5	0,03119	0,1401	0,08619
Propane	0,4819	0,0886	0,1368	0,0925
i-Butane	0,518	0,1315	0,1368	0,056
n-Butane	0,518	0,0597	0,1412	0,0626
i-Pentane	0,5	0,093	0,1297	0,06499
n-Pentane	0,5	0,09359	0,1347	0,0709
n-Hexane	0,5109	0,165	0,142	0,057
C7*	0,5	0,08	0,1	0,045
C8*	0,5	0,08	0,1	0,045
C9*	0,5	0,08	0,1	0,045
C10 – C12*	0,5	0,08	0,1	0,045
C13 – C15*	0,5	0,08	0,1	0,045
C16 – C17*	0,5	0,08	0,1	0,045
C18 – C20*	0,5	0,08	0,1	0,045
C21 – C24*	0,5	0,08	0,1	0,045
C25 – C28*	0,5	0,08	0,1	0,045
C29 – C34*	0,5	0,08	0,1	0,045
C35 – C43*	0,5	0,08	0,1	0,045
C44 – C80*	0,5	0,08	0,1	0,045

Table 5.2 : Binary Interaction Parameters between components of the wellstream fluid

5.4 Standard Equipment Specifications

Pressure drops across various equipments and efficiencies of pumps are compressors have a considerable impact on the process flow. This section gives the pressure drops over various equipments and the efficiencies that are used in the Hysys simulations. No additional pressures drops across vessels and piping are included in the simulation model. It is assumed that the pressure drops given in Table 5.3 are sufficient to account for pressure drop across equipments and piping.

5.4.1 Pressure Drop

Description	Tag No	Pressure Drop	
		(bara)	
Field 2 Inlet Separator	20-HA-001	1.0	
Field 1 Inlet Separator	20-HA-002	1.0	
Stabilization Separator Heater	20-HA-003	1.0	
Stabilization Separator Cross Heat Exchanger	20-HB-004	1.0	
Export Oil Cooler	21-HB-001	1.0	
1 st Stage Recompressor Suction Cooler	23-HB-001	0.5	
2 nd Stage Recompressor Suction Cooler	23-HB-002	0.5	
Dehydration Suction Coolers		1.0	
Dehydration Suction Superheaters		1.0	
Injection Compressor Suction Coolers		1.0	
Injection Compressor After Coolers		1.0	

Table 5.3 : Equipment pressure drop used in simulations

5.4.2 Pump Efficiencies

All pumps used in the simulation model are designed with an adiabatic efficiency of 75%.

5.4.3 Compressor Efficiencies

Table 5.4 gives the polytropic efficiencies of the each of the compressor units used in the Hysys simulation model.

Description	Tag No	Polytropic Efficiency	
		(%)	
1 st Stage Recompressor	23-KA-001	75.00	
2 nd Stage Recompressor	23-KA-002	75.00	
Field 1 1 st Stage Injection Compressor	23-KA-101	83.00	
Field 1 2 nd Stage Injection Compressor	23-KA-102	83.84	
Field 1 3 rd Stage Injection Compressor	23-KA-103	83.84	
Field 2 1 st Stage Injection Compressor	23-KA-202	84.00	
Field 2 2 nd Stage Injection Compressor	23-KA-202	78.95	
Field 2 3 rd Stage Injection Compressor	23-KA-203	78.95	

Table 5.4 : Compressor Efficiencies

5.5 Methodology of building Hysys Simulation Model

This section describes the methodology behind the development of the hysys model based on the process description given in Section 3.1. It also contains figures of each section of the hysys simulation model. The pictorial view of the Hysys simulation can be seen in Figure 5.1.

5.5.1 Inlet Arrangement

The well streams from the Field 1 and Field 2 wells are mixed and routed to the Field 1 and Field 2 manifold respectively. The pressure of the wellstream at both the manifolds is 16.5 bar. After a 0.5 bar pressure drop downstream the Field 1 and Field 2 manifolds, the wellstream from both the fields enters the respective inlet heaters at 16 bar. The pressure drop in both the heaters is set as 1 bar for the hot and cold stream.

The Field 1 Inlet Heater (20-HA-002) receives the hydrocarbon stream from the Field 1 manifold at a temperature of 28°C and heats it to 55°C. In the simulation, 20-HA-002 is modelled as a shell and tube heat exchanger (STHE) with the high pressure well stream as the tube side fluid (cold stream) and the heating medium as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for 20-HA-002 can be seen in Figure 5.2.

The Field 2 Inlet Heater (20-HA-001) receives the hydrocarbon stream from the Field 2 manifold at a temperature of 45° C and heats it to 55° C. In the simulation, 20-HA-001 is modelled similar to 20-HA-002, as a shell and tube heat exchanger with the high pressure well stream as the tube side fluid (cold stream) and the heating medium as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for 20-HA-001 can be seen in Figure 5.2.

The hydrocarbon streams from both the inlet heaters are mixed and routed downstream to the Inlet Separator (20-VA-001). 20-VA-001 is modelled as a 3-phase separator with the 5 vol% water dominant phase in hydrocarbon dominant phase. In Hysys, this specification is met by

setting the heavy liquid in light liquid as 0.05 under carry-over setup. The oil is routed downstream to the Secondary Separator (-20-VA-002) shown as stream Oil (Inlet Separator) in the figure below, the water routed to the produced water system and the gas directed to the gas compression and injection train (Stream 43).

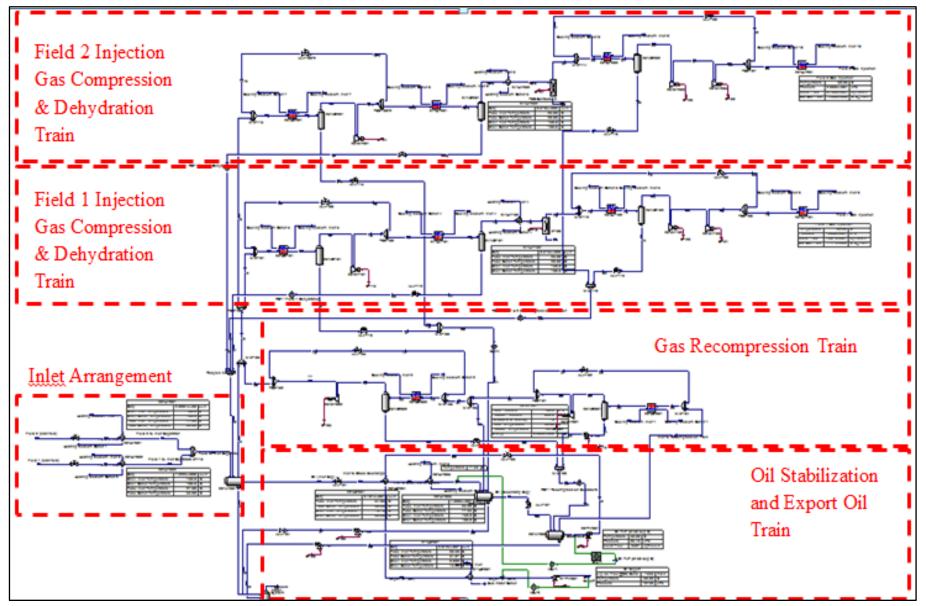


Figure 5.1 : HYSYS Simulation Model (Base Case Simulation)

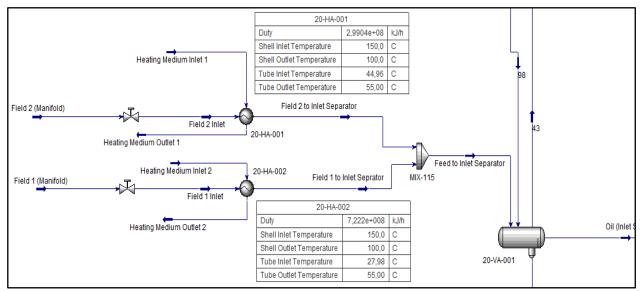


Figure 5.2 : Inlet Arrangement (Well stream to Inlet Separator) – HYSYS model

5.5.2 Oil Stabilization & Export Oil Train

The oil stream out of the 20-VA-001 is routed to the Secondary Separator (20-VA-002) through two heat exchangers – Stabilization Separator Cross Exchanger (20-HB-004) and Stabilization Separator Heater (20-HA-003). The Cross Exchanger integrates the heat from the stabilized oil into the process. The oil being routed from the inlet separator to the secondary separator is heated against the high temperature stabilized oil from the Stabilization Separator (20-VA-003). This pre-heating of the oil stream helps in conserving the energy balance of the system and reduces the heating duty of 20-HA-003. The pressure of the oil stream from the inlet separator is taken down from 15 bar to 9 bar across a valve before it enters the 20-HB-004.

The Cross Exchanger receives the oil stream at about 9 bar and 54° C and heats it to about 63° C against the high temperature stabilized oil which enters at around 75° C. In the simulation, 20-HB-004 is modelled as a shell and tube heat exchanger with the high pressure oil stream as the tube side fluid (cold stream) and the stabilized oil as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for 20-HB-004 can be seen in Figure 5.3.

The Stabilization Separator Heater (20-HA-003) receives the pre-heated oil at about 63° C. The outlet temperature of 20-HA-003 is regulated in order to obtain the oil product specifications – True Vapour Pressure of 0.965 bar at 30°C. 20-HA-003 is modelled as a shell and tube exchanger with the oil stream as the tube side fluid (cold stream) and the heating medium as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for the exchanger can be seen in Figure 5.3.

The heated oil stream is routed downstream to the separator 20-VA-002. This separator is operated at an intermediate pressure of 7 bar due to the 1 bar pressure drop each in both the upstream exchangers. 20-VA-002 is modelled as a 3-phase separator with the 5 vol% water dominant phase in hydrocarbon dominant phase. In Hysys, this specification is met by setting the

heavy liquid in light liquid as 0.05 under carry-over setup. From 20-VA-002, the oil dominant stream represented as stream 'Oil (Secondary Sep)' in Figure 5.3 is routed downstream to the Stabilization Separator (20-VA-003), the water is routed to the produced water system and the gas directed to the gas recompression train.

Downstream of 20-VA-002, the pressure of the oil stream is taken down by 5 bar before the hydrocarbon stream reaches 20-VA-003. This separator is operated at a pressure as low as possible (2 bar) while still maintaining sufficient pressure for the gas stream to be routed to the inlet of the recompression train. 20-VA-003 is modelled as a 3-phase separator with the 2 vol% water dominant phase in hydrocarbon dominant phase. In Hysys, this specification is met by setting the heavy liquid in light liquid as 0.02 under carry-over setup.

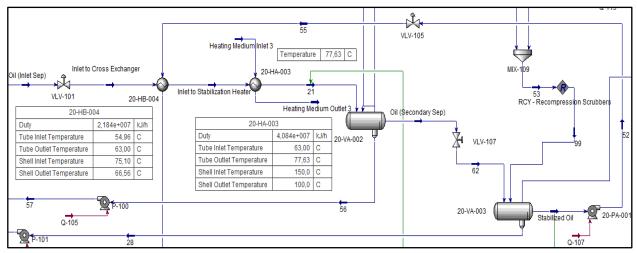


Figure 5.3 : Oil Stabilization Train – HYSYS model

The Stabilized Oil stream from 20-VA-003 is required to have the product specification of – True Vapour Pressure of 0.965 bar at 30° C. In Hysys, this requirement is modelled by connecting an 'Adjuster' (ADJ-1) between the Oil TVP stream and outlet stream from 20-HA-003 as seen in Figure 5.4. The adjuster regulates the outlet temperature of the oil stream from 20-HA-003 in order to get the required TVP in the Stabilized Oil stream.

The Oil TVP (at 30° C) stream is a material stream identical to the Stabilized Oil stream from 20-VA-003. It is specified to have the same component mole flow but at a temperature of 30° C instead of 75° C which is the outlet temperature of the stabilized oil. A 'Balance' function in Hysys is used to link the 2 streams since the production requirements are specified at 30° C. The oil product specifications from the Hysys simulation can be seen in the Oil TVP table in Figure 5.4. These specifications are in line with the product specifications give in Section 3.4.1.

The stabilized oil is pressurized by the Oil Booster Pumps (20-PA-001A/B/C) to 9 bar and routed to the cross exchanger for the pre-heating of the oil stream from 20-VA-001. In Hysys, these pumps are modelled with the required pressure ratio and having a 75% adiabatic efficiency. These pumps operate in a 2+1 configuration where 2 pumps are working pumps and 1 pump is a stand-by pump. In the process of heat integration, the stabilized oil is cooled from 75°C to 66°C

across 20-HB-003. The cooled down stabilized oil is routed downstream to the Crude Oil Cooler (21-HB-001) for further cooling to meet the export specifications given in Section 3.4.1. In the simulation, 21-HB-001 is modelled as a shell and tube heat exchanger with the high temperature stabilized oil stream as the tube side fluid (hot stream) and the low temperature sea water as the shell side fluid (cold stream). The inlet/outlet temperatures and heat duty of this exchanger can be seen in Figure 5.4.

Downstream of 21-HB-001, the crude oil is pressurized in the Export Oil Pumps (21-PA-001A/B/C) to the export oil pressure of 187 bar. Since the increase in pressure results in an increase of temperature, the outlet temperature from 21-HB-001 needs to be regulated such that the final temperature of the oil after pressurization is at the Export Oil temperature specification of 60°C. In Hysys, this is done by connecting a 'Adjuster' (ADJ-2) between the Oil Export stream and the outlet stream from the Crude Oil Cooler. The adjuster regulates the outlet temperature from 21-HB-001 such that after pressurization, the temperature of the oil export stream reaches 60°C. The flowrate, temperature and pressure of the Oil Export stream can be seen in the Oil Export table in Figure 5.4. These specifications are in line with the product specifications give in Section 3.4.1.

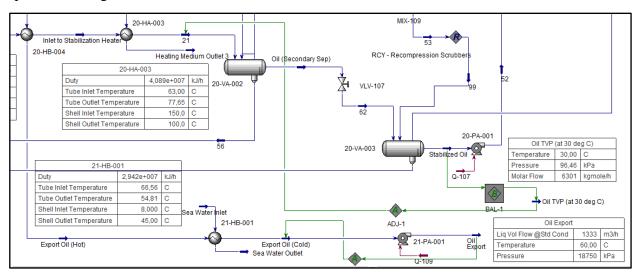


Figure 5.4 : Export Oil Train – HYSYS model

5.5.3 Gas Compression Train

The gas from 20-VA-003 is routed to the inlet of the recompression train vide the stream Inlet to Recompression Train as seen in Figure 5.5. The gas stream is at the minimum pressure of 2 bar and a temperature of 75° C. In the Hysys model, the inlet stream is mixed with the compressor recycle stream in order to simulate the compressor recycle loop. The gas stream is routed downstream to the 1st Stage Recompressor Inlet Cooler (23-HB-001) to cool down the gas to 28° C.

The gas stream enters 23-HB-001 at 75° C and is cooled down to 28° C against the cooling medium entering at 15° C and getting heated to 45° C. Based on the temperature profile of the

process fluids, this exchanger is designed a Compact Heat Exchanger (CHE) such as Plate & Frame Heat Exchanger (PFHE) or a Printed Circuit Heat Exchanger (PCHE). For the Hysys model, 23-HB-001 could not be designed as a shell & tube heat exchanger since hysys does not permit a shell & tube heat exchanger to be modelled with a temperature cross. Also plate and frame heat exchanger or printed circuit heat exchanger options do not feature in Hysys.

Based on a discussion with my supervisor, Prof. Jostein Pettersen, we agreed that in Hysys I would model all the compact heat exchangers in the simulation as LNG heat exchangers. LNG heat exchangers can operate with just 2 streams, one hot and one cold. The design of an LNG exchanger is similar to a compact heat exchanger and is therefore used for the simulation model. Thus 23-HB-001 is modelled as a counter-current LNG exchanger with the gas as the hot stream and the cooling medium as the cold stream. The exchanger is modelled to have an LMTD of 23° C.

The cooled down gas is routed to the 1st Stage Recompression Scrubber (23-VG-001) to separate out the liquid that has condensed during the cooling process. In the Hysys simulation, the scrubber 23-VG-001 is modelled as a 2-phase separator wherein the gas stream is routed downstream to the compressor and the liquid stream containing the heavy hydrocarbons is pressurized and then routed to the Stabilization Separator.

The gas stream is routed to the 1st Stage Recompressor (23-KA-001) to be pressurized from 1.5 bar to 6 bar. In the Hysys simulation, 23-KA-001 is modelled as a centrifugal compressor with 73% adiabatic efficiency. The performance table for 23-KA-001 can be seen in the Figure 5.5 below.

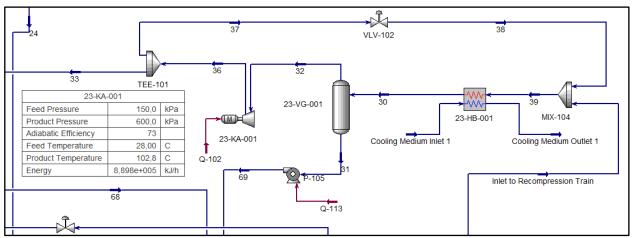


Figure 5.5 : Gas Recompression Train (Stage 1) - HYSYS model

Downstream of the 1st stage compression, the gas stream from the 1st stage compressor is mixed with the gas stream from the Secondary Separator as is seen in Figure 5.6. The mixed gas stream in the Hysys model is then linked to the compressor recycle stream in order to simulate the compressor recycle loop. The temperature of the mixed gas stream is quite high since the high temperature of the 1st stage compressed gas stream is the dominant factor.

The high temperature gas stream is routed downstream to the 2nd Stage Recompressor Cooler (23-HB-002) to be cooled down to 28°C. 23-HB-002 is also designed as a counter-current LNG exchanger with the gas as the hot stream and the cooling medium as the cold stream. The cooled down gas is routed to the 2nd Stage Recompression Scrubber (23-VG-002) to separate out the liquid that has condensed during the cooling process. In the Hysys simulation, the scrubber 23-VG-002 is modelled as a 2-phase separator wherein the gas stream is routed downstream to the compressor and the liquid stream containing the heavy hydrocarbons routed to the Stabilization Separator.

The gas stream is then routed to the 2nd Stage Recompressor (23-KA-002) to be pressurized from 6 bar to 15 bar to match the pressure of the gas stream from the inlet separator. In the Hysys simulation, 23-KA-002 is modelled as a centrifugal compressor with 73% adiabatic efficiency. The performance table for 23-KA-002 can be seen in the Figure 5.6 below.

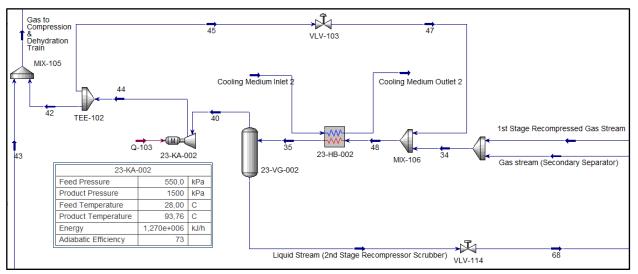


Figure 5.6 : Gas Recompression Train (Stage 2) – HYSYS model

Downstream the compressor, the recompressed gas is mixed with the main gas stream from 20-VA-001 and the total gas flow is routed to the compression and dehydration trains as seen in Figure 5.6.

5.5.4 Field 1 Injection Gas Compression and Dehydration Train

The total gas flow from the inlet separator and the recompression train are split into parts based on the capacity split between Field 1 and 2. In the Hysys model, a splitter is used to divide the gas flow between the 2 trains -47% to the Field 1 injection compression train and 53% to the Field 2 injection compression train.

The gas feed to Field 1 injection compression train enters as the stream 'Gas to Field 1 train' as seen in Figure 5.7. In the Hysys model, the feed gas stream is mixed with the compressor recycle stream in order to simulate the compressor recycle loop. The gas is first cooled in Field 1 1^{st}

Stage Injection Suction Cooler (23-HB-101) from the gas inlet temperature of 55°C to 28°C. 23-HB-101 is modelled as a counter-current LNG exchanger with the gas as the hot stream and the cooling medium as the cold stream as seen in Figure 5.7 below.

The cooled down gas is routed to the Field 1 1st Stage Injection Scrubber (23-VG-101) to separate out the liquid that has condensed during the cooling process. In the Hysys simulation, the scrubber 23-VG-101 is modelled as a 2-phase separator wherein the gas stream is routed downstream to the compressor and the liquid stream containing the heavy hydrocarbons is depressurized and then routed to the Secondary Separator.

The gas stream is then routed to the Field 1 1st Stage Injection Compressor (23-KA-101) to be pressurized from 14 bar to 50.3 bar. In the Hysys simulation, 23-KA-101 is modelled as a centrifugal compressor with 83% polytropic efficiency. The performance table for 23-KA-101 can be seen in the Figure 5.7.

Downstream the 1st stage compression, the hot gas needs to be cooled down before the dehydration process. The high temperature gas is cooled down to 25°C in the Field 1 Dehydration Suction Cooler (24-HJ-101). 24-HJ-101 is modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side.

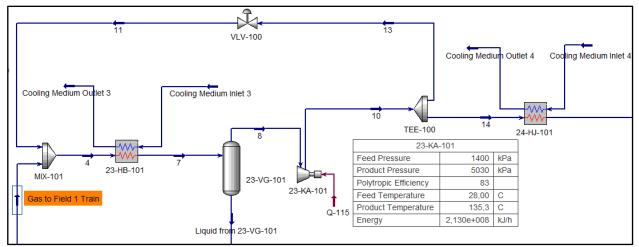


Figure 5.7 : Field 1 1st Stage Compression – HYSYS model

The gas that is cooled down in 24-HJ-101 is routed to the Field 1 Dehydration Scrubber (24-VG-101) in order to separate out the liquid that has condensed during the cooling process. This is necessary since we need to avoid any liquid phase entering the TEG contactors. In the Hysys simulation, 24-HJ-101 is modelled as a 2-phase separator wherein the gas stream is routed to the superheater and the liquid stream containing the heavy hydrocarbons is de-pressurized and then recycled to the Inlet Separator.

The gas stream is then superheated by 3°C in the Field 1 Dehydration Superheater (24-HA-102) to 28°C. This superheating is done to ensure that the gas stays above the hydrocarbon dew point during the dehydration process in the TEG contactor. In the Hysys simulation, 24-HA-102 is modelled as a shell and tube exchanger with the gas stream as the tube side fluid (cold stream)

and the heating medium as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for the exchanger can be seen in Figure 5.8.

In the Hysys simulation, the Field 1 TEG Contactor is modelled as a splitter with the specification that all hydrocarbons and 0.0405 molar of feed fraction of water is routed downstream as the vapour phase product.

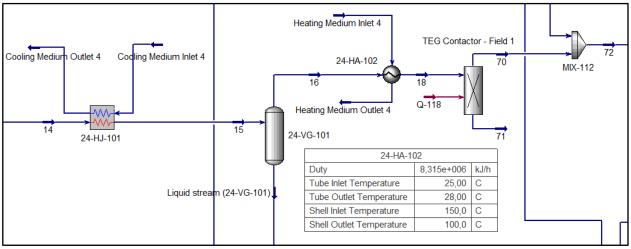
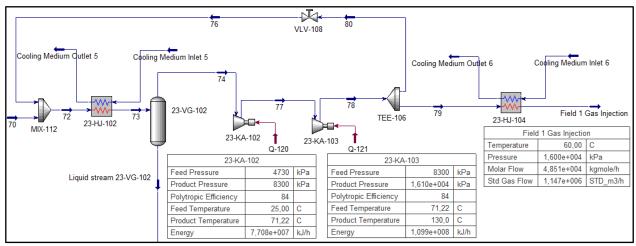


Figure 5.8 : Field 1 Dehydration Train – HYSYS model

The gas stream after removal of the required water content is cooled down again to 25° C in the Field 1 2nd Stage Gas Injection Suction Cooler (24-HJ-102). Based on the temperature profile of the heat exchanger, 24-HJ-102 is modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side. The cooled down gas is routed downstream to the Field 1 2nd Stage Injection Scrubber (23-VG-102) to separate out the liquid that has condensed during the cooling process before the gas enters the compressors. In the Hysys simulation, the scrubber 23-VG-102 is modelled as a 2-phase separator wherein the gas stream is routed downstream to the compressors and the liquid stream containing the heavy hydrocarbons is de-pressurized and then routed to the Inlet Separator.

The intermediate pressure dehydrated gas stream is then routed to the Field 1 1st and 2nd Stage Injection Compressors (23-KA-102 & 23-KA-103 respectively). The gas stream is pressurized from 47.3 bar to 83.0 bar in 23-KA-102 and then from 83.0 bar to 161.0 bar in 23-KA-103. In the Hysys simulation, 23-KA-102 and 23-KA-103 are modelled as centrifugal compressors with 84% polytropic efficiency. The performance tables for 23-KA-102 and 23-KA-103 can be seen in the Figure 5.9. No intercooling followed by liquid removal is required between the 2nd and 3rd stage compression.

Downstream the compression process, the injection gas is cooled by the Field 1 3rd Stage Gas Injection After Cooler (23-HJ-104) to the injection gas temperature of 60°C. 23-HJ-104 is also modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side. The specification table of the Field 1 Injection Gas seen in Figure 5.9 is as per gas product specifications given in in Section 3.4.2.





5.5.5 Field 2 Injection Gas Compression and Dehydration Train

53% to the total gas flow from the inlet separator and the recompression train is routed to the Field 2 injection compression train as the stream 'Gas to Field 2 Train' seen in Figure 5.10. In the Hysys model, the feed gas stream is mixed with the compressor recycle stream in order to simulate the compressor recycle loop.

The gas is first cooled in the Field 2 1st Stage Injection Suction Cooler (23-HB-201) from the gas inlet temperature of 55°C to 28°C. 23-HB-201 is modelled as a counter-current LNG exchanger with the gas as the hot stream and the cooling medium as the cold stream as seen in Figure 5.10.

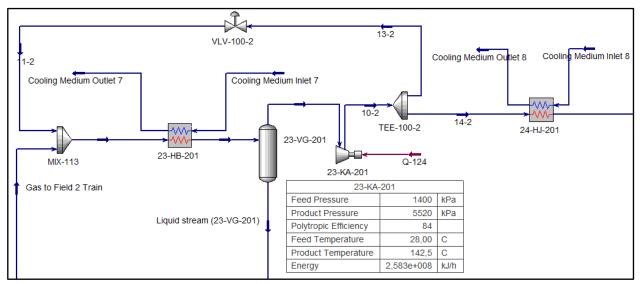


Figure 5.10 : Field 2 1st Stage Compression - HYSYS model

The cooled down gas is routed to the Field 2 1st Stage Injection Scrubber (23-VG-201) to separate out the liquid that has condensed during the cooling process. In the Hysys simulation, the scrubber 23-VG-201 is modelled as a 2-phase separator wherein the gas stream is routed

downstream to the compressor and the liquid stream containing the heavy hydrocarbons is depressurized and then routed to the Secondary Separator.

The gas stream is then routed to the Field 2 1st Stage Injection Compressor (23-KA-201) to be pressurized from 14 bar to 55.2 bar. In the Hysys simulation, 23-KA-201 is modelled as a centrifugal compressor with 84% polytropic efficiency. The performance table for 23-KA-101 can be seen in the Figure 5.10.

Downstream the 1st stage compression, the hot gas needs to be cooled down before the dehydration process. The high temperature gas is cooled down to 25°C in the Field 2 Dehydration Suction Cooler (24-HJ-201) as seen in Figure 5.11. 24-HJ-201 is modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side.

The gas that is cooled down in 24-HJ-201 is routed to the Field 2 Dehydration Scrubber (24-VG-201) in order to separate out the liquid that has condensed during the cooling process. This is necessary since we need to avoid any liquid phase entering the TEG contactors. In the Hysys simulation, 24-VG-201 is modelled as a 2-phase separator wherein the gas stream is routed to the superheater and the liquid stream containing the heavy hydrocarbons is de-pressurized and then recycled to the Inlet Separator.

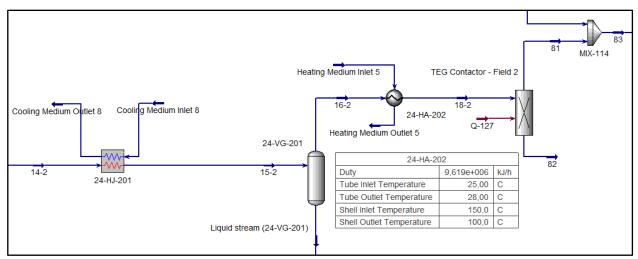


Figure 5.11 : Field 2 Dehydration Train – HYSYS model

The gas stream is then superheated by 3°C in the Field 2 Dehydration Superheater (24-HA-202) to 28°C. This superheating is done to ensure that the gas stays above the hydrocarbon dew point during the dehydration process in the TEG contactor. In the Hysys simulation, 24-HA-202 is modelled as a shell and tube exchanger with the gas stream as the tube side fluid (cold stream) and the heating medium as the shell side fluid (hot stream). The inlet/outlet temperatures and the heating duty for the exchanger can be seen in Figure 5.11.

In the Hysys simulation, the Field 2 TEG Contactor is modelled as a splitter with the specification that all hydrocarbons and 0.0405 molar of feed fraction of water is routed downstream as the vapour phase product.

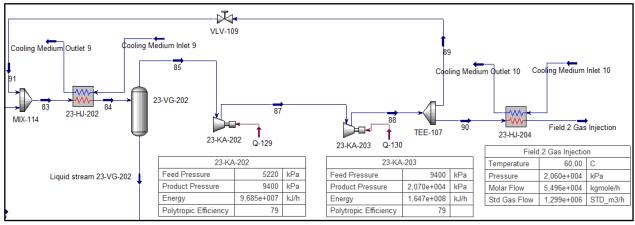


Figure 5.12 : Field 2 2nd & 3rd Stage Injection Gas Compression – HYSYS model

The gas stream after removal of the required water content is cooled down again to 25° C in the Field 2 2nd Stage Gas Injection Suction Cooler (24-HJ-202). Based on the temperature profile of the heat exchanger, 24-HJ-202 is modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side. The cooled down gas is routed downstream to the Field 2 2nd Stage Injection Scrubber (23-VG-202) as seen in Figure 5.12 to separate out the liquid that has condensed during the cooling process before the gas enters the compressors. In the Hysys simulation, the scrubber 23-VG-202 is modelled as a 2-phase separator wherein the gas stream is routed downstream to the compressors and the liquid stream containing the heavy hydrocarbons is de-pressurized and then routed to the Inlet Separator.

The intermediate pressure dehydrated gas stream is then routed to the Field 2 1st and 2nd Stage Injection Compressors (23-KA-202 & 23-KA-203 respectively). The gas stream is pressurized from 52.2 bar to 94.0 bar in 23-KA-202 and then from 94.0 bar to 207.0 bar in 23-KA-103. In the Hysys simulation, 23-KA-202 and 23-KA-203 are modelled as centrifugal compressors with 79% polytropic efficiency. The performance tables for 23-KA-202 and 23-KA-203 can be seen in the Figure 5.12. No intercooling followed by liquid removal is required between the 2nd and 3rd stage compression.

Downstream the compression process, the injection gas is cooled by the Field 2 3rd Stage Gas Injection After Cooler (23-HJ-2104) to the injection gas temperature of 60°C. 23-HJ-204 is also modelled as a counter-current LNG exchanger with the gas stream as the hot side and the cooling medium on the cold side. The specification table of the Field 2 Injection Gas seen in Figure 5.12 is as per gas product specifications given in in Section 3.4.2.

5.5.6 Deviation from Process Description

During development of the Hysys simulation model, certain deviations were made from the original process description. These deviations were done in order to simplify the simulation model and also to remove certain sections of the process design which were not relevant for this thesis work.

The deviations made in the simulation model developed for this thesis work are mentioned below:

- 1. No Test Manifold, Test Separator and Test Oil Separation train was modelled as part of the simulation model for this thesis work. This section was not included since the equipments in the test train would not be in operation at all times and will not have any major impact on the design of the heat exchangers.
- 2. The Electrostatic Coalescer downstream the Stabilization Separation was not modelled in the simulation since this equipment did not impact the heat duty of the overall system and would not affect the thermal design of the heat exchangers neither in the base case nor in the case studies.

5.5.7 Determination of Flowrate for Field 1 & Field 2

For obtaining the required oil production from both Field 1 and Field 2, it is critical that the inlet flowrate for each of these fields is fed into the Hysys simulation model correctly. As per the oil product specifications given in Section 3.4.2, the oil production from Field 1 and Field 2 is required to be 15000 Sm3/d (625 Sm3/hr) and 17000 Sm3/d (708,3 Sm3/hr) respectively.

Determination of Field 1 Flowrate

The stream Field 2 to Inlet Separator is disconnected from the Hysys simulation model as seen in Figure 5.13. As a result the total oil product generated downstream the Stabilization Separator is produced only from the Field 1 inlet. An adjuster is connected between the stream – Field 1 (Manifold) and Stabilized Oil. The flowrate of 'Field 1 (Manifold)'is set as the adjusted variable and the flowrate of the 'Stabilized Oil' stream is assigned as the target variable. The value of the target variable is set as 625 Sm3/hr with a 2% tolerance. Based on the composition and the liquid and vapour content of the Field 1 hydrocarbon stream, the inlet flowrate of Field 1 is calculated to be 7645Sm3/hr.

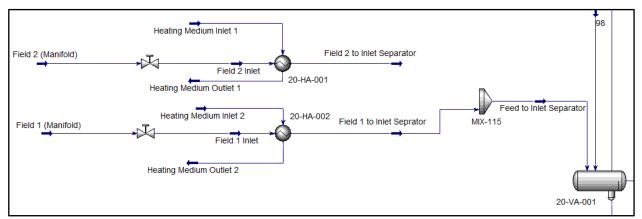


Figure 5.13 : Determination of Field 1 Flowrate

Determination of Field 2 Flowrate

The stream Field 1 to Inlet Separator is disconnected from the Hysys simulation model as seen in Figure 5.14. The similar procedure of connecting an adjuster between the stream Field 2 (Manifold) and the Stabilized Oil stream is followed as explained above. The flowrate of 'Field 2 (Manifold)' is set as the adjusted variable and the flowrate of the 'Stabilized Oil' stream is assigned as the target variable. The value of the target variable is set as 708,3 Sm3/hr with a 2% tolerance. Based on the composition and the liquid and vapour content of the Field 2 hydrocarbon stream, the inlet flowrate of Field 2 is calculated to be 8814 Sm3/hr.

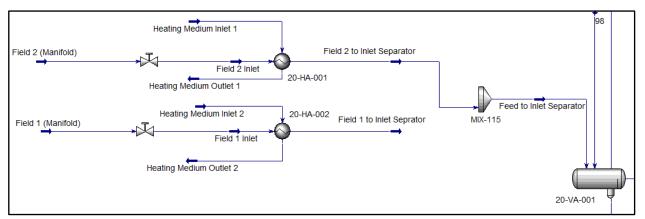


Figure 5.14 : Determination of Field 2 Flowrate

6.0 Base Case Simulation Results & Case Studies

6.1 Introduction

This chapter includes the results of the base case simulation and explains in detail each of the case studies that have been conducted on the base case simulation. The case studies are conducted in order to evaluate the impact on the heat exchanger design by changing the process parameters of the hot side and cold side streams. The three case studies done as part of this thesis work are:

- Case Study I Removal of Stabilization Separator Cross Exchanger (20-HB-004)
- Case Study II Feeding Low Temperature Heating Medium to Injection train Superheaters (24-HA-102 & 24-HA-202)
- Case Study III Removal of Superheater and Scrubber unit prior to Gas Dehydration

6.2 Base Case Simulation Results

This section gives the specifications and compositions of the oil product and gas product that has been extracted from the Hysys Simulation model.

6.2.1 Modelled Oil Product Specifications

Based on the simulation model (Base Case Simulation) that was developed as part of this thesis work, the specifications of the export oil stream can be seen in Figure 6.1. The adjuster (ADJ-1) seen in the figure below controls the temperature of the hydrocarbon stream out of the Stabilization Separator Heater such that the True Vapour Pressure of the stabilized oil out of the Stabilization Separator is achieved to be 0.96 bar at 30° C as per the requirements given in Section 3.4.1. This can be seen in the Oil TVP table in Figure 6.1.

The total flowrate of export oil as seen in Figure 6.1 is calculated to be 1333 Sm3/hr which accounts to approximately 32000 Sm3/day as per the requirement given in Section 3.4.1.

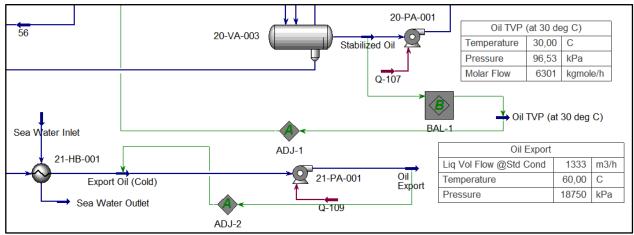


Figure 6.1 : Oil Product Specifications from Hysys model

Table 6.1 gives the oil product composition extracted from the Hysys simulation model.

	Mole Fraction	Liquid Phase	Aqueous Phase
Methane	0,0012	0,0015	0,0000
Ethane	0,0026	0,0034	0,0000
Propane	0,0085	0,0112	0,0000
i-Butane	0,0041	0,0054	0,0000
n-Butane	0,0111	0,0146	0,0000
i-Pentane	0,0079	0,0104	0,0000
n-Pentane	0,0097	0,0128	0,0000
n-Hexane	0,0172	0,0227	0,0000
H2O	0,2428	0,0020	1,0000
C7*	0,0358	0,0472	0,0000
Nitrogen	0,0000	0,0000	0,0000
C8*	0,0495	0,0653	0,0000
C9*	0,0384	0,0506	0,0000
C10-C12*	0,1384	0,1825	0,0000
C13-C15*	0,1052	0,1387	0,0000
C16-C17*	0,0555	0,0732	0,0000
C18-C20*	0,0666	0,0878	0,0000
C21-C24*	0,0608	0,0802	0,0000
C25-C28*	0,0444	0,0585	0,0000
C29-C34*	0,0444	0,0585	0,0000
C35-C43*	0,0333	0,0439	0,0000
C44-C80*	0,0222	0,0293	0,0000
CO2	0,0002	0,0003	0,0000

Table 6.1 : Oil Product Composition from Hysys model

6.2.2 Modelled Injection Gas Specifications

Based on simulation model (Base Case Simulation) that was developed as part of this thesis work, the specifications of the injection gas from both Field 1 and Field 2 can be seen in Figures 6.2 & 6.3.

The total injection gas produced from the Field 1 gas injection train is 27.5 MSm3/day. The compressed gas exits the train at the injection pressure of 160 bara and at the injection temperature of 60° C as per the requirements given in Section 3.4.2. Details can be seen in the Field 1 Gas Injection table in Figure 6.2.

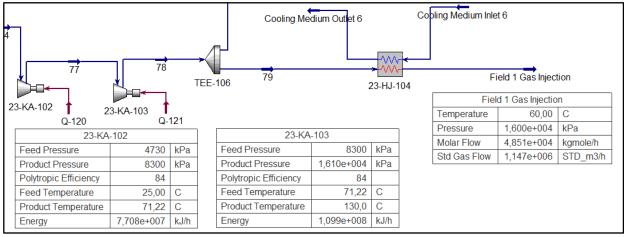


Figure 6.2 : Field 1 Gas Product Specifications from Hysys model

The total injection gas produced from the Field 2 gas injection train accounts to 31.2 MSm3/day. The compressed gas exits the train at the injection pressure of 206 bara and at the injection temperature of 60° C as per the requirements given in Section 3.4.2. Details can be seen in the Field 2 Gas Injection table in Figure 6.3.

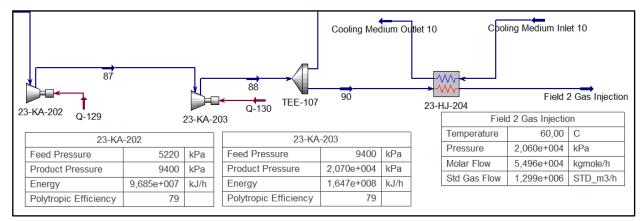


Figure 6.3 : Field 2 Gas Product Specifications from Hysys model

6.3 Case Study I – Removal of Stabilization Separator Cross Exchanger (20-HB-004)

In Case Study I, the Stabilization Separator Cross Exchanger (20-HB-004) between 20-VA-001 and 20-HA-003 is removed from the process design as seen in Figure 6.4. This exchanger was the first heat exchanger between the inlet and the secondary separators. The main application of this equipment was to integrate the heat from the high temperature stabilized oil into the hydrocarbon stream going to the secondary separator.

This case study is conducted in order to evaluate the possibility of removing one heat exchanger from the process flow and analyze the impact on the downstream equipments specially the heat exchangers that are linked to it. The intention is to simplify the process flow and reduce the number of equipments and the quantity of piping and then understand whether the connected heat exchangers can be redesigned to handle the additional heating and cooling duty and still produce the product within the required specifications.

The exchanger being studied (20-HB-004) has a two way application – First, it heats up the hydrocarbon stream from the inlet separator to about 63°C and this pre-heated hydrocarbon stream is heated further in the Stabilization Separator Heater (20-HA-003) to the required temperature of 77.6°C. However, owing to the pre-heating of the hydrocarbon stream, the required heating duty of 20-HA-003 is less resulting in a smaller exchanger being sufficient for the final heating application. This pre-heating is done against the stabilized oil stream. Secondly, 20-HB-004 cools downs the stabilized oil stream from the Stabilization Separator to about 66°C. This oil stream is pre-cooled in 20-HB-004 and then further cooled down in the Crude Oil Cooler (21-HB-001), downstream of 20-HB-004 to meet the export oil specifications. This pre-cooling results in a lower cooling duty for 21-HB-001 thereby making a smaller exchanger sufficient for the final cool down application.

Therefore to account for the heat integration into the process an additional exchanger (20-HB-004) is needed in order to reduce the heating and cooling duty demand of the mainstream exchangers (20-HA-003 & 21-HB-001).

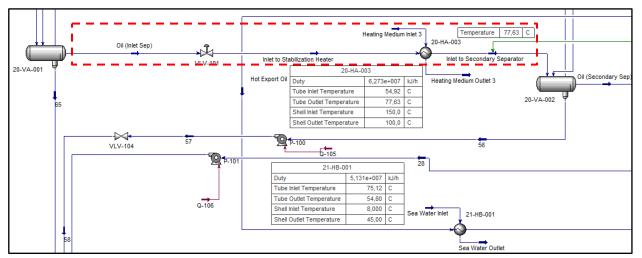


Figure 6.4 : Case Study I – Hysys model

In this Case Study, a low temperature hydrocarbon stream (around 54°C) from the inlet separator enters 20-HA-003 and needs to be heated up to the temperature of 77.6°C to attain the required vapour pressure specifications downstream of 20-VA-003. This causes the revised exchanger design to have a much higher heat duty than the heat duty demand in the base case wherein the hydrocarbon stream is pre heated before entering 20-HA-003. The thermal design of 20-HA-003 in the base case scenario with the pre-heated hydrocarbon stream is given in Section 7.3.1 while the thermal design of the exchanger with the revised process parameters of the hydrocarbon stream is given in Section 7.3.2.

The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.2. Owing to the removal of exchanger 20-HB-004, the temperature of the inlet stream into 20-HA-003 is lowered by 8° C. Since the outlet temperature of the hydrocarbon stream remains the same, an additional 53% of heating medium (mass flow) is required to meet the heating duty. Since the heating medium is the shell side fluid, a 26% increase in shell diameter is needed to accommodate the additional mass flowrate. The removal of 20-HB-004 results in a 40% increase in the heating duty of 20-HA-003 in order to meet the required outlet temperature of 77° C.

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study I	Change
1	Flowrate of hydrocarbon Stream	kg/s	329	329	
2	Inlet temperature of hydrocarbon stream	°C	63	55	-8
3	Outlet temperature of hydrocarbon stream	°C	77	77	
4	Required flowrate of heating medium	kg/s	72	110	+53%
5	Total heat duty	KW	6352	8634	+40%
6	Shell – Inner Diameter (D)	mm	775	975	+26%
7	Tube length (L)	mm	6500	6500	
8	Effective Surface Area per unit	m^2	611	986	+61%
9	Number of shells per unit		2	2	
10	Number of shells in series		1	1	
11	Number of shells in parallel		2	2	
12	L/D Ratio (Ratio of tube length to shell ID)		8.4	6.7	
13	Footprint	m ²	6.5	8.5	+31%
14	Weight/Shell	kg	5804	8848	+52%

Table 6.2 : Comparison of exchanger design between Base case & Case study I (20-HA-003)

Also as seen in the table above, an additional 61% of effective surface area is required to ensure that the necessary heating duty is met. In both the cases, the number of shells per unit stays the same with 2 shells in parallel and 1 shell in series. Considering the increase in dimensions, the footprint of each shell increases by 31% alongwith a 52% increase in the weight per shell. The L/D ratio also in both cases is within the range of 5 to 10 which is the standard range for optimum exchanger design.

The Crude Oil Cooler (21-HB-001), which cools the stabilized oil stream, is also impacted by the removal of 20-HB-004 from the process flow. It results in a very high temperature stabilized oil stream (around 75°C) from the Stabilization Separator being routed downstream to 21-HB-001 to be cooled down to 54°C to meet the export oil temperature specification. 21-HB-001 designed for this scenario requires a much higher cooling duty than the exchanger designed for the base case wherein the hot oil stream is pre-cooled in 20-HB-004. The base case thermal design of 21-HB-004 is given in Section 7.4.1 while the thermal design of the case study exchanger with the high temperature oil stream feed is given in Section 7.4.2.

The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.3. Owing to the removal of exchanger 20-HB-004, the temperature of the inlet stream into 21-HB-001 is raised by 8°C. Since the outlet temperature of the hydrocarbon stream after cooling remains the same, an additional 74% of cooling medium (mass flow) is required to meet the cooling duty. Since the cooling medium is the shell side fluid, a 5% increase in shell diameter is needed to accommodate the additional mass flowrate. Also a 7% increase in tube length is needed for the sufficient heat transfer. The removal of 20-HB-004 results in a 73% increase in the cooling duty of 21-HB-001 in order to meet the required outlet temperature of 54°C.

Also an additional 19% of effective surface area is required to ensure that the necessary cooling duty is met. In both the cases, the number of shells per unit stays the same with 1 shell in parallel and 1 shell in series. Considering the increase in dimensions, the footprint of each shell increases by 11% alongwith a 21% increase in the weight per shell. The L/D ratio also in both cases is within the range of 5 to 10 which is the standard range for optimum exchanger design.

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study I	Change
1	Flowrate of hydrocarbon Stream	kg/s	316	316	
2	Inlet temperature of hydrocarbon stream	°C	67	75	+8
3	Outlet temperature of hydrocarbon stream	°C	54	54	
4	Required flowrate of heating medium	kg/s	50	87	+74%
5	Total heat duty	KW	8175	14162	+73%
6	Shell – Inner Diameter (D)	mm	1050	1100	+5%

 Table 6.3 : Comparison of exchanger design between Base case & Case study I (21-HB-001)

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study I	Change
7	Tube length (L)	mm	6500	7000	+7%
8	Effective Surface Area per unit	m^2	562	668	+19%
9	Number of shells per unit		1	1	
10	Number of shells in series		1	1	
11	Number of shells in parallel		1	1	
12	L/D Ratio (Ratio of tube length to shell ID)		6.2	6.4	
13	Footprint	m^2	9.1	10.1	+11%
14	Weight/Shell	kg	9495	11453	+21%

Table 6.4 gives a comparison between the process parameters and dimensional details of the redesigned exchangers 20-HA-003 and 21-HB-001 and the base case exchanger 20-HB-004. The columns 20-HA-003 (added) and 21-HB-001 (added) show the quantum of the parameter that has been added by redesigning these exchangers while the column 20-HB-004 (removed) shows the quantum of that specific parameter has been saved by removing the exchanger 20-HB-004 from the process design.

This case study shows that removal of the exchanger 20-HB-004 will require the linked exchangers 20-HA-003 and 21-HB-001 to be redesigned. Table 6.2 and 6.3 show that the redesigned exchangers can handle the additional heating and cooling demand required to meet the product specifications. Table 6.4 shows that removal of 20-HB-004 and redesigning of 20-HA-003 and 21-HB-001 gives us a weight saving of 4032 kgs alongwith a footprint savings of 6.6m² which accounts for cost saving considering the cost impact of weight and footprint in topside systems. The sufficient heating duty available from the Waste Heat Recovery units can handle the additional 2208 KW of heating demand with minor changes to the heating medium system.

Sl No.	Process Parameter / Exchanger Specification	Unit	20-HA-003 Case Study I (Added)	21-HB-001 Case Study I (Added)	20-HB-004 Base Case (Removed)	Net Savings
1	Number of shells		0	0	2	+2
2	Weight	kg	3044	1958	9034	+4032
3	Footprint	m^2	2.0	1.0	9.6	+6.6
4	Total Heat Duty	KW	2282	5987	6061	-2208
5	Effective Surface Area per unit	m ²	375	106	405	-76

Table 6.4 : Comparison table for 20-HA-003, 21-HB-001 and 20-HB-004 – Case Study I

6.4 Case Study II – Feeding Low Temperature Heating Medium to Injection train Superheaters (24-HA-102 & 24-HA-202)

In the base case simulation, the process parameters of the gas flow through the Field 1 & 2 Dehydration Inlet Superheaters (24-HA-102 and 24-HA-202 respectively) are such that the heat exchangers designed for that application have a very non-optimum design. The 1st stage compressed gas from the Dehydration Scrubbers (24-VG-101 & 24-VG-201) needs to be heated up by 3°C while the heating medium has a temperature reduction of 50°C based on the specifications of the heating medium system. The pressure and temperature parameters make plate and frame exchangers an unviable option. The resulting shell and tube exchanger design has a very low L/D ratio (approximately 2) and also the low LMTD and the high viscosity make it difficult to obtain turbulent flow resulting in a non-optimum design of these heat exchangers.

In Case Study II, the non-optimum design of 24-HA-102 and 24-HA-202 is analyzed and probable options of improving the design are studied. Reducing the required outlet temperature of the hydrocarbon stream has a limited effect on improving the thermal design. However, reducing the inlet temperature of the heating medium as can be seen in Figure 6.5 and 6.6, has a substantial impact on improving the heat transfer and overall design of the heat exchanger.

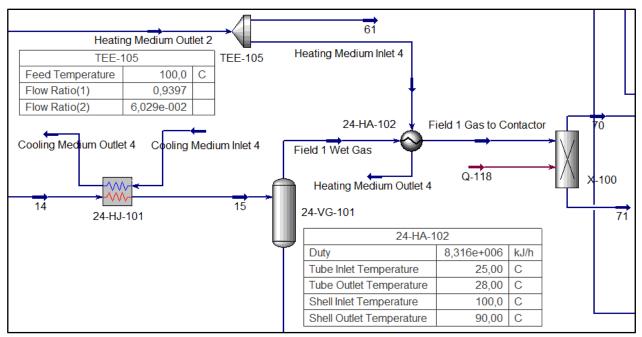


Figure 6.5 : Case Study II – Low Temperature Heating Medium to 24-HA-102 – Hysys model

Since a lower temperature heating medium helps in achieving a more favourable design, the cold heating medium at 100°C exiting the Field 1 and Field 2 Inlet Heaters (20-HA-001 & 20-HA-002) is routed to 24-HA-202 and 24-HA-102 respectively. Since the heating medium needs to return to the Waste Heat Recovery Unit around 100°C, it is assumed that the outlet temperature of the heating medium from 24-HA-102 and 24-HA-202 be set at 90°C so there is not much deviation from the specifications of the heating medium system. Also the difference in dimension

and heating duty between the inlet heaters and the wet gas superheaters requires that the flow of heating medium from the inlet heaters be spilt and part of it is sent to the superheaters while the remaining part of the heating medium is routed to the heating medium system.

As is seen in Figure 6.5, the heating medium outlet at 100°C from 20-HA-002 is routed to a flow splitter and one part is sent downstream to 24-HA-102. Since the inlet and outlet temperatures values of 100°C and 90°C are fed into the Hysys model, the required flowrate is automatically calculated and the split in flow is derived accordingly. In the case of 24-HA-102, 6% of the total heating medium outlet from 20-HA-002 is routed to 24-HA-102 and the remaining flow is routed to the heating medium system. The 6% flow is sufficient for superheating the Field 1 wet gas by 3°C. The base case thermal design of 24-HA-102 where normal heating medium with 150°C was used is given in Section 7.2.1 while the thermal calculations of the redesigned heat exchanger with the lower temperature heating medium is given in Section 7.2.2

The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.5. The high temperature of the heating medium in the base case design results in a non-optimum exchanger design with extreme dimensions (L/D ratio = 2) since the heating medium flowrate requirement is very less. However, on reducing the inlet temperature of the heating medium stream, the required flowrate increases by 4.5 times which in turn improves the dimensions of the revised exchanger.

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study II	Change
1	Flowrate of hydrocarbon Stream	kg/s	266	266	
2	Inlet temperature of heating medium	°C	150	100	-50
3	Outlet temperature of heating medium	°C	100	90	
4	Required flowrate of heating medium	kg/s	15	77	+413%
5	Total heat duty	KW	1950	2100	+7%
6	Shell – Inner Diameter (D)	mm	875	975	+11%
7	Tube length (L)	mm	1750	5000	+185%
8	Effective Surface Area per unit	m ²	73	261	257%
9	Number of shells per unit		1	1	
10	Number of shells in series		1	1	
11	Number of shells in parallel		1	1	
12	L/D Ratio (Ratio of tube length to shell ID)		2,00	5,13	
13	Footprint	m^2	3,24	6,90	+113%
14	Weight/Shell	kg	7045	14997	+113%

 Table 6.5 : Comparison of exchanger design between Base case & Case study II (24-HA-102)

The lower temperature of the heating medium results in longer tube lengths (increase of around 200%) with a slight increase in shell diameter (around 11%). The increased tube length gives a L/D ratio within the range of 5 and 10 which is one of the important criteria for an optimum heat exchanger design. The heat duty of the redesigned exchanger remains quite similar to that of the original design and so does the number of shells per unit. Only 1 shell per unit is sufficient to handle the required heating duty both in the base case design and in the case study. The revised dimensions of the case study heat exchanger cause a 113% increase in the footprint of the equipment which is also the reason for the weight of the equipment to increase from 7045 kgs to 14997kgs. Therefore, a major concern with the redesigned exchanger is the increase in the weight per unit.

A similar kind of arrangement as is explained above has been done for the superheater on the Field 2 gas injection train – 24-HA-202, seen in Figure 6.6. The heating medium outlet at 100° C from 20-HA-001 is routed to a flow splitter and one part is sent downstream to 24-HA-202. Since the inlet and outlet temperatures values of 100° C and 90° C are fed into the Hysys model, the required flowrate is automatically calculated and the split in flow is derived accordingly. In the case of 24-HA-202, 17% of the total heating medium outlet from 20-HA-001 is routed to 24-HA-202 and the remaining flow is routed to the heating medium system. The 17% flow is sufficient for superheating the Field 2 wet gas by 3°C. The base case thermal design of 24-HA-202 where normal heating medium with 150°C was used is given in Section 7.2.1 while the thermal calculations of the redesigned heat exchanger is given in Section 7.2.2

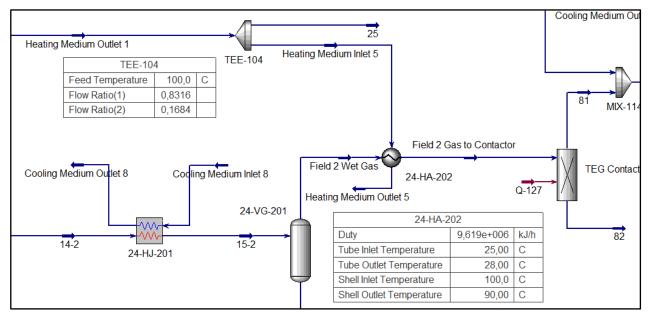


Figure 6.6 : Case Study II – Low Temperature Heating Medium to 24-HA-202 – Hysys model

The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.6. Similar to the discussion above, the high temperature of the heating medium in the base case design results in a non-optimum exchanger

design with extreme dimensions (L/D ratio = 2) since the heating medium flowrate requirement is very less. However, on reducing the inlet temperature of the heating medium stream, the dimensions of the redesigned exchanger are improved owing to a drastic increase in the flowrate requirement of the heating medium. To allow for the necessary heat transfer to occur with the lower temperature of the heating medium, the tube length is increased (increase of around 270%) with a slight increase in shell diameter (around 14%). The increased tube length gives a L/D ratio within the range of 5 and 10 which is one of the important criteria for an optimum heat exchanger design.

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study II	Change
1	Flowrate of hydrocarbon Stream	kg/s	301	301	
2	Inlet temperature of heating medium	°C	150	100	-50
3	Outlet temperature of heating medium	°C	100	90	
4	Required flowrate of heating medium	kg/s	17	89	+423%
5	Total heat duty	KW	2350	2175	
6	Shell – Inner Diameter (D)	mm	875	1000	+14%
7	Tube length (L)	mm	1750	6500	+271%
8	Effective Surface Area per unit	m ²	73	368	+400%
9	Number of shells per unit		1	1	
10	Number of shells in series		1	1	
11	Number of shells in parallel		1	1	
12	L/D Ratio (Ratio of tube length to shell ID)		2,00	6,50	
13	Footprint	m ²	3,24	8,62	+166%
14	Weight/Shell	kg	7045	17402	+147%

 Table 6.6 : Comparison of exchanger design between Base case & Case study II (24-HA-102)

The heat duty of the redesigned exchanger remains quite similar to that of the original design and so does the number of shells per unit. Only 1 shell per unit is sufficient to handle the required heating duty both in the base case design and in the case study. The revised dimensions of the case study heat exchanger cause a 166% increase in the footprint of the equipment which is also the reason for the weight of the equipment to increase from 7045 kgs to 17402 kgs. Therefore, a major concern with the redesigned exchanger is the increase in the weight per unit.

In the offshore oil and gas industry, considering the importance of weight and footprint of equipments in topside systems, the cost and other benefits of optimizing the exchanger design will have to be evaluated against the additional cost due to weight increase and then a decision will have to be made based on the evaluation.

6.5 Case Study III – Removal of Superheater and Scrubber unit prior to Gas Dehydration

In the base case process design, the wet gas in the Field 1 and Field 2 gas injection trains is cooled down in the dehydration inlet coolers (24-HJ-101 and 24-HJ-201) downstream of the Field 1 and Field 2 1st Stage Injection Compressors (23-KA-101 and 23-KA-201). After cooling the liquid phase is extracted in the dehydration inlet scrubbers in both the trains (24-VG-101 and 24-VG-201) and the gas phase is superheated by 3°C in the dehydration inlet superheaters (24-HA-102 and 24-HA-202). The superheated gas at around 28°C to 30°C is then routed downstream to the Field 1 and Field 2 TEG Contactors for dehydration.

In this case study, the dehydration inlet scrubbers and the wet gas superheaters in both the trains are removed from the process design. As a result, the wet gas needs to be cooled less since there is no extraction of the liquid phase. The outlet temperature of the wet gas from 24-HJ-101 and 24-HJ-201 is set in order to avoid any chance of condensation in the TEG Contactors. This case study is also conducted in order to simplify the process design by reducing certain equipments in the Field 1 and Field 2 gas injection trains and then analyze the impact on the heat exchangers upstream of the equipments that have been removed.

As is seen in Figure 6.7, the wet gas downstream of 23-KA-101 is cooled down to 51°C in 24-HJ-101 before being routed to the Field 1 TEG contactor for dehydration. The outlet temperature of the wet gas stream from 24-HJ-101 is decided based the hydrocarbon phase envelope in order to ensure that the temperature of the wet gas stream entering the TEG Contactor is above the hydrocarbon dew point. The base case thermal design of 24-HJ-101 is given in Section 7.5.1 while the thermal calculations of the redesigned heat exchanger with a much lower cooling duty demand is given in Section 7.5.2.

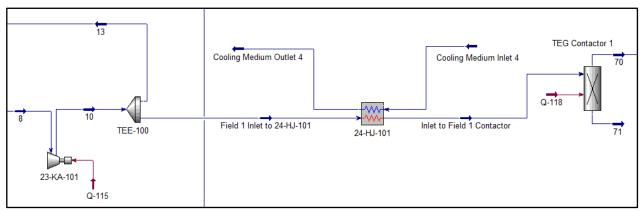


Figure 6.7 : Case Study III – Removal of Scrubber and Superheater unit before TEG Contactor 1 – Hysys model

The inlet and outlet temperatures of the cooling medium stream (20° C and 80° C respectively) are kept the same in the base case design and the case study. The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.7.

· · · · · · · · · · · · · · · · · · ·			1	1 1	
SI	Process Parameter / Exchanger	Unit	Base	Case Study	Change
No.	Specification		Case	III	
1	Flowrate of hydrocarbon Stream	kg/s	268	268	
2	Inlet temperature of wet gas stream	°C	135	135	
3	Outlet temperature of wet gas stream	°C	25	51	+26
4	Required flowrate of cooling medium	kg/s	446	342	-23%
5	Total Cooling Duty	KW	74541	57144	-24%
6	Shell – Inner Diameter (D)	mm	2000	1550	-23%
7	Tube length (L)	mm	7500	9000	+20%
8	Effective Surface Area per unit	m ²	3512	2589	-26%
9	Number of shells per unit		2	2	
10	Number of shells in series		1	1	
11	Number of shells in parallel		2	2	
12	L/D Ratio (Ratio of tube length to shell ID)		3,75	5,81	
13	Footprint	m ²	14.4	7,5	-48%
14	Weight/Shell	kg	76914	46586	-40%

Table 6.7 : Comparison of exchanger design between Base Case & Case study III (24-HJ-101)

The weight, footprint and dimensions of the base case exchanger shows that the equipment is of a very non-optimum design. Even the L/D ratio of this exchanger is outside the range for optimum design. In the case of the redesigned exchanger, the higher outlet temperature results in a lower cooling duty which causes a reduction in the scale of the exchanger. The revised dimensions of the case study exchanger give a 40% reduction in the weight per shell alongwith a 48% reduction in footprint. The L/D ratio also increases to 5.81 which is within the range required for optimum design. The process parameters in the base case design result in a very high effective surface area requirement which remains still high even in the case study redesigned exchanger. The weight of this equipment, both in the base case scenario and in the case study will account for a huge cost factor and it is advisable to substitute this shell and tube exchanger with a compact heat exchanger.

Since the pressure of the hot stream is higher than 35 bar, plate and frame exchanger is not a viable option. However, a Printed Circuit Heat Exchanger (PCHE) can be designed for this application. A PCHE can operate within this pressure range, handle the required scale of heat transfer and at the same time the exchanger design will be much more compact with a drastically lower weight and footprint factor. The cost benefit owing to weight and footprint savings will definitely favour the selection of a compact heat exchanger for this application.

The arrangement for the Field 2 injection train is similar to that as explained above for the Field 1 injection train. As seen in Figure 6.8, the Field 2 wet gas in compressed in 23-KA-201 and then routed downstream to the Field 2 Dehydration Inlet Cooler (24-HJ-201). In this case study, 24-HJ-201 cools downs the gas from 135°C to 53°C before it is routed downstream to the Field 2 TEG Contactor. The outlet temperature of the wet gas from 24-HJ-201 is determined from the hydrocarbon phase envelope of the gas phase such that the gas entering the TEG contactor is above its hydrocarbon dew point. This is done to ensure that no condensation occurs inside the TEG contactor. The base case thermal design of 24-HJ-201 is given in Section 7.5.1 while the thermal calculations of the redesigned heat exchanger with a much lower cooling duty demand is given in Section 7.5.2.

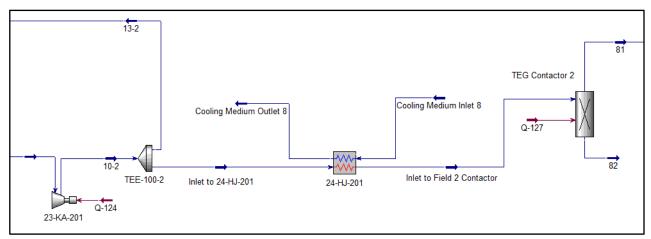


Figure 6.8 : Case Study III – Removal of Scrubber and Superheater unit before TEG Contactor 2 – Hysys model

The changes in the main process parameters and exchanger design specifications between the base case and case study can be seen in Table 6.8. Even in the case of this exchanger, the weight, footprint and dimensions of the base case design shows that the equipment is of a very non-optimum design. Even the L/D ratio of this exchanger is outside the range for optimum design. In the case of the redesigned exchanger, the higher outlet temperature results in a lower cooling duty which causes a reduction in the scale of the exchanger. The revised dimensions of the case study exchanger give a 26% reduction in the weight per shell alongwith a 15% reduction in footprint. The L/D ratio also increases to 5.29 which is within the range required for optimum design. The process parameters in the base case design result in a very high effective surface area requirement which remains still high even in the case study redesigned exchanger. The weight of this equipment, both in the base case scenario and in the case study will account for a huge cost factor and it is advisable to substitute this shell and tube exchanger with a compact heat exchanger too.

Since the pressure of the hot stream is higher than 35 bar, plate and frame exchanger is not a viable option. However, a Printed Circuit Heat Exchanger (PCHE) can be designed for this application also. A PCHE can operate within this pressure range, handle the required scale of heat transfer and at the same time the exchanger design will be much more compact with a drastically

lower weight and footprint factor. The cost benefit owing to weight and footprint savings will definitely favour the selection of a compact heat exchanger for this application.

Sl No.	Process Parameter / Exchanger Specification	Unit	Base Case	Case Study III	Change
1	Flowrate of hydrocarbon Stream	kg/s	304	304	
2	Inlet temperature of wet gas stream	°C	142	142	
3	Outlet temperature of wet gas stream	°C	25	53	+28
4	Required flowrate of cooling medium	kg/s	546	418	-24%
5	Total Cooling Duty	KW	90985	69726	-24%
6	Shell – Inner Diameter (D)	mm	2000	1700	-15%
7	Tube length (L)	mm	8500	9000	+6%
8	Effective Surface Area per unit	m ²	3999	3096	-23%
9	Number of shells per unit		2	2	
10	Number of shells in series		1	1	
11	Number of shells in parallel		2	2	
12	L/D Ratio (Ratio of tube length to shell ID)		4,25	5,29	
13	Footprint	m ²	24,5	20,9	-15%
14	Weight/Shell	kg	81906	60439	-26%

 Table 6.8 : Comparison of exchanger design between Base Case & Case study III (24-HJ-201)

7.0 Thermal Calculations of Heat Exchangers

This chapter includes the thermal calculations of the heat exchangers in the base case simulation followed by the thermal calculations of the heat exchangers in the different case studies wherein the process parameters are modified and the exchanger has been redesigned.

7.1 Thermal calculations for Inlet Heaters (20-HA-001 & 20-HA-002) – Base Case Design

Heat Exchanger Specification Sheet

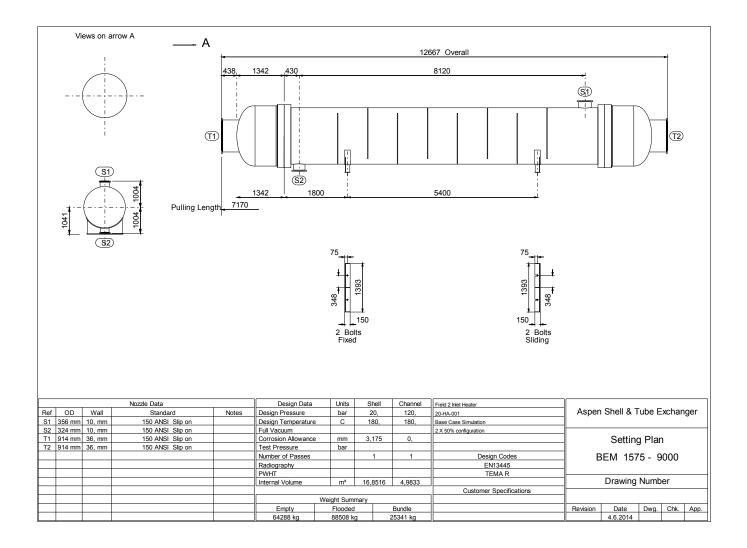
1 1								
1	Field 2 Inlet Heater							
2	20-HA-001							
3	Base Case Simulation	n						
4	2 X 50% configuration	n						
5								
6		9000		ype BEM	Hor		2 parallel	1 series
7	Surf/unit(eff.)	2028	m ² Shells	/unit 2		Surf	/shell (eff.)	1014 m²
8			PERF	ORMANCI	e of on	E UNIT		
9	Fluid allocation				Shell		Tube	
10	Fluid name			He		dium Inlet 1	Field 2	Inlet
	Fluid quantity, Total		kg/s		262,9		1007	
12	Vapor (In/Out)		kg/s	0		0	104,3228	171,2098
13	Liquid		kg/s	262,9		262,9586	902,7936	835,9066
14	Noncondensable		kg/s	0		0	0	0
15								
	Temperature (In/Out)		°C	15	0	110,9	46	55,67
17	Dew / Bubble poir		0°	ļ				
	Density	Vapor/Liquid	kg/m³	<u> </u>	1003	/ 1054	12,62 / 819,54	12,16 / 816
19	Viscosity		mPa s	/	1,15	/ 1,2046	0,1106 / 4,1438	0,1034 / 4,1145
20	Molecular wt, Vap						20,94	20,85
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,29	/ 3,273	2,19 / 2,074	2,19 / 2,077
-	Thermal conductivity		W/(m K)	//	0,231	/ 0,2309	0,0351 / 0,1123	0,0352 / 0,1123
24	Latent heat		kJ/kg				18,6	18,6
	Pressure (abs)		bar	11		10,86387	16	15,51067
26	Velocity		m/s		1,	29	10,7	75
27	Pressure drop, allow.	/calc.	bar	1		0,13613	0,5	0,48933
28	Fouling resist. (min)		m² K/W		0		0	0 Ao based
29	Heat exchanged	41528	kW				corrected	102,09 ° C
30	Transfer rate, Service		Dirty	616,2		Clean 616,2	. <u></u>	W/(m² K)
31			TRUCTION OF ON				Ska	tch
-		CONS					Ske	
32		CONS	Shell S			Tube Side	Ske	
32 33	Design/vac/test press	sure:g bar	Shell S 20/ /		120		JKe	
32 33 34	Design temperature	sure:g bar °C	Shell S 20/ / 180		120)/ / 180		
32 33 34	Design temperature Number passes per s	sure:g bar °C	Shell S 20/ / 180 1	ide	120	1/ / 180 1		
32 33 34	Design temperature	sure:g bar °C shell mm	Shell S 20/ / 180 1 3,18	ide	120	/ / 180 1 0	°[(]]	
32 33 34 35 36 37	Design temperature Number passes per s Corrosion allowance Connections	sure:g bar °C shell In mm	Shell S 20/ / 180 1 3,18 1 350/	ide	120 120	/ / 180 1 0 900/ -		
32 33 34 35 36 37	Design temperature Number passes per s Corrosion allowance	sure:g bar °C shell mm	Shell S 20/ / 180 1 3,18	ide		/ / 180 1 0		
32 33 34 35 36 37 38 39	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal	sure:g bar °C shell In mm Out Intermediate	Shell S 20/ / 180 1 3,18 1 1 350/ 1 300/	ide		/ / 180 1 0 900/ - 900/ - / -		
32 33 34 35 36 37 38 39	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180	sure:g bar °C shell In mm Out	Shell S 20/ / 180 1 3,18 3,18 1 350/ 1 300/ / / /5 Tks-Avg	ide	1 1 1 mm	/ / 180 1 0 900/ - 900/ - 900/ - / - Length 9000	•[[]] •[]] mm Pitch	<u>°</u> 40 mm
32 33 34 35 36 37 38 39	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain	sure:g bar °C shell In mm Out Intermediate OD 31,7	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / 75 Tks-Avg #/m M	ide - - - 2,11 aterial 22	1	/ / 180 1 0 900/ - 900/ - / - Length 9000 Mo steel	•[[]]	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel	sure:g bar °C shell In mm Out Intermediate OD 31,7	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / '5 Tks-Avg #/m M. D 1575 OD	ide	1 1 1 mm	/ / 180 1 0 900/ - 900/ - / - Length 9000 Mo steel Shell cover	•[[]] •[]] mm Pitch	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain	sure:g bar °C shell In mm Out Intermediate OD 31,7	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / '5 Tks-Avg #/m M. D 1575 OD	ide - - - 2,11 aterial 22	1 1 mm 2Cr,5Ni,3l	/ / 180 1 0 900/ - 900/ - / - Length 9000 Mo steel	•[[]] •[]] mm Pitch	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo	Shell S 20/ / 180 1 3,18 1 1 350/ 1 300/ /' // '5 Tks-Avg #/m M D 1575 OD steel	ide - - - 2,11 aterial 22	1 1 mm 2Cr,5Ni,3l	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating	mm Pitch Tube pattern 30 - - -	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42 43 44	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo	Shell S 20/ / 180 1 3,18 1 1 350/ 1 300/ /' // '5 Tks-Avg #/m M D 1575 OD steel	ide - - - 2,11 aterial 22	1 1 mm 2Cr,5Ni,3l	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover	mm Pitch Tube pattern 30 - - -	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo -	Shell S 20/ / 180 1 3,18 1 1 350/ 1 300/ /'5 Tks-Avg #/m M D 1575 OD steel -	ide - - - 2,11 aterial 22	1 1 2Cr,5Ni,3 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	mm Pitch Tube pattern 30 - - - - -	<u>°</u> 40 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo -	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - Type Single steel	ide - - 2,11 aterial 22 1609	1 1 2Cr,5Ni,3 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protection Sut(%d) 10	mm Pitch Tube pattern 3i - - - - - - - - - - - - -	<u>40 mm</u>
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo -	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - Type Single steel	ide - - 2,11 aterial 22 1609 segmental	1 1 2Cr,5Ni,3 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	mm Pitch Tube pattern 3i - - - - - - - - - - - - -	<u>40 mm</u> 0 850 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo -	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / 75 Tks-Avg #/m M D 1575 OD steel - Type Single s See See	ide - - 2,11 aterial 22 1609 segmental eal type	1 1 2Cr,5Ni,3 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	mm Pitch Tube pattern 3i - - - - - - - - - - - - -	<u>40 mm</u> 0 850 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo -	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / 75 Tks-Avg #/m M D 1575 OD steel - Type Single s See See	ide - - 2,11 aterial 22 1609 segmental eal type	1 1 2Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - / - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	mm Pitch Tube pattern 3i - - - - - - - - - - - - -	<u>40 mm</u> 0 850 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / '5 Tks-Avg #/m M. D 1575 OD steel - - Type Single s Se U-bend Se -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu	1 1 2Cr,5Ni,31 mm CC	/ / 180 1 0 900/ - 900/ - 900/ - / - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	mm Pitch Tube pattern 3i - - - - - - - - - - - - -	<u>40 mm</u> 0 850 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / '5 Tks-Avg #/m M. D 1575 OD steel - - Type Single s Se U-bend Se -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type	1 1 2Cr,5Ni,31 mm C besheet j None 188	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp.	mm Pitch Tube pattern 3 - - - - - - - - - - - - - - - - - - -	40 mm 0 850 mm 1332,48 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	sure:g bar °C shell In mm Out Intermediate OD 31,7 OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 2203 -	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / '5 Tks-Avg #/m M. D 1575 OD steel - - Type Single s Se U-bend Se -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm C besheet j None 188	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp.	mm Pitch Tube pattern 3 - - - - - - - - - - - - - - - - - - -	40 mm 0 850 mm 1332,48 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	sure:g bar °C shell In mm Out Intermediate OD 31,7 OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 2203 -	Shell S 20/ / 180 1 3,18 1 350/ 1 300/ / / 75 Tks-Avg #/m M D 1575 OD steel - Steel - U-bend Se U-bend Bundl	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm C besheet j None 188	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - -	40 mm 0 850 mm 1332,48 mm
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	sure:g bar °C shell In mm Out Intermediate OD 31,7 UI 22Cr,5Ni,3Mo	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - - Type Single s Se U-bend Bund - 45 - -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC C besheet j None 188 ide	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect iut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - -	40 mm 40 mm 0 850 mm 1332,48 mm kg/(m s ²) hery service
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 3\\ 6\\ 3\\ 7\\ 3\\ 8\\ 3\\ 9\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating he	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Di 22Cr,5Ni,3	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - - Type Single s Se U-bend Bund - 45 - -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC C besheet j None 188 ide	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect iut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	40 mm 40 mm 50 mm 1332,48 mm kg/(m s²) hery service
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 3\\ 6\\ 3\\ 7\\ 3\\ 8\\ 3\\ 9\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Di 22Cr,5Ni,3	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - - Type Single s Se U-bend Bund - 45 - -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC C besheet j None 188 ide	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect iut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	40 mm 40 mm 50 mm 1332,48 mm kg/(m s²) hery service
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1180 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g bar °C shell In mm Out Intermediate OD 31,7 II 22Cr,5Ni,3Mo 22Cr,5Ni,3Di 22Cr,5Ni,3	Shell S 20/ / 180 1 3,18 1 1350/ 1 1300/ / '5 Tks-Avg #/m M D 1575 OD steel - - Type Single s Se U-bend Bund - 45 - -	ide - - 2,11 aterial 22 1609 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC C besheet j None 188 ide	/ / 180 1 0 900/ - 900/ - 900/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect iut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	40 mm 40 mm 50 mm 1332,48 mm kg/(m s²) hery service

Shell&Tube V7.3.1 CP1

Date: 4.6.2014

Time: 18:31:58

Setting Plan

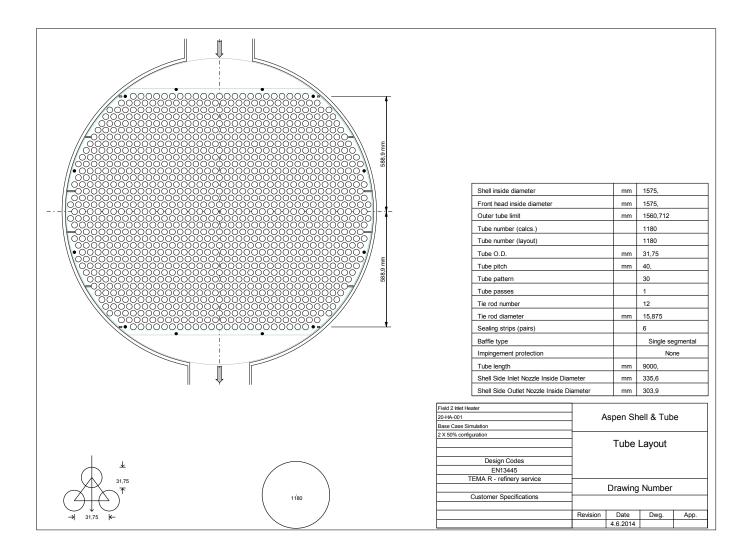


Shell&Tube V7.3.1 CP1

Date: 4.6.2014

Time: 18:31:58

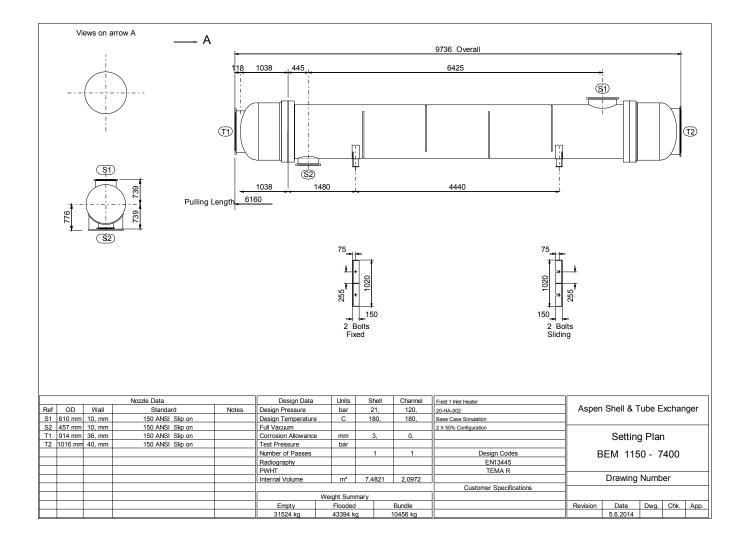
Tube Layout



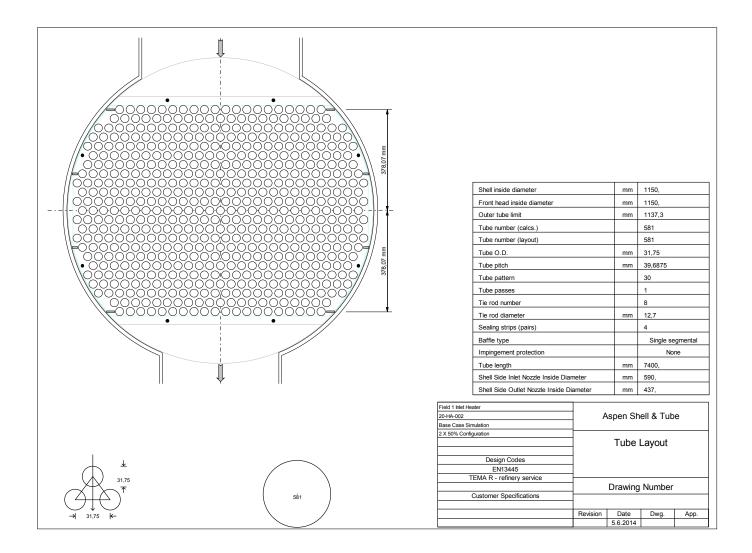
Heat Exchanger Specification Sheet

1	Field 1 Inlet Heater									
2	20-HA-002									
3	Base Case Simulation	on								
4	2 X 50% Configurati	on								
5										
6)7400		mm		pe BEM	Hor		2 parallel	1 series
7	Surf/unit(eff.)	82	24,2	m²		/unit 2			urf/shell (eff.)	412,1 m ²
8					PERF	ORMANCE				
9	Fluid allocation						Shell		Tube	
10	Fluid name					Hea		dium Inlet 2	Field	
11	Fluid quantity, Total				kg/s		635,		910,	
12	Vapor (In/Out)				kg/s	0		0	117,4927	129,1628
13	Liquid				kg/s	635,0	072	635,072	793,3034	781,6333
14	Noncondensable				kg/s	0		0	0	0
15	To any construct (in (Out	<u>,</u>				4.54		440.40		5474
16	Temperature (In/Out	•			<u> </u>	150)	116,12	29,81	54,71
17	Dew / Bubble poir		.:		0°	/	4000	/ 105	40.75 / 004.00	11.00 / 000.01
18	Density	Vapor/Liqu	uu		kg/m ³	<u>├</u> /	1003	/ 1054		
19	Viscosity				mPa s		1,15	/ 2,43		
20	Molecular wt, Vap								20,08	20,07
21	Molecular wt, NC				1//1 1/2	· ,	2 20	/ 0.00	2 172 / 2 000	2 101 / 2 057
22 23	Specific heat Thermal conductivity	,			J/(kg K)	<u>├</u> /	3,29	/ 3,02		2,191 / 2,057 0,0351 / 0,1139
23 24	Latent heat	/		V	N/(m K)	/	0,231	/ 0,229	0,0333 / 0,1144 25,7	
24 25	Pressure (abs)				kJ/kg bar	11		10,39471	16	27,4 15,0095
25	Velocity							93	17,	+
20	Pressure drop, allow	/calc			m/s bar	1		0,60529	1	0,9905
27	Fouling resist. (min)	./ calc.			m² K/W	1	0	,	0	0 Ao based
29	Heat exchanged	5024	11	kW			0		TD corrected	101,68 ° C
30	Transfer rate, Servic				Dirty	668,8		Clean 668,8		W/(m² K)
31				TRUCTIO		-			Ska	etch
32					Shell Si			Tube Side		
33	Design/vac/test pres	sure:a	bar	21/	/		120		_	
34	Design temperature	ouroig	°C		180		120	<u>, ,</u> 180		_
35	Number passes per	shell			1			1		
36	Corrosion allowance		mm		3			0		
37	Connections	In	mm	1	600/	-	1	900/ -		-
38	Size/rating	Out		1	450/	-	1	1000/ -	_	
39		Intermediat	е		. /	-		/ -		
40	Tube No. 581		31,7	5	Tks-Avg	2,11	mm	Length 7400	mm Pitch	39,69 mm
41	Tube type Plain							Mo steel		30
42	Shell Carbon Stee		ID	0 1150	OD [·]		mm	Shell cover	-	
43	Channel or bonnet	22Cr,5N	i,3Mo s	steel				Channel cover		
44	Tubesheet-stationary	y 22Cr,5N	i,3Mo s	steel	-			Tubesheet-floatin	g -	
45	Floating head cover	-						Impingement pro	tection None	
46	Baffle-crossing SS	316L		Туре	Single s	segmental	C	ut(%d) 12,99	H Spacing: c/c	1370 mm
47	Baffle-long -				Se	eal type			Inlet	1500,48 mm
48	Supports-tube			U-bend				Туре		
49	Bypass seal					Tube-tu	besheet	joint Exp).	
50	Expansion joint	-				Туре	None			
51	RhoV2-Inlet nozzle	1	345		Bundl	le entrance	941		Bundle exit 911	kg/(m s²)
52	Gaskets - Shell side	-				Tube S	de	F	lat Metal Jacket Fibe	
53	Floating h	ead -								
54	Code requirements		EN1344					-	TEMA class R - ref	inery service
	Weight/Shell	3	81523,9)	Filled	with water	43393,5	; I	Bundle 10455	,6 kg
55										
56	Remarks									
	Remarks									

Setting Plan



Tube Layout



7.2 Thermal Calculations of Superheaters in the Gas Compression Train

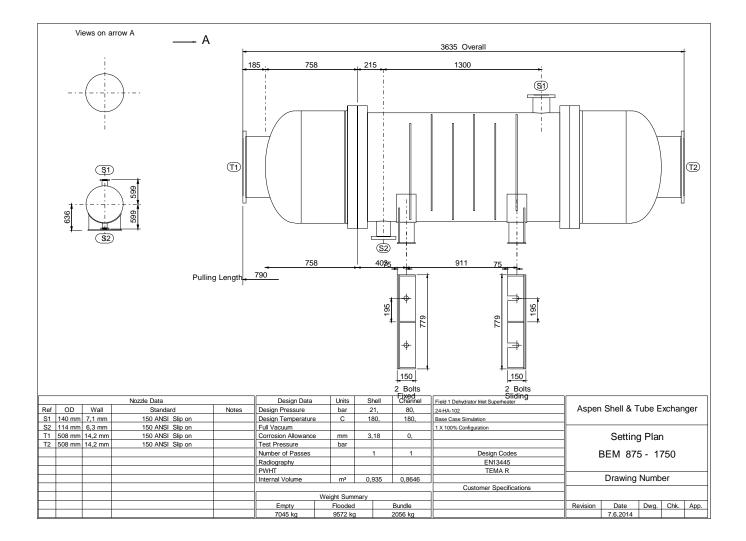
This section contains the thermal design calculations of the relevant heat exchangers in Case Study II.

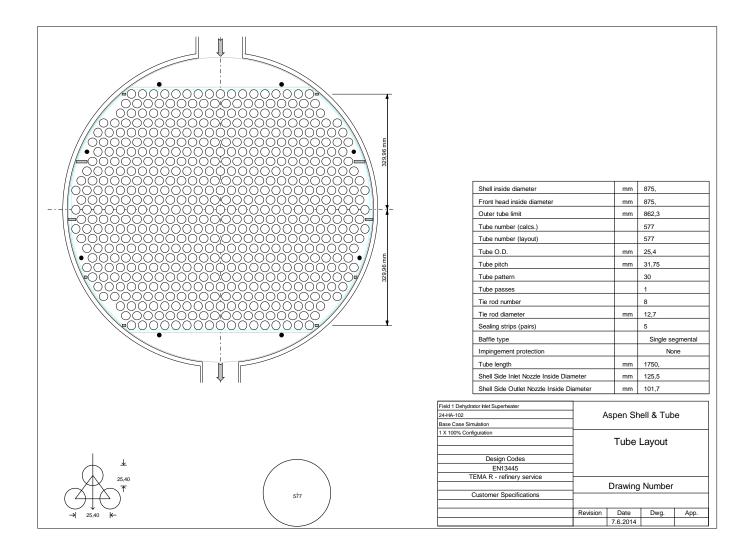
7.2.1 Thermal Calculations of 24-HA-102 & 24-HA-202 – Base Case Design

Heat Exchanger Specification Sheet

2	Field 1 Dehydrator Ir	niet Supernea	ater						
	24-HA-102								
3	Base Case Simulation								
4	1 X 100% Configura	uon							
6	Size 875	1750			ype BEM	Hor	Connected in	1 parallel	1 series
7	Size 075 Surf/unit(eff.)		72,8		ype b⊏ivi /unit 1			f/shell (eff.)	72,8 m ²
8	Sull/ullit(ell.)		12,0						72,0 111-
9	Fluid allocation			FENF		Shell		т	be Side
10	Fluid name				He		dium Inlet 4	-	1 Wet Gas
11	Fluid quantity, Total			kg/s		14,6			5,9028
12	Vapor (In/Out)			kg/s kg/s	0	14,0	0	265,9028	265,9028
13	Liquid			kg/s kg/s	14,62	047	14,6247	0	0
14	Noncondensable			kg/s kg/s	0		0	0	0
15	Nonochachoable			Kg/S	0		0	0	0
	Temperature (In/Out)		°C	150	า	107,5	25	29,64
17	Dew / Bubble poir			ي ℃	100	5	107,0	20	20,04
	Density	Vapor/Liqu	uid	kg/m³	/	1003	/ 1004,88	3 44,78 /	43,4 /
_	Viscosity	tapor/Eiqu		mPa s	/	1,15	/ 1,1976		0,0127 /
	Molecular wt, Vap				· · · ·	1,10	, 1,1370	19,72	19,72
21	Molecular wt, NC							13,72	13,72
22	Specific heat			kJ/(kg K)	/	3,29	/ 3,28	2,48 /	2,469 /
+	Thermal conductivity	,		W/(m K)	/	0,231	/ 0,2309		0.0357 /
	Latent heat			kJ/kg	/	0,201	7 0,2000	0,0000 /	
	Pressure (abs)			bar	11		10,96306	49,3	48,74384
	Velocity			m/s			54	'	27,68
27	Pressure drop, allow	/calc.		bar	1	0,0	0,03694	1	0,55616
	Fouling resist. (min)			m² K/W		0		0	0 Ao based
	Heat exchanged	1950		kW) corrected	100,44 ° C
20	r loat oxerlangea	1000							
30	Transfer rate. Servic	e 266.7	,	Dirty	736.5				,
	Transfer rate, Servic			Dirty	736,5 IE SHELL		Clean 736,5	1	W/(m² K)
31	Transfer rate, Servic			TRUCTION OF ON	NE SHELL		Clean 736,5	1	,
31 32			CONS	TRUCTION OF ON Shell S	NE SHELL	80	Clean 736,5 Tube Side	1	W/(m² K)
31 32	Design/vac/test pres		CONS bar	TRUCTION OF ON Shell S 21/ /	NE SHELL	80	Clean 736,5 Tube Side /	1	W/(m² K)
31 32 33 34	Design/vac/test pres Design temperature	sure:g	CONS	TRUCTION OF ON Shell S	NE SHELL	80	Clean 736,5 Tube Side	1	W/(m² K)
31 32 33 34	Design/vac/test pres	sure:g	CONS bar °C	TRUCTION OF ON Shell S 21/ / 180	IE SHELL	80	Clean 736,5 Tube Side ////////////////////////////////////	1	W/(m² K)
31 32 33 34 35	Design/vac/test pres Design temperature Number passes per	sure:g	CONS bar °C mm	TRUCTION OF ON Shell S 21/ 180 1 3,18	IE SHELL	80	Clean 736,5 Tube Side / / 180 1	1	W/(m² K)
31 32 33 34 35 36 37	Design/vac/test pres Design temperature Number passes per Corrosion allowance	sure:g	CONS bar °C mm mm	TRUCTION OF ON Shell S 21/ 180 1 3,18	IE SHELL		Clean 736,5 Tube Side / / 180 1 0	1	W/(m² K)
31 32 33 34 35 36 37 38	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections	sure:g shell In	CONS bar °C mm mm	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/	IE SHELL ide	1	Clean 736,5 Tube Side / / 180 1 0 500/ -	1	W/(m² K)
31 32 33 34 35 36 37 38 39	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating	sure:g shell In Out Intermediate	CONS bar °C mm mm	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/	IE SHELL ide / - - -	1	Clean 736,5 Tube Side / / 180 1 0 500/ -	1	W/(m ² K) Sketch
31 32 33 34 35 36 37 38 39 40	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	sure:g shell In Out Intermediate	CONS bar °C mm mm	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg	IE SHELL ide / - - - - 1,65	1	Clean 736,5 Tube Side / / / 180 ////////////////////////////////////		W/(m ² K) Sketch
31 32 33 34 35 36 37 38 39 40	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577	sure:g shell In Out Intermediate OD	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg	IE SHELL ide - - 1,65 aterial 22	1 1 mm	Clean 736,5 Tube Side / / / 180 ////////////////////////////////////	mm Pit	W/(m ² K) Sketch Ch 31,75 mm
31 32 33 34 35 36 37 38 39 40 41 42	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain	sure:g shell In Out Intermediate OD	CONS bar °C mm mm e 25,4	TRUCTION OF OF Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m M 0.875 OD	IE SHELL ide - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	Clean 736,5 Tube Side / / / 180 ////////////////////////////////////	mm Pit	W/(m ² K) Sketch Ch 31,75 mm
31 32 33 34 35 36 37 38 39 40 41 42 43	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel	sure:g shell In Out Intermediate OD	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m M 0.875 OD steel Steel	IE SHELL ide - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	Clean 736,5 Tube Side / / / 180 ////////////////////////////////////	mm Pit	W/(m ² K) Sketch Ch 31,75 mm
31 32 33 34 35 36 37 38 39 40 41 42 43 44	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet	sure:g shell In Out Intermediate OD	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m M 0.875 OD steel Steel	IE SHELL ide - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	Clean 736,5 Tube Side / / / 180 ////////////////////////////////////	mm Pit Tube pattern -	W/(m ² K) Sketch Ch 31,75 mm
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni -	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0.875 OD steel -	IE SHELL ide - - 1,65 aterial 22	1 1 Cr,5Ni,31 mm	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating	mm Pit Tube pattern -	W/(m ² K) Sketch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni -	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0 875 OD steel	IE SHELL ide / - 1,65 aterial 22 899	1 1 Cr,5Ni,31 mm	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote	mm Pit Tube pattern - - ction None	W/(m ² K) Sketch
31 32 33 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni -	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0 875 OD steel	IE SHELL ide - - 1,65 aterial 22 899 segmental	1 1 Cr,5Ni,31 mm	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch ch 31,75 mm 30 175 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni -	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ Ks-Avg #/m 0875 OD steel steel Steel Steel Steel Steel Steel Steel Steel	IE SHELL ide - - 1,65 aterial 22 899 segmental eal type	1 1 Cr,5Ni,31 mm	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch ch 31,75 mm 30 175 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni -	CONS bar °C mm mm e 25,4	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ Ks-Avg #/m 0875 OD steel steel Steel Steel Steel Steel Steel Steel Steel	IE SHELL ide - - 1,65 aterial 22 899 segmental eal type	1 1 Cr,5Ni,31 mm C	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch ch 31,75 mm 30 175 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni - 316L	CONS bar °C mm mm e 25,4	TRUCTION OF OF Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0.875 OD steel steel Steel U-bend	IE SHELL ide - - 1,65 aterial 22 899 segmental eal type Tube-tu	1 1 Cr,5Ni,3I mm Cc,5Ni,3I mm	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch ch 31,75 mm 30 175 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni - 316L	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s	TRUCTION OF OF Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0.875 OD steel steel Steel U-bend	IE SHELL ide - - 1,65 aterial 22 899 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3I mm Cc,5Ni,3I mm Cc	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp.	mm Pit Tube pattern - - ction None H Spacing: c/c Inlet	W/(m ² K) Sketch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	sure:g shell In Out Intermediate OD 22Cr,5Ni - 22Cr,5Ni - 316L - 1 1	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s 394	TRUCTION OF OF Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0.875 OD steel steel Steel U-bend	IE SHELL ide / - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cc,5Ni,3I mm Cc	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp.	mm Pit Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 112	W/(m ² K) Sketch
$\begin{array}{c} 31\\ 32\\ 3\\ 3\\ 3\\ 4\\ 35\\ 36\\ 3\\ 3\\ 3\\ 3\\ 3\\ 3\\ 3\\ 3\\ 3\\ 4\\ 4\\ 4\\ 4\\ 5\\ 4\\ 4\\ 4\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\ 5\\$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	sure:g shell In Out Intermediate OD 22Cr,5Ni - 316L - - 1 ead -	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s 394	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0875 0D steel steel Steel Steel Steel Bund	IE SHELL ide / - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cc,5Ni,3I mm Cc	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 56\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni 22Cr,5Ni - 316L - - 1 - -	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 3,18 1 125/ 1 7 875 8 9 9 9 10 10 10 10 11 10	IE SHELL ide / - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cc besheet j None 116 ide	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - -	W/(m² K) Sketch Sketch Image: sketch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni 22Cr,5Ni - 316L - - 1 - -	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s i,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 3,18 1 125/ 1 7 875 8 9 9 9 10 10 10 10 11 10	IE SHELL ide / - - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 116 ide	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	mm Pit Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 112 at Metal Jacket Fib	W/(m² K) Sketch Sketch Image: sketch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni 22Cr,5Ni - 316L - - 1 - -	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s i,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 3,18 1 125/ 1 7 875 8 9 9 9 10 10 10 10 11 10	IE SHELL ide / - - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 116 ide	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	mm Pit Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 112 at Metal Jacket Fib	W/(m² K) Sketch Sketch Image: sketch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 56 55 55 56 5 5 5 5 55 56	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g shell In Out Intermediate OD 22Cr,5Ni 22Cr,5Ni 22Cr,5Ni - 316L - - 1 - -	CONS bar °C mm mm 25,4 i,3Mo s i,3Mo s i,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3,18 1 125/ 1 100/ / Tks-Avg #/m 0875 0B Steel Steel Steel Steel Steel Bund Bund 45	IE SHELL ide / - - 1,65 aterial 22 899 segmental eal type Tube-tu Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 116 ide	Clean 736,5 Tube Side / / 180 1 0 500/ - 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	mm Pit Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 112 at Metal Jacket Fib	W/(m² K) Sketch Sketch Image: sketch

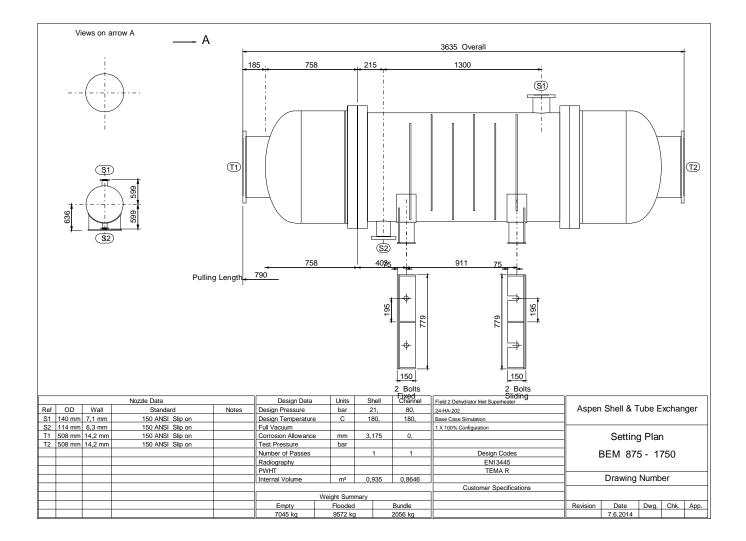
1	Size 875	x 1750) mm	Тур	e BEM	Hor		Connected ir		1 parallel	1 series
2	Surf/Unit (gross/e		80		72,8 /	m²		Shells/unit		1 parallel	i selles
2	Surf/Shell (gross/e	,	80 80	,	72,8 / 72,8 /	m²		Shens/unit		I	
4	Gan/Gheir (gross/			,0 / 1	2,0 /						
5	Design				PERFORMA	ANCE OF ON	E UNIT				
6			Shel	I Side	Tube	Side	Heat Tr	ransfer Param	eters		
7	Process Data		In	Out	In	Out	Total he	eat load		kW	1950
8	Total flow	kg/s	14	,6247	265,	9028	Eff. MT	D/ 1 pass MTE)	°C 1	00,44/100,27
9	Vapor	kg/s	0	0	265,9028	265,9028	Actual/	Reqd area rati	o - fouled/cl	ean	2,76 / 2,76
10	Liquid	kg/s	14,6247	14,6247	0	0					
11	Noncondensable	kg/s		0		0	Coef./F		W/(m² K)	m² K/W	
12	Cond./Evap.			0		0	Overall		736,5	0,0013	
13	Temperature	°C	150	107,5	25	29,64	Overall		736,5	0,0013	
14	Dew / Bubble poir	nt °C					Tube si		3025,3	0,0003	-
15	Quality		0	0	1	1		de fouling		0	0
16	Pressure (abs)	bar	11	10,96306	,	48,74384	Tube w		8893,7	0,0001	,
17	Delta P allow/calc		1	0,03694	1	0,55616		e fouling		0	0
18	Velocity	m/s	0,54	0,52	26,83	27,68	Outside	etilm	1093	0,0009	1 67,38
19 20	Liguid Propertie						Shall S	ide Pressure	Dron	bar	%
20	Density	s kg/m³	1003	1004,88			Inlet no		ыор	0,00752	20,35
22	Viscosity	mPa s	1,15	1,1976				ace Xflow		0,00732	7,44
23	Specific heat	kJ/(kg K)	3,29	3,28			Baffle X			0,00999	27,05
24	Therm. cond.	W/(m K)	0,231	0,2309			Baffle v			0,00303	5,53
25	Surface tension	N/m	0,201	0,2000				space Xflow		0,00204	7,47
26	Molecular weight						Outlet r	•		0,01188	32,16
27	Vapor Properties							diate nozzle		0,01100	02,10
28	Density	kg/m³			44,78	43,4		ide Pressure	Drop	bar	%
29	Viscosity	mPa s			0,0126	0,0127	Inlet no			0,11839	21,47
30	Specific heat	kJ/(kg K)			2,48	2,469	Enterin			0,07818	14,18
31	Therm. cond.	W/(m K)			0,0356	0,0357	Inside t	0		0,13392	24,29
32	Molecular weight	,()			19,72	19,72	Exiting			0,10732	19,47
33	Two-Phase Prop	erties			-,	- ,	Outlet r			0,11354	20,59
34	Latent heat	kJ/kg					Interme	diate nozzle			
35		-									
36	Heat Transfer Pa	rameters					Velocit	y / Rho*\	/2	m/s	kg/(m s²)
37	Reynolds No. vap	or			2107147	2097887	Shell n	ozzle inlet		1,18	1394
38	Reynolds No. liqu	id	12048,66	11569,93			Shell b	undle Xflow	0,	54 0,52	2
39	Prandtl No. vapor				0,88	0,87	Shell b	affle window	0,	46 0,44	-
40	Prandtl No. liquid		16,38	17,01				ozzle outlet		1,79	3225
41	Heat Load			kW		kW	Shell n	ozzle interm			
42	Vapor only			0		950				m/s	kg/(m s²)
43	2-Phase vapor			0		0		ozzle inlet		32,87	48380
44	Latent heat			0		0	Tubes		26	,83 27,6	
45	2-Phase liquid			0		0		ozzle outlet		33,92	49921
46	Liquid only		-	1950		0	Tube n	ozzle interm			
47	Tuboo				Pofflag		1	Noz-les: //			
48	Tubes				Baffles	Single	egmental	Nozzles: (I	-	Shall Sida	Tubo Sida
49 50	Type ID/OD		22,1 / 2		Type Number	Single Se	egmentai 6	Inlet		Shell Side / 139,7	Tube Side 1 / 508
50 51					Number Cut(%d)	10	U	Outlet		/ 139,7 / 114,3	1 / 508
51	Length act/eff Tube passes	mm 17	100/1		Cut(%d) Cut orientation	10	н	Other	1	/ 114,3	1 / 508
53	Tube passes Tube No.					mm	п 175		nt protoctio		, None
53 54	Tube No. Tube pattern				Spacing: c/c Spacing at inlet		352,98	Impingeme	ni protectio		NULLE
54 55	Tube pattern	mm	-		Spacing at met		352,98 352,98				
56	Insert		c c	None	opaoning at outin	or 11111	552,30				
50 57	Vibration problem		1	No/No			RhoV2 vi	olation			No
<i></i>							1110 12 11				

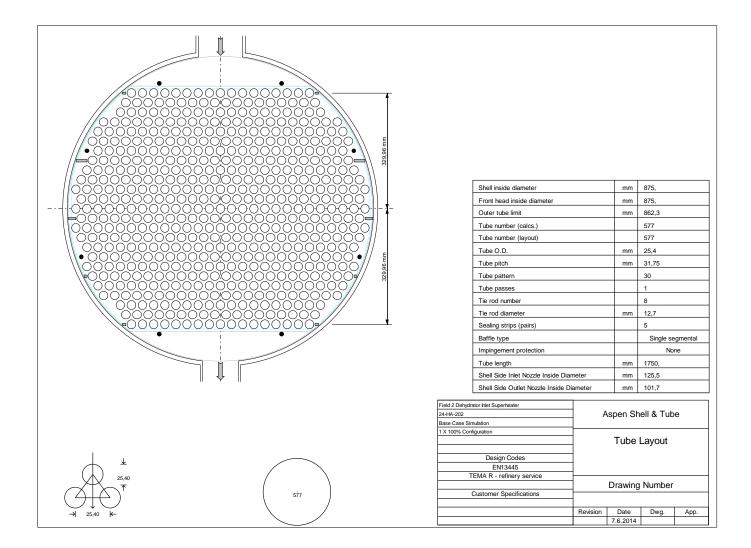




1 1	Field 2 Debydratar l	alat Cunarkaatar						
1	Field 2 Dehydrator I 24-HA-202	niet Superneater						
3	Base Case Simulatio	20						
4	1 X 100% Configura							
5	TX 100% Conligue							
6	Size 875	5 1750	mm Ty	pe BEM	Hor	Connected in	1 parallel	1 series
7	Surf/unit(eff.)	72,8		/unit 1			/shell (eff.)	72,8 m ²
8		,0		ORMANCE	OF ON			
9	Fluid allocation				Shell	Side	Tub	e Side
10	Fluid name			Hea	ating Me	dium Inlet 5	Field 2	Wet Gas
11	Fluid quantity, Total		kg/s		16,9	167	301	,2883
12	Vapor (In/Out)		kg/s	0		0	301,2883	301,2883
13	Liquid		kg/s	16,91	67	16,9167	0	0
14	Noncondensable		kg/s	0		0	0	0
15								
16	Temperature (In/Out	:)	°C	150)	108,35	25	29,77
17	Dew / Bubble poi	nt	°C					
18	Density	Vapor/Liquid	kg/m³	/	1003	/ 1005,46	49,89 /	48,25 /
19	Viscosity		mPa s	/	1,15	/ 1,2122	0,0128 /	0,0128 /
20	Molecular wt, Vap						19,72	19,72
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,29	/ 3,277	2,54 /	2,527 /
23	Thermal conductivity	/	W/(m K)	/	0,231	/ 0,2309	0,0362 /	0,0363 /
24	Latent heat		kJ/kg					
25	Pressure (abs)		bar	11		10,95169	54,2	53,56083
26	Velocity		m/s		0,		28	3,21
27	Pressure drop, allow	./calc.	bar	1		0,04831	1	0,63918
28	Fouling resist. (min)		m² K/W		0		0	0 Ao based
29	Heat exchanged	2175	kW				corrected	100,93 ° C
30	Transfer rate, Servic		Dirty	801,2		Clean 801,2		W/(m² K)
31		CONS	TRUCTION OF ON				Sk	ketch
32			Shell S	ide		Tube Side		
0.0				/ I				
	Design/vac/test pres			'	80			Îm
34	Design temperature	°C	180	,	80	180		
34 35	Design temperature Number passes per	° C shell	180 1	,	80	180 1		
34 35 36	Design temperature Number passes per Corrosion allowance	°C shell mm	180 1 3,18			180 1 0		
34 35 36 37	Design temperature Number passes per Corrosion allowance Connections	°C shell In mm	180 1 3,18 1 125/	-	1	180 1 0 500/ -		
34 35 36 37 38	Design temperature Number passes per Corrosion allowance Connections Size/rating	°C shell In mm Out	180 1 3,18	- -		180 1 0		
34 35 36 37 38 39	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	°C shell In mm Out Intermediate	180 1 3,18 1 125/ 1 100/ /		1	180 1 0 500/ - 500/ -	mm Pitc	h 31 75 mm
34 35 36 37 38 39 40	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577	°C shell In mm Out	180 1 3,18 1 125/ 1 100/ 1 Tks-Avg	- - - 1,65	1 1 mm	180 1 0 500/ - 500/ - / - Length 1750	mm Pitc	
34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain	°C shell In mm Out Intermediate OD 25,4	180 1 3,18 1 125/ 1 100/ 1 Tks-Avg #/m M	- - 1,65 aterial 220	1 1 mm Cr,5Ni,3	180 1 0 500/ - 500/ - / - Length 1750 Mo steel	mm Pitc Tube pattern	h 31,75 mm 30
34 35 36 37 38 39 40 41 42	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee	shell nmm Out Intermediate OD 25,4	180 1 3,18 1 125/ 1 100/ 1 100/ Tks-Avg #/m M D 875 OD	- - 1,65 aterial 220	1 1 mm	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover	Tube pattern	
34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet	°C shell In mm Out Intermediate OD 25,4	180 1 3,18 1 125/ 1 100/ 1 100/ Tks-Avg #/m M D 875 OD 3 steel	- - 1,65 aterial 220	1 1 mm Cr,5Ni,3	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover	Tube pattern -	
34 35 36 37 38 39 40 41 42 43 44	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar	°C shell In mm Out Intermediate OD 25,4	180 1 3,18 1 125/ 1 100/ 1 100/ Tks-Avg #/m M D 875 OD 3 steel	- - 1,65 aterial 220	1 1 mm Cr,5Ni,3	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating	Tube pattern - - -	
34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 100/ 1 100/ K-Avg #/m M D 875 OD 3 steel steel -	- - 1,65 aterial 220	1 1 Cr,5Ni,31 mm	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern - - - ction None	
34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 100/ Tks-Avg #/m M. D 875 OD a steel steel steel - Type Single s	- - 1,65 aterial 220	1 1 Cr,5Ni,31 mm	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern - - - tion None	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 100/ Tks-Avg #/m M. D 875 OD a steel steel steel - Type Single s	- - 1,65 aterial 220 899 segmental	1 1 Cr,5Ni,31 mm	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern - - tion None H Spacing: c/c	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 100/ Tks-Avg #/m M. D 875 OD 3 steel steel steel - Type Single s Se	- - 1,65 aterial 220 899 segmental	1 1 Cr,5Ni,31 mm C	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - tion None H Spacing: c/c	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 100/ Tks-Avg #/m M. D 875 OD 3 steel steel steel - Type Single s Se	- - 1,65 aterial 220 899 segmental eal type Tube-tub	1 1 Cr,5Ni,31 mm C	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - tion None H Spacing: c/c	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long Supports-tube Bypass seal	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo -	180 1 3,18 1 125/ 1 125/ 1 125/ 1 100/ / Tks-Avg #/m M D 875 OD 8 steel steel steel Steel Steel Steel U-bend	- - 1,65 aterial 220 899 segmental eal type Tube-tut	1 1 Cr,5Ni,3I mm Cc Desheet J None	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - tion None H Spacing: c/c	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	°C shell In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo - 3316L - 3316L - - 1865	180 180 1 3,18 1 125/ 1 100/ 1 100/ 1 100/ 1 00/ 1 00/	- 1,65 aterial 220 899 segmental eal type Tube-tub Type	1 1 Cr,5Ni,31 mm Cr C C Desheet J None 156	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	Tube pattern - - ction None H Spacing: c/c Inlet	30 175 mm 352,98 mm kg/(m s ²)
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 3 316L - 1865 -	180 180 1 3,18 1 125/ 1 100/ 1 100/ 1 100/ 1 00/ 1 00/	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance	1 1 Cr,5Ni,31 mm Cr C C Desheet J None 156	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	Tube pattern - - stion None H Spacing: c/c Inlet Bundle exit 149	30 175 mm 352,98 mm kg/(m s ²)
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV/2-Inlet nozzle Gaskets - Shell side	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 3 316L - 1865 -	180 180 1 3,18 1 125/ 1 100/ 1 100/ 1 100/ 1 00/ 1 00/	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance	1 1 Cr,5Ni,31 mm Cr C C Desheet J None 156	180 1 0 500/ - 500/ - / - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 149 t Metal Jacket Fibe	30 175 mm 352,98 mm kg/(m s ²)
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 3316L - 1865 - nead -	180 1 3,18 1 125/ 1 100/ / // Tks-Avg #/m #/m M D 875 OD 8 steel - Type Single s Seel - Steel - Bundl - 45 -	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance	1 1 Cr,5Ni,31 mm Cc Sesheet J None 156 de	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 149 t Metal Jacket Fibe	30 175 mm 352,98 mm kg/(m s²) efinery service
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo - 22Cr,5Ni,3Mo - 3316L - 1865 - 186 - 18 18 18 18 18 18 18 18 18 18	180 1 3,18 1 125/ 1 100/ / // Tks-Avg #/m #/m M D 875 OD 8 steel - Type Single s Seel - Steel - Bundl - 45 -	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance Tube Sid	1 1 Cr,5Ni,31 mm Cc Sesheet J None 156 de	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	Tube pattern	30 175 mm 352,98 mm kg/(m s²) efinery service
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head cover Baffle-long	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo - 22Cr,5Ni,3Mo - 3316L - 1865 - 186 - 18 18 18 18 18 18 18 18 18 18	180 1 3,18 1 125/ 1 100/ / // Tks-Avg #/m #/m M D 875 OD 8 steel - Type Single s Seel - Steel - Bundl - 45 -	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance Tube Sid	1 1 Cr,5Ni,31 mm Cc Sesheet J None 156 de	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	Tube pattern	30 175 mm 352,98 mm kg/(m s²) efinery service
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 577 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head cover Baffle-long	°C shell mm In mm Out Intermediate OD 25,4 I I 22Cr,5Ni,3Mo - 22Cr,5Ni,3Mo - 3316L - 1865 - 186 - 18 18 18 18 18 18 18 18 18 18	180 1 3,18 1 125/ 1 100/ / // Tks-Avg #/m #/m M D 875 OD 8 steel - Type Single s Seel - Steel - Bundl - 45 -	- 1,65 aterial 220 899 segmental eal type Tube-tub Type le entrance Tube Sid	1 1 Cr,5Ni,31 mm Cc Sesheet J None 156 de	180 1 0 500/ - 500/ - Length 1750 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	Tube pattern	30 175 mm 352,98 mm kg/(m s²) efinery service

1	Size 875	x 1750	mm	Тур	e BEM	Hor		Connected in		1 parallel	1 series
2	Surf/Unit (gross/eff/	/finned)	80	,6 / 7	2,8 /	m²		Shells/unit		1	
3	Surf/Shell (gross/ef	ff/finned)	80	,6 / 7	2,8 /	m²					
4											
5	Design				PERFORMA	NCE OF ON	E UNIT				
6			She	II Side	Tube	Side	Heat Tr	ansfer Parame	eters		
7	Process Data		In	Out	In	Out	Total he	eat load		kW	2175
8	Total flow	kg/s	16	6,9167	301,	2883	Eff. MT	D/ 1 pass MTD		°C 10	00,93/ 100,69
9	Vapor	kg/s	0	0	301,2883	301,2883	Actual/I	Reqd area ratio	- fouled/cl	ean 2	2,71 / 2,71
10	Liquid	kg/s	16,9167	16,9167	0	0					
11	Noncondensable	kg/s		0		0	Coef./R		V/(m² K)	m² K/W	
12	Cond./Evap.			0		0	Overall		801,2	0,00128	
13	Temperature	°C	150	108,35	25	29,77	Overall		801,2	0,0012	
14	Dew / Bubble point	°C					Tube si		3397	0,00029	,
15	Quality		0	0	1	1		de fouling		0	0
16	Pressure (abs)	bar	11	10,95169	54,2	53,56083	Tube w		8893	0,00011	,
17	Delta P allow/calc	bar	1	0,04831	1	0,63918		e fouling	4400.0	0	0
18	Velocity	m/s	0,63	0,6	27,28	28,21	Outside	e film	1188,6	0,00084	4 67,41
19 20	Liquid Proportion						Shall S	ide Pressure I)ron	bar	%
20	Liquid Properties Density	kg/m³	1003	1005,46			Inlet no		лор	0,01006	20,82
22	Viscosity	mPa s	1,15	1,2122				ace Xflow		0.00353	7,3
23	•	kJ/(kg K)	3,29	3,277			Baffle X			0,00000	26,14
24	•	W/(m K)	0,231	0,2309			Baffle w			0,00266	5,51
25	Surface tension	N/m	0,201	0,2000				pace Xflow		0,00354	7,34
26	Molecular weight						Outlet r	•		0,01589	32,88
27	Vapor Properties						Interme	diate nozzle		-,	- ,
28	Density	kg/m³			49,89	48,25		ide Pressure D	Drop	bar	%
29	Viscosity	mPa s			0,0128	0,0128	Inlet no	zzle		0,13642	21,53
30	Specific heat	kJ/(kg K)			2,54	2,527	Entering	g tubes		0,09018	14,23
31		W/(m K)			0,0362	0,0363	Inside t	ubes		0,15205	24
32	Molecular weight				19,72	19,72	Exiting	tubes		0,1238	19,54
33	Two-Phase Proper	rties					Outlet r	nozzle		0,13111	20,69
34	Latent heat	kJ/kg					Interme	diate nozzle			
35											
36	Heat Transfer Para	ameters					Velocit	y / Rho*V	2	m/s	kg/(m s²)
37	Reynolds No. vapor	r			2346587	2343083	Shell no	ozzle inlet		1,36	1865
38	Reynolds No. liquid	ł	13936,89	13221,5				undle Xflow	,	63 0,6	
39	Prandtl No. vapor				0,9	0,89		affle window	0,	54 0,51	
40	Prandtl No. liquid		16,38	17,2				ozzle outlet		2,07	4313
41	Heat Load			kW		kW	Shell no	ozzle interm		,	
42	Vapor only			0		175	_			m/s	kg/(m s ²)
43	2-Phase vapor			0		0		ozzle inlet	07	33,43	55751
44	Latent heat			0		0	Tubes		27	,28 28,21	
45 46	2-Phase liquid Liquid only			0 2175		0 0		ozzle outlet		34,57	57649
40 47				2175		<u> </u>					
47	Tubes				Baffles			Nozzles: (N	lo./OD)		
49	Туре				Type	Single se	egmental			Shell Side	Tube Side
50		mm 2	2,1 / 2		Number	- 5	6	Inlet	mm 1	/ 139,7	1 / 508
51					Cut(%d)	10		Outlet		/ 114,3	1 / 508
52	Tube passes				Cut orientation		н	Other		1	/
53	Tube No.			577	Spacing: c/c	mm	175	Impingemer	nt protection	n	None
54	Tube pattern			30	Spacing at inlet	mm	352,98				
55	Tube pitch	mm	:	31,75	Spacing at outle	et mm	352,98				
56	Insert			None							
57	Vibration problem			No/No			RhoV2 vi	olation			No

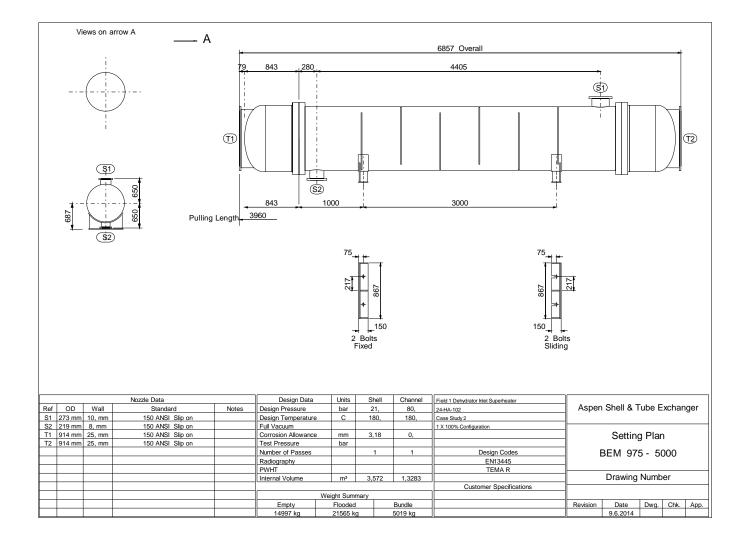


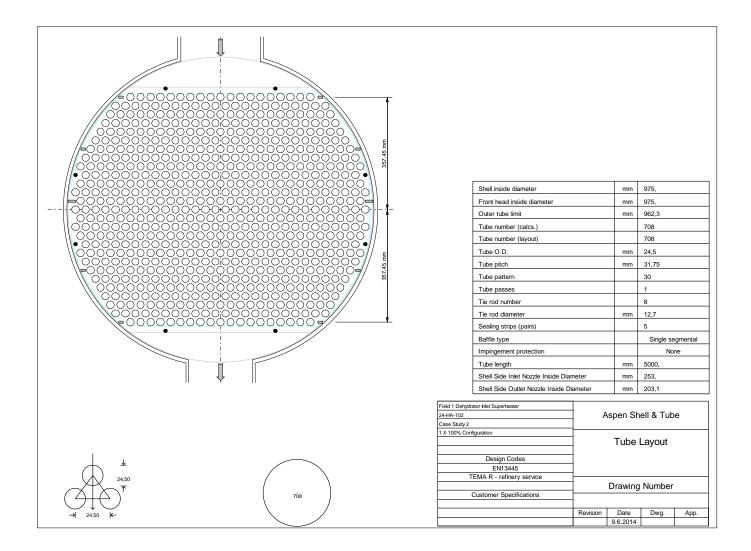


7.2.2 Thermal Calculations of 24-HA-102 & 24-HA-202 – Case Study II

1		nlet Superheater						
2								
3	Case Study 2							
4	1 X 100% Configura	ition						
5								
6		55000	mm Ty	ype BEM	Hor	Connected in	1 parallel	1 series
7	Surf/unit(eff.)	261,7	m ² Shells,	/unit 1		Surf	/shell (eff.)	261,7 m ²
8			PERF	ORMANCE	OF ON	E UNIT	i	
9	Fluid allocation				Shell	Side	Tul	be Side
10	Fluid name			Hea	ating Med	dium Inlet 4	Field 2	1 Wet Gas
11	Fluid quantity, Total		kg/s		76,5	775	26	5,9025
12	Vapor (In/Out)		kg/s	0		0	265,9025	265,9025
13	Liquid		kg/s	76,57	75	76,5775	0	0
14	Noncondensable		kg/s	0		0	0	0
15								
16	Temperature (In/Out)	°C	100)	89,28	25	29,65
17	Dew / Bubble poi	nt	°C					
18	Density	Vapor/Liquid	kg/m³	/	1054	/ 1055,5	44,78 /	43,49 /
19	Viscosity		mPa s	/	2,438	/ 2,529	0,0126 /	0,0126 /
20	Molecular wt, Vap						19,72	19,72
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,03	/ 3,028	2,48 /	2,47 /
-	Thermal conductivity	1	W/(m K)	/	0,2295	/ 0,2293		0,0357 /
-	Latent heat		kJ/kg	,	0,2200	, 0,2200		
	Pressure (abs)		bar	11		10,83342	49,3	48,81579
26	Velocity		m/s		1,8	1		4,47
	Pressure drop, allow	/calc	bar	1	1,	0,16658	1	0,48421
	Fouling resist. (min)	., ouio.	m² K/W	1	0	,	0	0 Ao based
	Heat exchanged	2100	kW		0		corrected	67,38 ° C
30			Dirty	850,1			Confected	,
30 31	Transfer rate, Servic			,		Clean 850,1		W/(m² K)
32		CONS	Shell S			Tube Side	3	ketch
	Design/vac/test pres		, ,				-	
3.5		sure:g bar			80	/ <u>/</u> 180	-	
						180		0
34	Design temperature	°C						
34 35	Design temperature Number passes per	°C shell	1			1		
34 35 36	Design temperature Number passes per Corrosion allowance	°C shell mm	1 3,18			1 0		e la
34 35 36 37	Design temperature Number passes per Corrosion allowance Connections	°C shell In mm	1 3,18 1 250/	-	1	1 0 900/ -		
34 35 36 37 38	Design temperature Number passes per Corrosion allowance Connections Size/rating	°C shell In mm Out	1 3,18		1	1 0		°
34 35 36 37 38 39	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	°C shell In mm Out Intermediate	1 3,18 1 250/ 1 200/ /		1	1 0 900/ - 900/ - / -		
34 35 36 37 38 39 40	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708	°C shell In mm Out	1 3,18 1 250/ 1 200/ 1 200/ / Tks-Avg	- - - 1,65	1 mm	1 0 900/ - 900/ - / - Length 5000	mm Pite	
34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain	shell mm In Out Intermediate OD 24,5	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M	- - 1,65 aterial 22	1 mm Cr,5Ni,3I	1 0 900/ - 900/ - / - Length 5000 Mo steel	mm Pite Tube pattern	ch 31,75 mm 30
34 35 36 37 38 39 40 41 42	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee	shell mm In Out Intermediate OD 24,5	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD	- - 1,65 aterial 22	1 mm	1 0 900/ - 900/ - / - Length 5000 Mo steel Shell cover		
34 35 36 37 38 39 40 41 42 43	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet	°C shell In mm Out Intermediate OD 24,5 I 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ 1 200/ / 5 Tks-Avg #/m M D 975 OD steel	- - 1,65 aterial 22	1 mm Cr,5Ni,3I	1 0 900/ - 900/ - / - Length 5000 Mo steel Shell cover Channel cover		
34 35 36 37 38 39 40 41 42 43 44	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	°C shell In mm Out Intermediate OD 24,5 I 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ 1 200/ / 5 Tks-Avg #/m M D 975 OD steel	- - 1,65 aterial 22	1 mm Cr,5Ni,3I	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating	Tube pattern - - -	
34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover	°C shell In mm Out Intermediate OD 24,5 OD 24,5 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ / 5 Tks-Avg #/m M D 975 OD 5 steel steel -	- - 1,65 aterial 22 1001	1 mm Cr,5Ni,3I mm	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote	Tube pattern - - - ction None	30
34 35 36 37 38 39 40 41 42 43 44 45 46 46	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS	°C shell In mm Out Intermediate OD 24,5 I 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Single s	- - 1,65 aterial 22 1001 segmental	1 mm Cr,5Ni,3I mm	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating	Tube pattern - - ction None H Spacing: c/c	30 610 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long	°C shell In mm Out Intermediate OD 24,5 OD 24,5 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel - Type Singles Se	- - 1,65 aterial 22 1001	1 mm Cr,5Ni,3I mm	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote	Tube pattern - - - ction None	30
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	°C shell In mm Out Intermediate OD 24,5 OD 24,5 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Single s	- - 1,65 aterial 22 1001 segmental	1 mm Cr,5Ni,3I mm	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote	Tube pattern - - ction None H Spacing: c/c	30 610 mm
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long	°C shell In mm Out Intermediate OD 24,5 OD 24,5 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel - Type Singles Se	- 1,65 aterial 22 1001 segmental eal type	1 mm Cr,5Ni,3I mm	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	Tube pattern - - ction None H Spacing: c/c	30 610 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	°C shell In mm Out Intermediate OD 24,5 OD 24,5 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 3,18 1 250/ 1 200/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel - Type Singles Se	- 1,65 aterial 22 1001 segmental eal type	1 mm Cr,5Ni,31 mm C	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	Tube pattern - - ction None H Spacing: c/c	30 610 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	°C shell mm In mm Out Intermediate OD 24,5 OD 24,5 I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 3316L - 2201	1 3,18 1 250/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel steel - Type Singles Se U-bend	- 1,65 aterial 22 1001 segmental eal type Tube-tul	1 mm Cr,5Ni,3I mm C C Desheet j None	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type	Tube pattern - - ction None H Spacing: c/c	30 610 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	°C shell mm In mm Out Intermediate OD 24,5 OD 24,5 I 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 3316L - 2201	1 3,18 1 250/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel steel - Type Singles Se U-bend	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type	1 mm Cr,5Ni,3I mm C C C Desheet j None 227	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote- ut(%d) 10 Type joint Exp.	Tube pattern - - ction None H Spacing: c/c Inlet	30 610 mm 876,48 mm kg/(m s²)
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	°C shell In mm Out Intermediate OD 24,5 I II 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 316L - 2201 -	1 3,18 1 250/ 1 200/ 5 Tks-Avg #/m M D 975 OD steel steel steel - Type Singles Se U-bend	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance	1 mm Cr,5Ni,3I mm C C C Desheet j None 227	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote- ut(%d) 10 Type joint Exp.	Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 225	30 610 mm 876,48 mm kg/(m s²)
$\begin{array}{c} 3 \\ 3 \\ 3 \\ 5 \\ 3 \\ 6 \\ 3 \\ 7 \\ 3 \\ 3 \\ 3 \\ 9 \\ 4 \\ 4 \\ 4 \\ 4 \\ 5 \\ 6 \\ 1 \\ 4 \\ 4 \\ 4 \\ 5 \\ 5 \\ 1 \\ 5 \\ 2 \\ 1 \\ 5 \\ 2 \\ 1 \\ 5 \\ 2 \\ 1 \\ 5 \\ 2 \\ 1 \\ 5 \\ 2 \\ 1 \\ 5 \\ 2 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1$	Design temperature Number passes per Cornosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell In mm Out Intermediate OD 24,5 I II 22Cr,5Ni,3Mo y 22Cr,5Ni,3Mo - 316L - 2201 -	1 3,18 1 250/ 1 200/ 1 200/ 5 Tks-Avg #/m M D 975 OD 5 steel 5	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance	1 mm Cr,5Ni,3I mm C C C Desheet j None 227	1 0 900/ - 900/ - / - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 225 at Metal Jacket Fibe	30 610 mm 876,48 mm kg/(m s²)
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationan Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell In mm Out Intermediate OD 24,5 I 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 316L - 2201 - 2201 - ead -	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Singles Se U-bend Bund	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance	1 mm Cr,5Ni,3I mm Cr C C C besheet j None 227 de	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	Tube pattern - - ction None H Spacing: c/c Inlet Bundle exit 225 at Metal Jacket Fibe	30 610 mm 876,48 mm kg/(m s²) e efinery service
34 35 36 37 38 39 40 41 42 43 44 45 64 47 48 49 50 51 52 53 54 55	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell In mm Out Intermediate OD 24,5 OD 24,5 I 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C C C C C C C C C C C C C	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Singles Se U-bend Bund	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance Tube Si	1 mm Cr,5Ni,3I mm Cr C C C besheet j None 227 de	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	Tube pattern ction None H Spacing: c/c Inlet Bundle exit 225 at Metal Jacket Fibe	30 610 mm 876,48 mm kg/(m s²) e efinery service
34 35 36 37 38 39 40 41 42 43 44 45 64 47 48 49 50 51 52 53 54 55	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationan Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	°C shell In mm Out Intermediate OD 24,5 OD 24,5 I 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C C C C C C C C C C C C C	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Singles Se U-bend Bund	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance Tube Si	1 mm Cr,5Ni,3I mm Cr C C C besheet j None 227 de	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	Tube pattern ction None H Spacing: c/c Inlet Bundle exit 225 at Metal Jacket Fibe	30 610 mm 876,48 mm kg/(m s²) e efinery service
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 45 56	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 708 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell Remarks	°C shell In mm Out Intermediate OD 24,5 OD 24,5 I 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo C C C C C C C C C C C C C	1 3,18 1 250/ 1 200/ / Tks-Avg #/m M D 975 OD steel steel - Type Singles Se U-bend Bund	- - 1,65 aterial 22 1001 segmental eal type Tube-tul Type le entrance Tube Si	1 mm Cr,5Ni,3I mm Cr C C C besheet j None 227 de	1 0 900/ - 900/ - Length 5000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement prote ut(%d) 10 Type joint Exp. Fla	Tube pattern ction None H Spacing: c/c Inlet Bundle exit 225 at Metal Jacket Fibe	30 610 mm 876,48 mm kg/(m s²) e efinery service

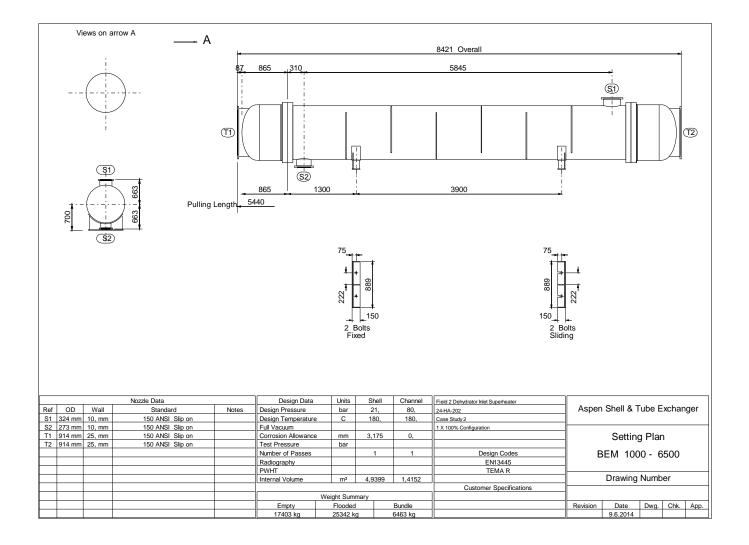
1	Size 975 x	5000	mm	Тур	e BEM	Hor		Connected in	1	parallel	1 series
2	Surf/Unit (gross/eff/fi		272		261,7 /	m²		Shells/unit	1		
3	Surf/Shell (gross/eff/	,			261,7 /	m²		Chickey drift			
4				-,0 , _	.o.,,. ,						
5	Design				PERFORMA	NCE OF ON	E UNIT				
6			Shel	I Side	Tube	Side	Heat T	ransfer Param	eters		
7	Process Data		In	Out	In	Out	Total he	eat load		kW	2100
8	Total flow	kg/s	76	6,5775	265,9	9025	Eff. MT	D/ 1 pass MTD)	°C 6	7,38 / 67,27
9	Vapor	kg/s	0	0	265,9025	265,9025	Actual/	Reqd area ratio	o - fouled/cle	ean 7	7,14 / 7,14
10	Liquid	kg/s	76,5775	76,5775	0	0					
11	Noncondensable	kg/s		0	()	Coef./F	Resist. \	//(m² K)	m² K/W	%
12	Cond./Evap.			0	()	Overall	fouled	850,1	0,00118	;
13	Temperature	°C	100	89,28	25	29,65	Overall	clean	850,1	0,00118	;
14	Dew / Bubble point	°C					Tube s	ide film	2771	0,00036	30,68
15	Quality		0	0	1	1	Tube s	ide fouling		0	0
16	Pressure (abs)	bar	11	10,83342	49,3	48,81579	Tube w	all	8871,2	0,00011	9,58
17	Delta P allow/calc	bar	1	0,16658	1	0,48421	Outside	e fouling		0	0
18	Velocity	m/s	0,6	0,59	23,76	24,47	Outside	e film	1422,9	0,0007	59,74
19											
20	Liquid Properties							ide Pressure I	Drop	bar	%
21	Density	kg/m³	1054	1055,5			Inlet no			0,01338	8,03
22	Viscosity	mPa s	2,438	2,529				ace Xflow		0,01761	10,57
23	-	J/(kg K)	3,03	3,028			Baffle >			0,05002	30,03
24	Therm. cond. V	V/(m K)	0,2295	0,2293			Baffle v			0,04676	28,07
25	Surface tension	N/m						space Xflow		0,0177	10,63
26	Molecular weight						Outlet			0,0211	12,67
27	Vapor Properties							ediate nozzle			
28	Density	kg/m³			44,78	43,49		ide Pressure I	Drop	bar	%
29	Viscosity	mPa s			0,0126	0,0126	Inlet no			0,00106	0,22
30		J/(kg K)			2,48	2,47		g tubes		0,06167	12,89
31		V/(m K)			0,0356	0,0357	Inside t			0,32026	66,96
32	Molecular weight				19,72	19,72	Exiting			0,09075	18,97
33	Two-Phase Propert						Outlet			0,00454	0,95
34	Latent heat	kJ/kg					Interme	ediate nozzle			
35 36	Heat Transfer Parar						Valacit	v / Rho*V	10	m/s	kg/(m s²)
30	Reynolds No. vapor	neters			1790166	1783313	Velocit	ozzle inlet	Z	1,45	2201 kg/(III S-)
	, ,		6044 70	6446 50	1790100	1703313			0	,	2201
38 39	Reynolds No. liquid Prandtl No. vapor		6344,78	6116,59	0,88	0,88		undle Xflow affle window	0, 1,8		
39 40	Prandtl No. liquid		22.10	22.20	0,00	0,00			1,0		5202
40	Heat Load		32,19	33,39 kW		kW		ozzle outlet ozzle interm		2,24	5293
41	Vapor only			кvv 0		00	Snell N			m/s	kg/(m s²)
42	2-Phase vapor			0		00	Tubo o	ozzle inlet		10,13	4593
43	Latent heat			0		2	Tubes		23,		
44 45	2-Phase liquid			0		2		ozzle outlet	23,	10,43	4732
45 46	Liquid only			0 2100		2		ozzle outlet		10,43	4132
40 47				2100		J					
48	Tubes				Baffles			Nozzles: (N	lo./OD)		
49	Туре			Plain	Туре	Sinale se	egmental		-	hell Side	Tube Side
50		m 2	1,2 / 2	24,5	Number	engle of	6	Inlet	mm 1		1 / 914
51				803	Cut(%d)	10	÷	Outlet	1		1 / 914
52	Tube passes			1	Cut orientation		н	Other	•	/	/ 011
53	Tube No.			708	Spacing: c/c	mm	610		nt protection	·	, None
54	Tube pattern			30	Spacing at inlet		876,48	p.ingoinoi			
55	•	m		30 31,75	Spacing at outle		876,48				
56	Insert			None	epacing at outle		510,40				
57	Vibration problem			No / No			RhoV2 vi	olation			No
	p. 00.000										

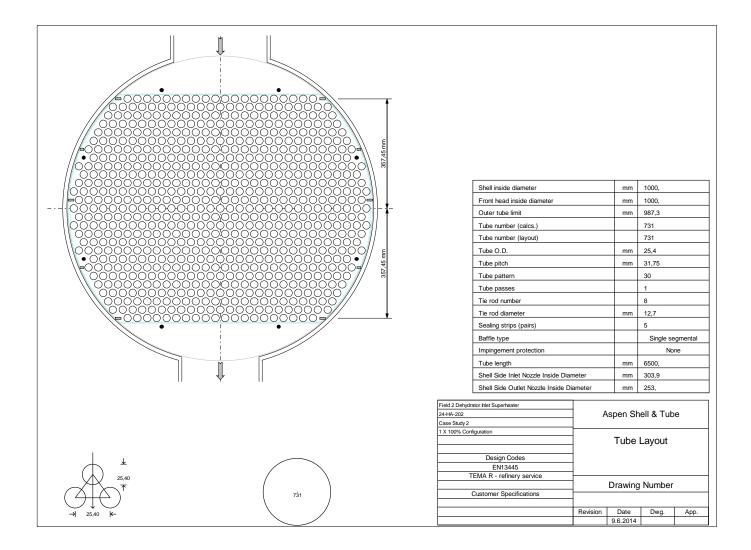




1 1								
1	Field 2 Dehydrator I	nlet Superheater						
2	24-HA-202							
3	Case Study 2							
4	1 X 100% Configura	ition						
5								
6)6500	mm Ty	ype BEM	Hor	Connected in	1 parallel	1 series
7	Surf/unit(eff.)	367,2	m ² Shells,	/unit 1		Surf	/shell (eff.)	367,2 m ²
8			PERF	ORMANCE	E OF ON	E UNIT		
9	Fluid allocation				Shell	Side	Tub	e Side
10	Fluid name			Hea	ating Med	dium Inlet 5	Field 2	Wet Gas
11	Fluid quantity, Total		kg/s		88,	58	30	1,2119
12	Vapor (In/Out)		kg/s	0		0	301,2119	301,2119
13	Liquid		kg/s	88,5	58	88,58	0	0
14	Noncondensable		kg/s	0		0	0	0
15								
16	Temperature (In/Out)	°C	100	C	89,88	25	29,61
17	Dew / Bubble poir	nt	°C					
18	Density	Vapor/Liquid	kg/m³	/	1054	/ 1055,22	49,89 /	48,45 /
	Viscosity		mPa s	/	2,436	/ 2,5105	0,0128 /	0,0129 /
	Molecular wt, Vap				,	,- ,-	19,72	19,72
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,03	/ 3,029	2,54 /	2,53 /
-	Thermal conductivity	1	W/(m K)	/	0,2295	/ 0,2294	0.0362 /	0,0363 /
-	Latent heat	·	kJ/kg	/	0,2200	7 0,2204	0,0002 /	
-	Pressure (abs)		bar	10	1	9,86414	54,2	53,69001
26	Velocity		m/s	10	1,4			2,17
	Pressure drop, allow	/calc	bar	1	1,-	0,13586	1	0,50999
-	•	./caic.	m² K/W	1	0		0	0 Ao based
	Fouling resist. (min)	0050			0		-	
	Heat exchanged	2350	kW	055.0			corrected	
30	Transfer rate, Servic		Dirty TRUCTION OF ON	855,8		Clean 855,8		W/(m² K)
							S	ketch
31		CONS	t			T I 0' I		
32			Shell S			Tube Side		
32 33	Design/vac/test pres	sure:g bar	Shell S 21/ /	ide	80			
32 33 34	Design temperature	sure:g bar °C	Shell S 21/ / 180	ide	80	/ / / 180		
32 33 34 35	Design temperature Number passes per	sure:g bar °C shell	Shell S 21/ / 180 1	ide	80	/ / 180 1	∞([]]	
32 33 34 35 36	Design temperature Number passes per Corrosion allowance	sure:g bar °C shell mm	Shell S 21/ / 180 1 3,18	ide		/ / 180 1 0	•[[]]	e la
32 33 34 35 36 37	Design temperature Number passes per Corrosion allowance Connections	sure:g bar °C shell In mm	Shell S 21/ / 180 1 3,18 1 300/	ide	1	/ / 180 1 0 900/ -	۰([]]	
32 33 34 35 36 37 38	Design temperature Number passes per Corrosion allowance Connections Size/rating	sure:g bar °C shell In mm Out	Shell S 21/ / 180 1 3,18	ide		/ / 180 1 0	۰([]]	<u> </u>
32 33 34 35 36 37 38 39	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	sure:g bar °C shell In mm Out Intermediate	Shell S 21/ / 180 1 3,18 1 1 300/ 1 250/ / /	ide	1	/ / 180 1 0 900/ - 900/ - / -	•[[]]	°
32 33 34 35 36 37 38 39 40	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731	sure:g bar °C shell In mm Out	Shell S 21/ / 180 1 3,18 3,00/ 1 250/ / / Tks-Avg	ide	1 1 1 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500	of	· · · · · · · · · · · · · · · · · · ·
32 33 34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain	sure:g bar °C shell In mm Out Intermediate OD 25,4	Shell S 21/ / 180 1 3,18 300/ 1 250/ / / Tks-Avg /	ide - - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel	•[[]]	h 31,75 mm 30
32 33 34 35 36 37 38 39 40 41 42	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee	sure:g bar °C shell In mm Out Intermediate OD 25,4	Shell S 21/ / 180 1 3,18 300/ 1 250/ / / Tks-Avg #/m D1000 OD	ide	1 1 1 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover	of	· · · · · · · · · · · · · · · · · · ·
32 33 34 35 36 37 38 39 40 41 42 43	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet	sure:g bar °C shell In mm Out Intermediate OD 25,4	Shell S 21/ / 180 1 3,18 1 1 300/ 1 250/ / / Tks-Avg // #/m M D 1000 OD	ide - - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover	of	· · · · · · · · · · · · · · · · · · ·
32 33 34 35 36 37 38 39 40 41 42 43 44	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	sure:g bar °C shell In mm Out Intermediate OD 25,4	Shell S 21/ / 180 1 3,18 1 1 300/ 1 250/ / / Tks-Avg // #/m M D 1000 OD	ide - - - 1,65 aterial 22	1 1 mm :Cr,5Ni,3I	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating	mm Pito Tube pattern - -	· · · · · · · · · · · · · · · · · · ·
32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M. D 1000 OD steel -	ide - - 1,65 aterial 22	1 1 Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	of mm Pitc mm Pitc Tube pattern - - - tion None	30
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M D 1000 OD steel -	ide - - - 1,65 aterial 22	1 1 Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	• (· · · · · · · · · · · · · · · · · · ·
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M 01000 OD steel - Type Single s Steel -	ide - - 1,65 aterial 22	1 1 Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	of mm Pitc mm Pitc Tube pattern - - - tion None	30
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M 01000 OD steel - Type Single steel	ide - - 1,65 aterial 22 1026 segmental	1 1 Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	• (30 855 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M 01000 OD steel - Type Single s Steel -	ide - - 1,65 aterial 22 1026 segmental eal type	1 1 Cr,5Ni,31 mm	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type	• (30 855 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M 01000 OD steel - Type Single s Steel -	ide - - 1,65 aterial 22 1026 segmental eal type	1 1 Cr,5Ni,3I mm C	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type	• (30 855 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 95	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s - 3 316L	Shell S 21/ / 180 1 3,18 300/ 1 250/ / / Tks-Avg // #/m M. D 1000 OD steel - Steel - Steel - U-bend Se	ide - - 1,65 aterial 22 1026 segmental eal type Tube-tu	1 1 Cr,5Ni,31 mm Cc	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type	• (30 855 mm
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s - 3 316L	Shell S 21/ / 180 1 3,18 300/ 1 250/ / / Tks-Avg // #/m M. D 1000 OD steel - Steel - Steel - U-bend Se	ide - - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type	1 1 Cr,5Ni,31 mm Cc besheet j None 242	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp.	• Mm Pitc mm Pitc Tube pattern - - - tion None H Spacing: c/c Inlet	30 855 mm 1009,98 mm kg/(m s²)
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 95 51	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s - 3 316L - - 1415 -	Shell S 21/ / 180 1 3,18 300/ 1 250/ / / Tks-Avg // #/m M. D 1000 OD steel - Steel - Steel - U-bend Se	ide - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance	1 1 Cr,5Ni,31 mm Cc besheet j None 242	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp.	mm Pitc mm Pitc Tube pattern - - - - - - - - - - - - - - - - - - -	30 855 mm 1009,98 mm kg/(m s²)
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	sure:g bar °C shell In mm Out Intermediate OD 25,4 I IE 22Cr,5Ni,3Mo s y 22Cr,5Ni,3Mo s - 3 316L - - 1415 -	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / / Tks-Avg // #/m M D 1000 OD steel - Type Single s Se U-bend Bundl	ide - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance	1 1 Cr,5Ni,31 mm Cc besheet j None 242	/ / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp. Fla	of mm Pitc mm Pitc Tube pattern - - tion None H Spacing: c/c Inlet Bundle exit 240 t Metal Jacket Fibe	30 855 mm 1009,98 mm kg/(m s²)
32 33 4 5 36 37 38 39 40 41 42 43 44 45 64 47 48 49 50 51 52 53 54	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	sure:g bar °C shell In mm Out Intermediate OD 25,4 OD 25,4 I IE 22Cr,5Ni,3Mo s - 3316L - - - 1415 - ead -	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M D 1000 OD steel - Steel - Steel - U-bend Se U-bend Bund 45 -	ide - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance	1 1 Cr,5Ni,3I mm Cr C besheet j None 242 ide	/ / / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp. Fla TE	mm Pitc mm Pitc Tube pattern - - tion None H Spacing: c/c Inlet Bundle exit 240 t Metal Jacket Fibe	30 855 mm 1009,98 mm kg/(m s²) efinery service
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Stee Channel or bonnet Tubesheet-stationar Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	sure:g bar °C shell In mm Out Intermediate OD 25,4 OD 25,4 I IE 22Cr,5Ni,3Mo s - 3316L - - 1415 - ead - EN1344	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M D 1000 OD steel - Steel - Steel - U-bend Se U-bend Bund 45 -	ide - - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cr C besheet j None 242 ide	/ / / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp. Fla TE	mm Pitc mm Pitc Tube pattern - - tion None H Spacing: c/c Inlet Bundle exit 240 t Metal Jacket Fibe MA class R - re	30 855 mm 1009,98 mm kg/(m s²) efinery service
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g bar °C shell In mm Out Intermediate OD 25,4 OD 25,4 I IE 22Cr,5Ni,3Mo s - 3316L - - 1415 - ead - EN1344	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M D 1000 OD steel - Steel - Steel - U-bend Se U-bend Bund 45 -	ide - - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cr C besheet j None 242 ide	/ / / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp. Fla TE	mm Pitc mm Pitc Tube pattern - - tion None H Spacing: c/c Inlet Bundle exit 240 t Metal Jacket Fibe MA class R - re	30 855 mm 1009,98 mm kg/(m s²) efinery service
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 731 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	sure:g bar °C shell In mm Out Intermediate OD 25,4 OD 25,4 I IE 22Cr,5Ni,3Mo s - 3316L - - 1415 - ead - EN1344	Shell S 21/ / 180 1 3,18 1 300/ 1 250/ / Tks-Avg // #/m M D 1000 OD steel - Steel - Steel - U-bend Se U-bend Bund 45 -	ide - - - 1,65 aterial 22 1026 segmental eal type Tube-tul Type le entrance Tube Si	1 1 Cr,5Ni,3I mm Cr C besheet j None 242 ide	/ / / 180 1 0 900/ - 900/ - 900/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 12,75 Type oint Exp. Fla TE	mm Pitc mm Pitc Tube pattern - - tion None H Spacing: c/c Inlet Bundle exit 240 t Metal Jacket Fibe MA class R - re	30 855 mm 1009,98 mm kg/(m s²) efinery service

1	Size 1000 x	6500	mm	Тур	be BEM	Hor		Connected in	1	parallel	1 series
2	Surf/Unit (gross/eff/fi				367,2 /	m²		Shells/unit	1	paranor	1 001100
3	Surf/Shell (gross/eff/f	,		,	367,2 /	m²			I		
4			57	<u>,</u> ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,							
5	Design				PERFORMA	NCE OF ON	1				
6			She	ell Side	Tube	Side	Heat Ti	ansfer Parame	eters		
7	Process Data		In	Out	In	Out	Total he	eat load		kW	2350
8	Total flow	kg/s		88,58	301,	2119	Eff. MT	D/ 1 pass MTD		°C 6	67,67 / 67,6
9	Vapor	kg/s	0	0	301,2119	301,2119	Actual/	Reqd area ratio	- fouled/cle	ean	9,05 / 9,05
10	Liquid	kg/s	88,58	88,58	0	0					
11	Noncondensable	kg/s		0		0	Coef./F		V/(m² K)	m² K/W	
12	Cond./Evap.			0		0	Overall		855,8	0,00117	
13	Temperature	°C	100	89,88	25	29,61	Overall		855,8	0,00117	
14	Dew / Bubble point	°C					Tube si		2828,4	0,0003	,
15	Quality		0	0	1	1		de fouling		0	0
16	Pressure (abs)	bar	10	9,86414		53,69001	Tube w		8894,4	0,0001	,
17	Delta P allow/calc	bar	1	0,13586		0,50999		fouling		0	0
18 19	Velocity	m/s	0,54	0,53	21,53	22,17	Outside	e film	1423,4	0,0007	60,12
20	Liquid Properties						Shell S	ide Pressure D	Drop	bar	%
21	Density	kg/m³	1054	1055,22			Inlet no			0,00899	6,62
22	Viscosity	mPas	2,436	2,5105			Inlet sp	ace Xflow		0,01676	12,34
23		l/(kg K)	3,03	3,029			Baffle X			0,0492	36,23
24		//(m K)	0,2295	0,2294			Baffle v	vindow		0,03183	23,44
25	Surface tension	N/m					Outlet s	pace Xflow		0,0168	12,38
26	Molecular weight						Outlet r	nozzle		0,0122	8,99
27	Vapor Properties						Interme	diate nozzle			
28	Density	kg/m³			49,89	48,45	Tube S	ide Pressure D	rop	bar	%
29	Viscosity	mPa s			0,0128	0,0129	Inlet no	zzle		0,0017	0,34
30	Specific heat k.	l/(kg K)			2,54	2,53	Enterin	g tubes		0,0558	11,06
31	Therm. cond. W	//(m K)			0,0362	0,0363	Inside t	ubes		0,36352	72,08
32	Molecular weight				19,72	19,72	Exiting	tubes		0,07731	15,33
33	Two-Phase Propert	ies					Outlet r	nozzle		0,00603	1,2
34	Latent heat	kJ/kg					Interme	diate nozzle			
35									-		
36	Heat Transfer Paran	neters					Velocit		2	m/s	kg/(m s²)
37	Reynolds No. vapor				1854655	1847295		ozzle inlet		1,16	1415
38	Reynolds No. liquid		5922,75	5747,1		0.0		undle Xflow	0,5		
39	Prandtl No. vapor		00.40	00.45	0,9	0,9		affle window	1,4		00.40
40	Prandtl No. liquid		32,16	33,15		1444		ozzle outlet		1,67	2942
41 42	Heat Load Vapor only			kW 0	01	kW		ozzle interm		m/s	$ka/(m c^2)$
42	2-Phase vapor			0		350	Tubor	azzlo inlot		m/s 10,3	kg/(m s²) 5291
43	2-Phase vapor Latent heat			0		0 0	Tube n	ozzle inlet	21,		
44	2-Phase liquid			0		0		ozzle outlet	∠1,	53 22,17 10,61	5450
45 46	Liquid only			-2350		0		ozzle outiet		10,01	0400
40				2000		~					
48	Tubes				Baffles			Nozzles: (N	o./OD)		
49	Туре			Plain	Туре	Single s	egmental		S	hell Side	Tube Side
50	ID/OD m	m 22	2,1 /	25,4	Number		6	Inlet	mm 1	/ 323,9	1 / 914
51	Length act/eff m	m 650	00 / 0	6295	Cut(%d)	12,75		Outlet	1	/ 273	1 / 914
52	Tube passes			1	Cut orientation		н	Other		/	/
53	Tube No.			731	Spacing: c/c	mm	855	Impingemen	t protection		None
54	Tube pattern			30	Spacing at inlet	mm	1009,98				
55	Tube pitch m	m		31,75	Spacing at outle	et mm	1009,98				
00				None							
56	Insert			None							



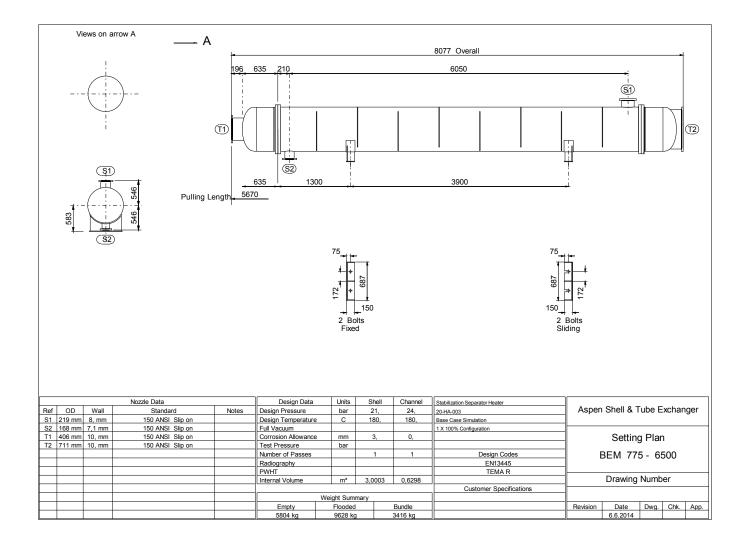


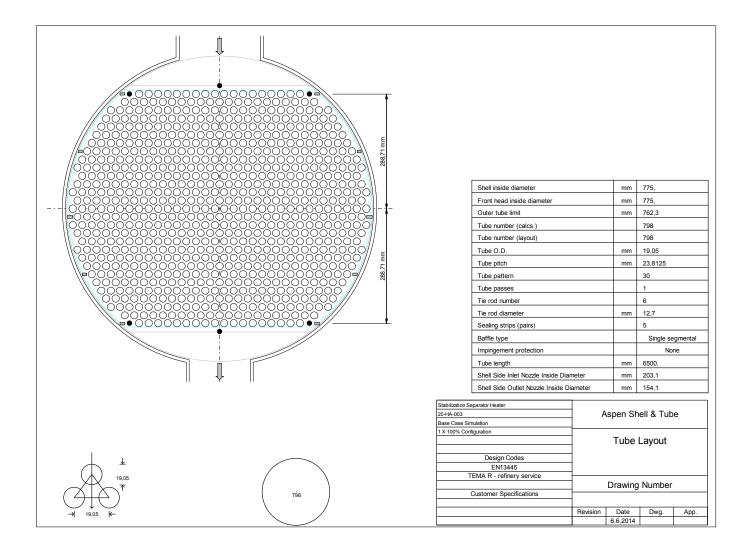
7.3 Thermal Calculations of Stabilization Separator Heater (20-HA-003)

This section contains the thermal design calculations of the relevant heat exchangers in Case Study I.

7.3.1 Thermal Calculation of 20-HA-003 – Base Case Design

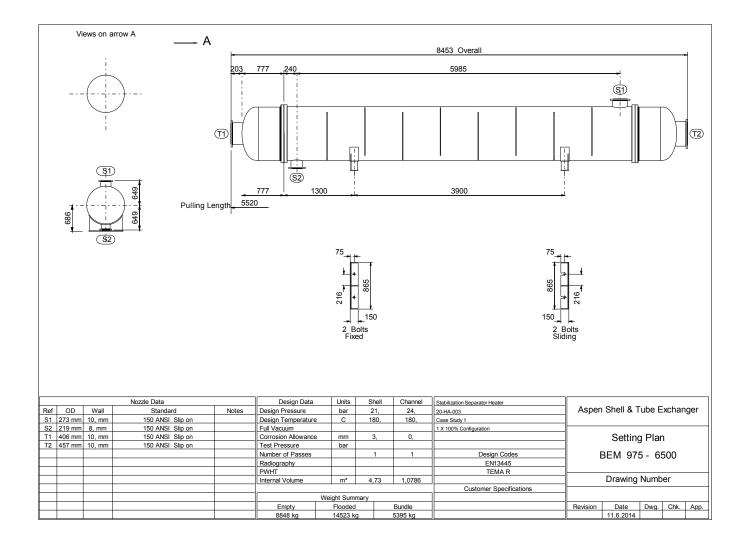
1	Stabilization Separate	or Hootor						
2	20-HA-003							
3	Base Case Simulatio	n						
4	1 X 100% Configurat							
5								
6	Size 775	6500	mm Ty	/pe BEM	Hor	Connected in	2 parallel	1 series
7	Surf/unit(eff.)	611,2	,	/unit 2	1101		shell (eff.)	305,6 m ²
8	ounium(on)	011,2		ORMANCE				000,0 m
9	Fluid allocation				Shell		Tube	Side
10	Fluid name			Hea		dium Inlet 3	Inlet to Stabiliz	
11	Fluid quantity, Total		kg/s		71,7		329,1	525
12	Vapor (In/Out)		kg/s	0		0	5,3652	6,6309
13	Liquid		kg/s	71,78	353	71,7853	323,7873	322,5216
14	Noncondensable		kg/s	0		0	0	0
15								
16	Temperature (In/Out)	i	°C	150)	118,42	63,13	77,94
17	Dew / Bubble poir	ıt	°c					
18	Density	Vapor/Liquid	kg/m³	/	1003	/ 1007,58	6,63 / 812,9	6,13 / 802,28
19	Viscosity		mPa s	/	1,15	/ 1,2656	0,012 / 3,5025	0,0126 / 3,0153
20	Molecular wt, Vap						23,16	23,1
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,29	/ 3,266	2,11 / 2,14	2,116 / 2,173
	Thermal conductivity		W/(m K)	/	0,231	/ 0,2309	0,034 / 0,1115	0,034 / 0,1075
24	Latent heat		kJ/kg				20,9	17,8
25	Pressure (abs)		bar	11		10,91026	8	7,04681
26	Velocity		m/s		1,4	45	31,3	
27	Pressure drop, allow.	/calc.	bar	1		0,08974	1	0,95319
28	Fouling resist. (min)		m² K/W		0		0	0 Ao based
	Heat exchanged	6352,2	kW				corrected	66,61 ° C
30	Transfer rate, Service		Dirty	616,6		Clean 616,6		W/(m² K)
31	Transfer rate, Service		TRUCTION OF ON	E SHELL			Ske	
31 32		CONS	TRUCTION OF ON Shell Si	E SHELL	24	Tube Side	Ske	
31 32 33	Design/vac/test press	CONS sure:g bar	TRUCTION OF ON Shell Si 21/ /	E SHELL	24	Tube Side	Ske	
31 32 33 34	Design/vac/test press Design temperature	CONS [®] sure:g bar °C	TRUCTION OF ON Shell Si 21/ / 180	E SHELL	24	Tube Side / / 180	Ske	
31 32 33 34 35	Design/vac/test press Design temperature Number passes per s	CONS sure:g bar °C shell	Shell Si 21/ / 180 1	E SHELL	24	Tube Side / / 180 1	Ske ∘[
31 32 33 34 35 36	Design/vac/test press Design temperature Number passes per s Corrosion allowance	CONS sure:g bar °C shell mm	TRUCTION OF ON Shell Si 21/ 180 1 3	IE SHELL		Tube Side / / 180 1 0	Ske ∘[〔 	
31 32 33 34 35 36 37	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections	CONS sure:g bar °C shell In mm	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/	E SHELL	1	Tube Side / / 180 1 0 400/ -	Ske •[[]	
31 32 33 34 35 36 37 38	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating	CONS sure:g bar °C shell In mm Out	TRUCTION OF ON Shell Si 21/ 180 1 3	IE SHELL		Tube Side / / 180 1 0	Ske ∘[(
31 32 33 34 35 36 37 38 39	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal	CONS sure:g bar °C shell In mm Out Intermediate	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/	E SHELL ide - - -	1	Tube Side / / 180 1 0 400/ - 700/ - / -	∘[(□[tch
31 32 33 34 35 36 37 38 39	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal	CONS sure:g bar °C shell In mm Out	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/ 5 Tks-Avg	E SHELL ide - - - 1,25	1	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500	•I(mm Pitch Tube pattern 3	<u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/ 5 Tks-Avg	E SHELL ide - - - 1,25 aterial 22	1 1 	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500	∘I(mm Pitch	<u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40 41	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/ 5 Tks-Avg #/m 0.775 OD	E SHELL ide - - - 1,25 aterial 22	1 1 	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel	∘I(mm Pitch	<u>tch</u> <u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40 41 42 43	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 0.775 O.775	E SHELL ide - - - 1,25 aterial 22	1 1 	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover	∘I(mm Pitch	<u>tch</u> <u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40 41 42 43 44	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 0.775 O.775	E SHELL ide - - - 1,25 aterial 22	1 1 	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover	•[(mm Pitch Tube pattern 30 - - - -	<u>tch</u> <u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 0.775 OD steel -	E SHELL ide - - - 1,25 aterial 22	1 1 Cr,5Ni,31 mm	Tube Side / / 180 1 0 400/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protec	otí find the pattern 30 r r r	<u>tch</u> <u>23,81 mm</u>
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 0.775 Steel steel - Type Single s	E SHELL ide - - 1,25 aterial 22 793	1 1 Cr,5Ni,31 mm	Tube Side / / 180 1 0 400/ - 700/ - Channel cover Tubesheet-floating Impingement protec	of(f	tch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 0.775 Steel steel - Type Single s	E SHELL ide - 1,25 aterial 22 793	1 1 Cr,5Ni,31 mm	Tube Side / / 180 1 0 400/ - 700/ - Channel cover Tubesheet-floating Impingement protec	of(f	tch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 20775 OD 775 Steel steel Steel Steel Steel Steel Steel Steel Steel Steel	E SHELL ide - - 1,25 aterial 22 793 segmental eal type	1 1 Cr,5Ni,31 mm	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10	of(f	tch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 5 Tks-Avg #/m 20775 OD 775 Steel steel Steel Steel Steel Steel Steel Steel Steel Steel	E SHELL ide - - 1,25 aterial 22 793 segmental eal type	1 1 Cr,5Ni,3I mm C	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10	of(f	tch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/ / 5 Tks-Avg #/m Mi 0 775 OD steel steel - Steel Steel U-bend	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance	1 1 Cr,5Ni,3I mm Cc besheet j None 219	Tube Side / / 180 1 0 400/ - 700/ - 700/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	of(f	tch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s 22Cr,5Ni,3Mo s - 316L - 1224 -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 150/ / 5 Tks-Avg #/m Mi 0 775 OD steel steel - Steel Steel U-bend	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tu Type	1 1 Cr,5Ni,3I mm Cc besheet j None 219	Tube Side / / 180 1 0 400/ - 700/ - 700/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	• [(]	tch 23,81 mm 0 730 mm 644,48 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 66\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s - 316L - 1224 - ead -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 33 1 200/ 1 5 Tks-Avg #/m 0 775 OD steel steel steel Seteel U-bend Bundl	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance	1 1 Cr,5Ni,3I mm Cc besheet j None 219	Tube Side / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat	of(f	tch 23,81 mm 23,81 mm 0 730 mm 644,48 mm kg/(m s ²)
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s - 316L - 1224 - ead - EN1344	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 3 1 200/ 1 5 Tks-Avg #/m 0 775 OD steel steel Steel Steel Steel Bundl Bundl	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 219 ide	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat TE	Imm Pitch Tube pattern 3i - - - - - - tion None H Spacing: c/c Inlet - Bundle exit 210 : Metal Jacket Fibe - MA class R - refin	tch 23,81 mm 0 730 mm 644,48 mm kg/(m s²) nery service
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s - 316L - 1224 - ead -	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 3 1 200/ 1 5 Tks-Avg #/m 0 775 OD steel steel Steel Steel Steel Bundl Bundl	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance	1 1 Cr,5Ni,3I mm Cc besheet j None 219 ide	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat TE	of(f	tch 23,81 mm 0 0 730 mm 644,48 mm kg/(m s²) 0 nery service 0
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s - 316L - 1224 - ead - EN1344	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 3 1 200/ 1 5 Tks-Avg #/m 0 775 OD steel steel Steel Steel Steel Bundl Bundl	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 219 ide	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat TE	Imm Pitch Tube pattern 3i - - - - - - tion None H Spacing: c/c Inlet - Bundle exit 210 : Metal Jacket Fibe - MA class R - refin	tch
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 798 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s - 316L - 1224 - ead - EN1344	TRUCTION OF ON Shell Si 21/ 180 1 3 1 200/ 1 3 1 200/ 1 5 Tks-Avg #/m 0 775 OD steel steel Steel Steel Steel Bundl Bundl	E SHELL ide - - 1,25 aterial 22 793 segmental sal type Tube-tul Type e entrance Tube Si	1 1 Cr,5Ni,3I mm Cc besheet j None 219 ide	Tube Side / / / 180 1 0 400/ - 700/ - 700/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat TE	Imm Pitch Tube pattern 3i - - - - - - tion None H Spacing: c/c Inlet - Bundle exit 210 : Metal Jacket Fibe - MA class R - refin	tch

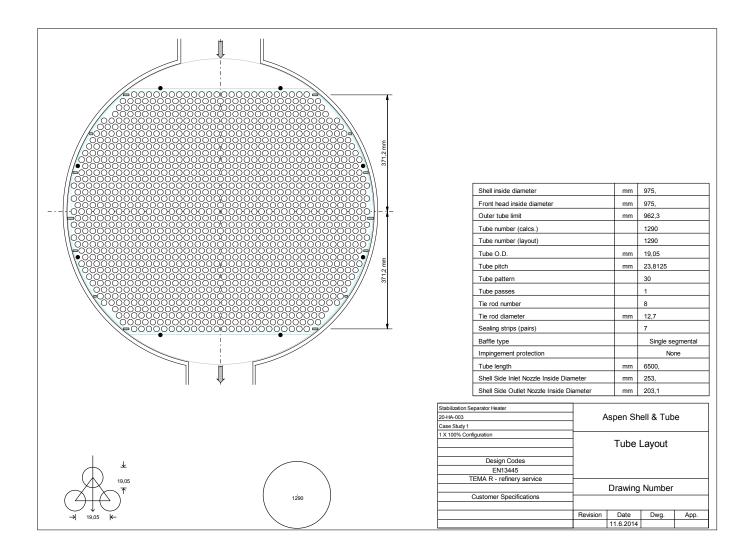




7.3.2 Thermal Calculation of 20-HA-003 – Case Study I

1	Stabilization Separat	or Heater						
2	20-HA-003							
3	Case Study 1							
4	1 X 100% Configura	tion						
5								
6	Size 975	6500	mm Ty	ype BEM	Hor	Connected in	2 parallel	1 series
7	Surf/unit(eff.)	985,9		/unit 2			/shell (eff.)	492,9 m²
8		,	PERF	ORMANCE	E OF ON			
9	Fluid allocation				Shell	Side	Tube	Side
10	Fluid name			He	ating Me	dium Inlet 3	Inlet to Stabiliza	ation Separator
11	Fluid quantity, Total		kg/s		110,3	3256	329,1	558
12	Vapor (In/Out)		kg/s	0		0	4,8715	6,5505
13	Liquid		kg/s	110,3	256	110,3256	324,2843	322,6053
14	Noncondensable		kg/s	0		0	0	0
15								
16	Temperature (In/Out)	۵°	150	0	125,86	55,07	76,49
17	Dew / Bubble poir	nt	۵°					
18	Density	Vapor/Liquid	kg/m³	/	1003	/ 1008,09	6,55 / 820,76	6,36 / 811,04
19	Viscosity		mPa s	/	1,15	/ 1,2786	0,0122 / 4,1764	0,0124 / 3,4016
20	Molecular wt, Vap						22,33	22,35
21	Molecular wt, NC							
22	Specific heat		kJ/(kg K)	/	3,29	/ 3,263	2,1 / 2,101	2,095 / 2,151
23	Thermal conductivity	,	W/(m K)	/	0,231	/ 0,2309	0,0337 / 0,1141	0,0339 / 0,113
24	Latent heat		kJ/kg				19,4	18,8
25	Pressure (abs)		bar	11		10,90013	8	7,14517
26	Velocity		m/s		1,	41	16,4	13
27	Pressure drop, allow.	/calc.	bar	1		0,09987	1	0,85483
28	Fouling resist. (min)		m² K/W		0		0	0 Ao based
29	Heat exchanged	8634	kW				corrected	77,05 ° C
30	Transfer rate, Servic	e 113,7	Dirty	628,2		Clean 628,2		W/(m² K)
			,					W /(III= K)
31			TRUCTION OF ON	NE SHELL	1		Ske	
32		CONS	TRUCTION OF ON Shell S	NE SHELL		Tube Side	Ske	
32 33	Design/vac/test pres	CONS sure:g bar	TRUCTION OF ON Shell S 21/ /	IE SHELL	24	Tube Side	Ske	
32 33 34	Design/vac/test pres Design temperature	CONS sure:g bar °C	TRUCTION OF ON Shell S 21/ / 180	IE SHELL	24	Tube Side / / 180	Ske	
32 33 34 35	Design/vac/test pres Design temperature Number passes per	CONS sure:g bar °C shell	TRUCTION OF ON Shell S 21/ 180 1	IE SHELL	24	Tube Side / / 180 1	Ske	
32 33 34 35 36	Design/vac/test press Design temperature Number passes per s Corrosion allowance	CONS sure:g bar °C shell mm	TRUCTION OF ON Shell S 21/ 180 1 3	IE SHELL ide		Tube Side / / 180 1 0	∘r[
32 33 34 35 36 37	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections	CONS sure:g bar °C shell In mm	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/	IE SHELL	1	Tube Side / / 180 1 0 400/ -	∘t([]	
32 33 34 35 36 37 38	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating	CONS sure:g bar °C shell In mm Out	TRUCTION OF ON Shell S 21/ 180 1 3	IE SHELL ide		Tube Side / / 180 1 0	∘Ľ	
32 33 34 35 36 37 38 39	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal	CONS sure:g bar °C shell In mm Out Intermediate	Shell S 21/ / 180 1 3 1 250/ 1 200/ /	IE SHELL ide / - - -	1	Tube Side / / 180 1 0 400/ - 450/ - / -	∘t(<mark>]</mark> Î	tch
32 33 34 35 36 37 38 39 40	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290	CONS sure:g bar °C shell In mm Out	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ 5 Tks-Avg	IE SHELL ide - - - - 1,2	1 1 1 mm	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500	∘[(], mm Pitch	tch
32 33 34 35 36 37 38 39 40 41	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ 5 Tks-Avg #/m	IE SHELL ide - - - 1,2 aterial 22	1 1 mm 2Cr,5Ni,3l	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel	∘t(<mark>]</mark> Î	tch
32 33 34 35 36 37 38 39 40 41 42	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m M 0 975 OD	IE SHELL ide - - - 1,2 aterial 22	1 1 1 mm	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover	∘[(], mm Pitch	tch
32 33 34 35 36 37 38 39 40 41 42 43	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 OD	IE SHELL ide - - - 1,2 aterial 22	1 1 mm 2Cr,5Ni,3l	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover	•[()] mm Pitch Tube pattern 30 - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 OD	IE SHELL ide - - - 1,2 aterial 22	1 1 mm 2Cr,5Ni,3l	Tube Side / / 180 1 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating	o[mm Pitch Tube pattern 3 - - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 Steel -	IE SHELL ide / - - 1,2 aterial 22 999	1 1 CCr,5Ni,3i mm	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	ot mm Pitch Tube pattern 30 - - - tion None	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ 5 Tks-Avg #/m 0 975 Steel steel - Type Singles	IE SHELL ide - - 1,2 aterial 22 999 segmental	1 1 CCr,5Ni,3i mm	Tube Side / / 180 1 0 400/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	•L mm Pitch Tube pattern 30 - - - - - - - - - - - - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m M 0975 OD steel - Steel - Type Single steel	IE SHELL ide / - - 1,2 aterial 22 999	1 1 CCr,5Ni,3i mm	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10	•L mm Pitch Tube pattern 3i - - - - - - - - - - - - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ 5 Tks-Avg #/m 0 975 Steel steel - Type Singles	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type	1 1 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	•L mm Pitch Tube pattern 3i - - - - - - - - - - - - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m M 0975 OD steel - Steel - Type Single steel	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu	1 1 (Cr,5Ni,3) mm C C besheet j	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	•L mm Pitch Tube pattern 3i - - - - - - - - - - - - -	tch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 OD steel steel - Type Single s U-bend	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3I mm CC C besheet J None	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	•[()] mm Pitch Tube pattern 3i - - - - - - - - - - - - - - - - - - -	tch 23,81 mm 0 700 mm 742,48 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 OD steel steel - Type Single s U-bend	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protec ut(%d) 10 Type joint Exp.	of (tch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 If 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1200 -	TRUCTION OF ON Shell S 21/ 180 1 3 1 250/ 1 200/ / 5 Tks-Avg #/m 0 975 OD steel steel - Type Single s U-bend	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu Type	1 1 Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protec ut(%d) 10 Type joint Exp.	•[()] mm Pitch Tube pattern 3i - - - - - - - - - - - - - - - - - - -	tch 23,81 mm 0 700 mm 742,48 mm
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 If 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 1 250/ 1 250/ 1 200/ 5 Tks-Avg #/m M 0 975 OD steel - Steel - Steel - Steel - Steel - Bund -	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 400/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flat	ot	tch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 19,0 19,0 19,0 19,0 10,0 19,0 10	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 1 250/ 1 200/ 5 Tks-Avg #/m M 0 975 OD steel - Steel - Steel - Steel - Bund - 45 -	IE SHELL ide - - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC besheet j None 224 ide	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flai	ot mm Pitch Tube pattern 3r	1 23,81 mm 23,81 mm 0 0 700 mm 742,48 mm kg/(m s²) 10 nery service 10
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ \end{array}$	Design/vac/test pres Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 If 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 1 250/ 1 200/ 5 Tks-Avg #/m M 0 975 OD steel - Steel - Steel - Steel - Bund - 45 -	IE SHELL ide - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC besheet j None 224 ide	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flai	ot	tch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 19,0 19,0 19,0 19,0 10,0 19,0 10	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 1 250/ 1 200/ 5 Tks-Avg #/m M 0 975 OD steel - Steel - Steel - Steel - Bund - 45 -	IE SHELL ide - - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC besheet j None 224 ide	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flai	ot mm Pitch Tube pattern 3r	1 23,81 mm 23,81 mm 0 0 700 mm 742,48 mm kg/(m s²) 10 nery service 10
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ \end{array}$	Design/vac/test pres Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 1290 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	CONS sure:g bar °C shell In mm Out Intermediate OD 19,0 19,0 19,0 19,0 19,0 10,0 19,0 10	TRUCTION OF ON Shell S 21/ / 180 1 3 1 250/ 1 1 250/ 1 200/ 5 Tks-Avg #/m M 0 975 OD steel - Steel - Steel - Steel - Bund - 45 -	IE SHELL ide - - - 1,2 aterial 22 999 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC besheet j None 224 ide	Tube Side / / 180 1 0 400/ - 450/ - 450/ - 450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Flai	ot mm Pitch Tube pattern 3r	1 23,81 mm 23,81 mm 0 0 700 mm 742,48 mm kg/(m s²) 10 nery service 10



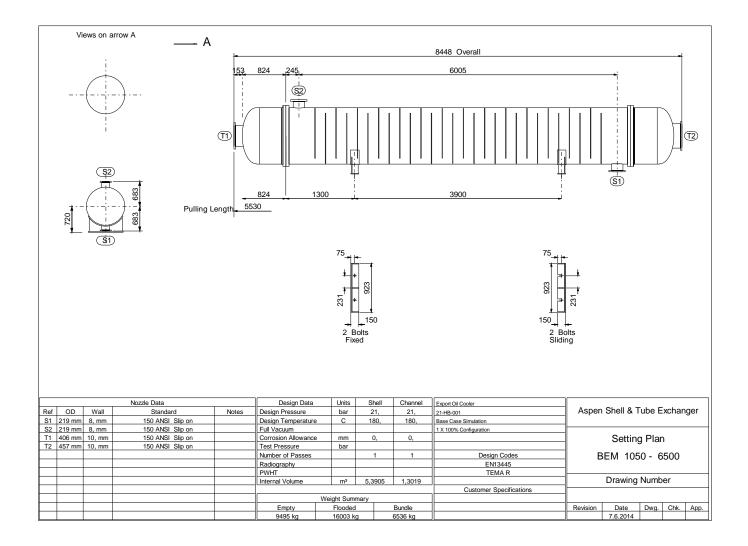


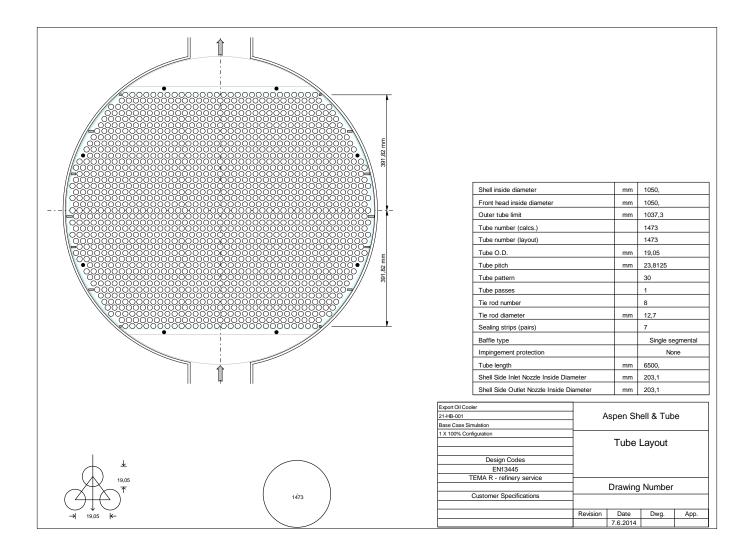
7.4 Thermal Calculations of Crude Oil Cooler (21-HB-001)

This section contains the thermal design calculations of the relevant heat exchangers in Case Study I.

7.4.1 Thermal Calculations of 21-HB-001 – Base Case Design

1	Export Oil Cooler							
2	21-HB-001							
3	Base Case Simulation							
4	1 X 100% Configuration	n						
5								
6	Size 10506	6500	mm Ty	ype BEM	Hor	Connected in	1 parallel	1 series
7	Surf/unit(eff.)	562,2	m ² Shells,	/unit 1		Surf	/shell (eff.)	562,2 m²
8			PERF	ORMANCE	OF ON	E UNIT		
9	Fluid allocation				Shell	Side	Tube	Side
10	Fluid name				Sea V	Vater	Expor	t Oil
11	Fluid quantity, Total		kg/s		49,8		316,2	
12	Vapor (In/Out)		kg/s	0		0	0	0
13	Liquid		kg/s	49,86	56	49,8656	316,2761	316,2761
14	Noncondensable		kg/s	0		0	0	0
15								
16	· · · · · · · · · · · · · · · · · · ·		°C	8		47,64	66,5	54,73
17	Dew / Bubble point		0°	ļ			,	/
18		Vapor/Liquid	kg/m³	/	1020	/ 1012,4	/ 817,5	/ 818,99
19	Viscosity		mPa s	<u> </u>	1,375	/ 1,1631	/ 3,696	/ 3,8612
20	Molecular wt, Vap							
21	Molecular wt, NC			ļ,		· · · · ·		/
22	Specific heat		kJ/(kg K)	<u>├</u> ,	4,44	/ 4,437	/ 2,2	/ 2,193
23	Thermal conductivity		W/(m K)	├ ────́	0,5834	/ 0,5981	/ 0,1182	/ 0,1184
24	Latent heat		kJ/kg					
25	Pressure (abs)		bar	10		9,7287	6,5	6,35436
26	Velocity	-1-	m/s	<u> </u>	1,:	35	1,2	
27	Pressure drop, allow./ca	alC.	bar	1		0,2713	1	0,14564
28	Fouling resist. (min)		m² K/W	<u> </u>	0		0	0 Ao based
29	Heat exchanged	8174,5	kW) corrected	<u>30,93</u> °C
30	Transfer rate, Service	470,2		464,8		Clean 464,8		W/(m² K)
31 32		CONS	TRUCTION OF ON Shell S			Tube Side	Sket	cn
32 33	Design/vac/test pressur	in her	/ /		21		-	
33 34	Design temperature	re:g bar °C	· · ·			<u>/ /</u> 180	-	
35	Number passes per she		180			1		пппппп п .
36	Corrosion allowance		0			0	- °I	
37	Corrosion allowance	mm			1	-	-	
	Connections					400/ -		
	Connections In Size/rating O	mm		-	4	400/ -	-	
	Size/rating O	mm ut	1 200/	-	1	400/ - 450/ -	-	
39	Size/rating O Nominal In	mm ut termediate	1 200/	- - 1 2	1	450/ -	mm Pitch	23.81 mm
39 40	Size/ratingONominalInTube No.1473	mm ut	1 200/ / 5 Tks-Avg		1 mm	450/ - / - Length 6500	mm Pitch	23,81 mm
39 40 41	Size/ratingONominalInTube No.1473Tube typePlain	ut termediate OD 19,0	1 200/ / 5 Tks-Avg #/m M	aterial 220	1 mm Cr,5Ni,3I	450/ - / - Length 6500 Mo steel	Tube pattern 30	
39 40 41 42	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo s	teel II	1 200/ /5 Tks-Avg #/m M D 1050 OD		1 mm	450/ - / - Length 6500 Mo steel Shell cover	Tube pattern 3(
39 40 41 42 43	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnet	teel II 22Cr,5Ni,3Mo	1 200/ /5 Tks-Avg #/m M D 1050 OD steel	aterial 220	1 mm Cr,5Ni,3I	450/ - Length 6500 Mo steel Shell cover Channel cover	Tube pattern 30	
39 40 41 42 43 44	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetTubesheet-stationary	teel II 22Cr,5Ni,3Mo	1 200/ /5 Tks-Avg #/m M D 1050 OD steel	aterial 220	1 mm Cr,5Ni,3I	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating	Tube pattern 30 - - -	
39 40 41 42 43 44 45	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 200/ /5 Tks-Avg #/m M D 1050 OD steel steel -	aterial 220 1066	1 mm Cr,5Ni,3I mm	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern 30 - - - ction None)
39 40 41 42 43 44 45 46	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetTubesheet-stationaryFloating head coverBaffle-crossingSS 31	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 200/ 15 Tks-Avg #/m M D 1050 OD steel steel - Type Single s	aterial 220 1066 segmental	1 mm Cr,5Ni,3I mm	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern 3(- - ction None H Spacing: c/c	200 mm
39 40 41 42 43 44 45 46 47	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetChannel or bonnetTubesheet-stationaryFloating head coverBaffle-crossingSS 31Baffle-long-	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 200/ 15 Tks-Avg #/m M D 1050 OD steel steel - Type Singles Se	aterial 220 1066	1 mm Cr,5Ni,3I mm	450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10	Tube pattern 3(- - ction None H Spacing: c/c)
39 40 41 42 43 44 45 46 47 48	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	1 200/ 15 Tks-Avg #/m M D 1050 OD steel steel - Type Single s	aterial 220 1066 segmental eal type	1 mm Cr,5Ni,3I mm C	450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	Tube pattern 3(- - ction None H Spacing: c/c	200 mm
39 40 41 42 43 44 45 46 47 48 49	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube Bypass seal	mm ut OD 19,0 teel II 22Cr,5Ni,3Mo -	1 200/ 15 Tks-Avg #/m M D 1050 OD steel steel - Type Singles Se	aterial 220 1066 segmental eal type Tube-tut	1 mm Cr,5Ni,31 mm Cr C	450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	Tube pattern 3(- - ction None H Spacing: c/c	200 mm
39 40 41 42 43 44 45 46 47 48	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetTubesheet-stationaryFloating head coverBaffle-crossingBaffle-long-Supports-tubeBypass sealExpansion joint-	mm ut OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - I6L	1 200/ / /5 Tks-Avg #/m M. D 1050 OD steel steel - Type Singles Se U-bend	aterial 220 1066 segmental eal type Tube-tut Type	1 mm Cr,5Ni,3I mm C C Desheet j None	450/ - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type	Tube pattern 3(- - ction None H Spacing: c/c) 200 mm 488,48 mm
39 40 41 42 43 44 45 46 47 48 49 50 51	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetTubesheet-stationaryFloating head coverBaffle-crossingSS 31Baffle-long-Supports-tubeBypass sealExpansion jointRhoV2-Inlet nozzle	mm ut OD 19,0 teel II 22Cr,5Ni,3Mo - I6L	1 200/ / /5 Tks-Avg #/m M. D 1050 OD steel steel - Type Singles Se U-bend	aterial 220 1066 segmental eal type Tube-tub Type le entrance	1 mm Cr,5Ni,3I mm Cr C C C Desheet j None 464	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp.	Tube pattern 3(- - ction None H Spacing: c/c Inlet Bundle exit 475) 200 mm 488,48 mm
39 40 41 42 43 44 45 46 47 48 49 50 51 52	Size/ratingONominalInTube No.1473Tube typePlainShell22Cr,5Ni,3Mo sChannel or bonnetTubesheet-stationaryFloating head coverBaffle-crossingSS 31Baffle-long-Supports-tubeBypass sealExpansion jointRhoV2-Inlet nozzleGaskets - Shell side	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo - 22Cr,5Ni,3Mo - 16L - 2323 -	1 200/ / /5 Tks-Avg #/m M. D 1050 OD steel steel - Type Singles Se U-bend	aterial 220 1066 segmental eal type Tube-tut Type	1 mm Cr,5Ni,3I mm Cr C C C Desheet j None 464	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp.	Tube pattern 3(- - ction None H Spacing: c/c) 200 mm 488,48 mm
39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - - - - - 2323 - - - - 2323 - -	1 200/ / /5 Tks-Avg #/m M D 1050 OD steel steel - Type Singles Se U-bend Bund	aterial 220 1066 segmental eal type Tube-tub Type le entrance	1 mm Cr,5Ni,3I mm Cr C C C Desheet j None 464	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp. Fla	Tube pattern 3(- - ction None H Spacing: c/c Inlet Bundle exit 475 at Metal Jacket Fibe) 200 mm 488,48 mm kg/(m s²)
39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head Code requirements Floating head	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - - - - - - 2323 - - - 2323 - - - 2323 - - - 2323 - -	1 200/ 1 200/ 15 Tks-Avg #/m M D 1050 OD steel - steel - Type Single s Se U-bend Bund 45	aterial 220 1066 segmental eal type Tube-tub Type le entrance Tube Sid	1 mm Cr,5Ni,3I mm C C Desheet j None 464 de	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp. Fla	Tube pattern 3(- - ction None H Spacing: c/c Inlet Bundle exit 475 at Metal Jacket Fibe) 200 mm 488,48 mm kg/(m s²)
39 40 41 42 43 45 46 47 48 49 50 51 52 53 53 54 55	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head Code requirements Weight/Shell	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - - - - - 2323 - - - - 2323 - -	1 200/ 1 200/ 15 Tks-Avg #/m M D 1050 OD steel - steel - Type Single s Se U-bend Bund 45	aterial 220 1066 segmental eal type Tube-tub Type le entrance	1 mm Cr,5Ni,3I mm C C Desheet j None 464 de	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp. Fla	Tube pattern 3(- - ction None H Spacing: c/c Inlet Bundle exit 475 at Metal Jacket Fibe) 200 mm 488,48 mm kg/(m s²)
39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	Size/rating O Nominal In Tube No. 1473 Tube type Plain Shell 22Cr,5Ni,3Mo s Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS 31 Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head Code requirements Weight/Shell	mm ut termediate OD 19,0 teel II 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - - - - - - 2323 - - - 2323 - - - 2323 - - - 2323 - -	1 200/ 1 200/ 15 Tks-Avg #/m M D 1050 OD steel - steel - Type Single s Se U-bend Bund 45	aterial 220 1066 segmental eal type Tube-tub Type le entrance Tube Sid	1 mm Cr,5Ni,3I mm C C Desheet j None 464 de	450/ - / - Length 6500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect sut(%d) 10 Type joint Exp. Fla	Tube pattern 3(- - ction None H Spacing: c/c Inlet Bundle exit 475 at Metal Jacket Fibe) 200 mm 488,48 mm kg/(m s²)

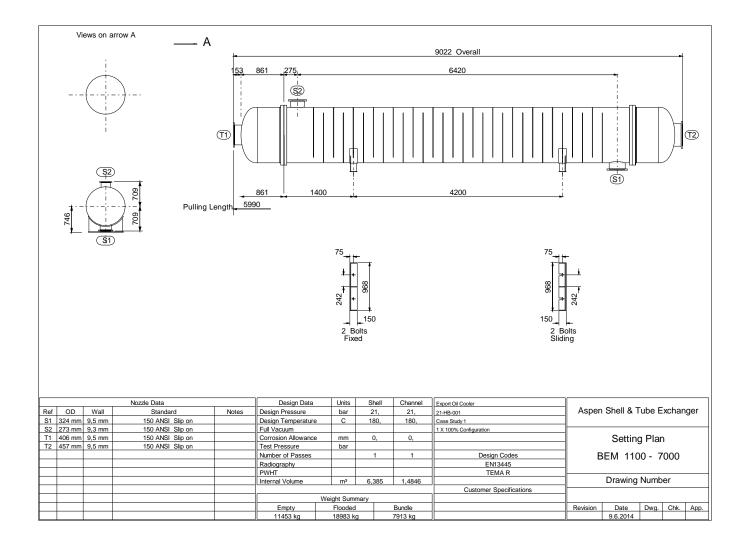


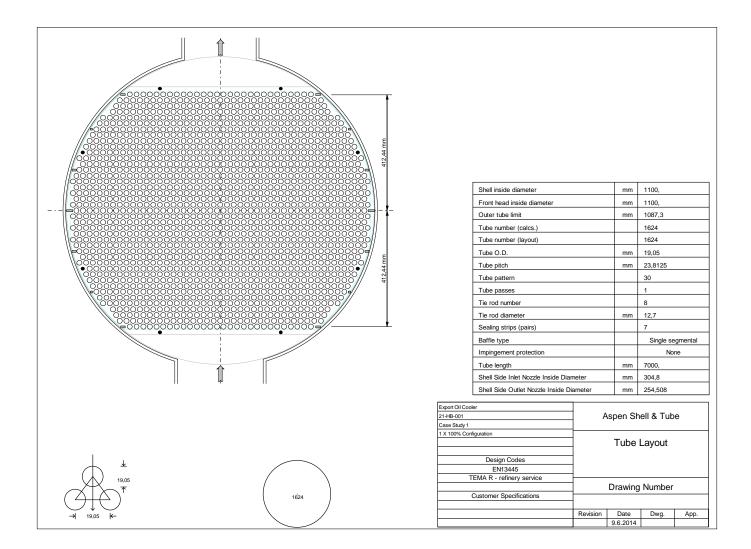


7.4.2 Thermal Calculations of 21-HB-001 – Case Study I

1	Export Oil Cooler								
2	21-HB-001								
3	Case Study 1								
4	1 X 100% Configura	tion							
5									
6	Size 1100	7000		mm T	ype BEM	Hor	Connected in	1 parallel	1 series
7	Surf/unit(eff.)	6	668	m ² Shells	s/unit 1		Surf	/shell (eff.)	668 m²
8				PERF	ORMANC	e of on	E UNIT		
9	Fluid allocation					Shell	Side	Tube S	Side
10	Fluid name					Sea V	Vater	Export	t Oil
11	Fluid quantity, Total			kg/s		86,8	636	316,2	758
12	Vapor (In/Out)			kg/s			0	0	0
13	Liquid			kg/s		636	86,8636	316,2758	316,2758
14	Noncondensable			kg/s	1		0	0	0
15									
	Temperature (In/Out)		0°	8		45,34	75,1	54,9
17	Dew / Bubble poir			2°	-			70,1	
	Density	Vapor/Liqui	d	kg/m³		1020	/ 1002,29	/ 810,1	/ 812,5
19	Viscosity	vaporiziqui	u.	mPa s		1,375	/ 0,881	/ 3,092	/ 3,3291
	Molecular wt, Vap			11154 S	1 /	1,375	/ 0,001	/ 3,092	/ 3,3291
	· · ·								
	Molecular wt, NC			1.1/0	,	·	/	/ 0.00	/ 0.010
22	Specific heat			kJ/(kg K)		4,45	/ 4,437	/ 2,23	/ 2,219
	Thermal conductivity	/		W/(m K)		0,5834	/ 0,6177	/ 0,1171	/ 0,1174
24	Latent heat			kJ/kg					
	Pressure (abs)			bar			9,36757	7,5	7,36364
26	Velocity	<i>,</i> .		m/s			24	1,12	
	Pressure drop, allow	./calc.		bar			0,63243	1	0,13636
	Fouling resist. (min)			m² K/W		0		0	0 Ao based
	Heat exchanged	14161	,9	kW				corrected	37,73 ° C
30	Transfer rate, Servic	e 561,9		D' 1	405 4		A 1 A A A		
				Dirty	495,1		Clean 495,1	i	W/(m² K)
31	,,,		CONS	TRUCTION OF O			Clean 495,1	Sket	
31 32			CONS	,	NE SHELL		Clean 495,1 Tube Side	Sket	
32	Design/vac/test pres	C	CONS bar	TRUCTION OF O	NE SHELL	21	Tube Side	Sket	
32 33		C		TRUCTION OF ON Shell S	NE SHELL Side	21	Tube Side	Sket	
32 33 34	Design/vac/test pres	C sure:g	bar	TRUCTION OF OF Shell S 21/	NE SHELL Side	21	Tube Side	Sket	
32 33 34	Design/vac/test pres Design temperature	C sure:g shell	bar	TRUCTION OF ON Shell S 21/ , 180	NE SHELL Side	21	Tube Side / / 180	Sket	
32 33 34 35	Design/vac/test pres Design temperature Number passes per	C sure:g shell	bar °C	TRUCTION OF OI Shell S 21/ 180 1 304,8/	NE SHELL Side		Tube Side / / 180 1		
32 33 34 35 36 37	Design/vac/test pres Design temperature Number passes per Corrosion allowance	C sure:g shell	bar °C mm	TRUCTION OF OF Shell S 21/ 180 1 0	NE SHELL Side /	1 4	Tube Side / / 180 1 0	Sket	
32 33 34 35 36 37 38	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections	C sure:g shell In	bar °C mm mm	TRUCTION OF OI Shell S 21/ 180 1 304,8/	NE SHELL Side /	1 4	Tube Side / / 180 1 0 406,4/ -	Sket	
32 33 34 35 36 37 38 39	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating	C sure:g shell In Out Intermediate	bar °C mm mm	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/	NE SHELL Side / - - -	1 4	Tube Side / / 180 1 0 406,4/ -	sket	
32 33 34 35 36 37 38 39	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	C sure:g shell In Out Intermediate	bar °C mm mm	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5	NE SHELL Side / - - - - - - - - - - -	1 4	Tube Side / / 180 1 0 406,4/ - 457,2/ - / - Length 7000		ch
32 33 34 35 36 37 38 39 40	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624	C sure:g shell In Out Intermediate OD	bar °C mm mm 19,0	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m	NE SHELL Side / - - - - - - - - - - -	1 4 1 4 mm	Tube Side / / 180 1 0 406,4/ - 457,2/ - / - Length 7000	ot mm Pitch	ch
32 33 34 35 36 37 38 39 40 41	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain	C sure:g shell In Out Intermediate OD	bar °C mm mm 19,0	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0	NE SHELL Side / - - - - - - 1,24 laterial 22	1 4 1 4 mm 2Cr,5Ni,3l	Tube Side / / 180 1 0 406,4/ - 457,2/ - / - Length 7000 Mo steel	ot mm Pitch	ch
32 33 34 35 36 37 38 39 40 41 42	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni,	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 5 Tks-Avg #/m 0 0	NE SHELL Side / - - - - - - 1,24 laterial 22	1 4 1 4 mm 2Cr,5Ni,3l	Tube Side / / 180 1 0 406,4/ - 457,2/ - / - Length 7000 Mo steel Shell cover	ot mm Pitch	ch
32 33 34 35 36 37 38 39 40 41 42 43 44	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni,	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 5 Tks-Avg #/m 0 0	NE SHELL Side / - - - - - - 1,24 laterial 22	1 4 1 4 mm 2Cr,5Ni,3l	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating	mm Pitch Tube pattern 30 -	ch
32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, -	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 1100 OD steel -	NE SHELL Side / - - 1,24 laterial 22 1118	1 4 1 4 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protee	mm Pitch Tube pattern 30 - - - - - - - - - -	ch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, -	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D steel - Type Single	NE SHELL Side / - - 1,24 laterial 22 1118 segmental	1 4 1 4 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protee	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, -	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 0 100 0D steel steel	NE SHELL Side / - - 1,24 laterial 22 1118	1 4 1 4 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, -	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D steel - Type Single	NE SHELL Side / - - - - 1,24 laterial 22 1118 segmental eal type	1 4 1 4 2Cr,5Ni,33 mm	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 7 22Cr,5Ni, 7 316L	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 0 100 0D steel steel	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu	1 4 1 4 2Cr,5Ni,31 mm C	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, - 3316L	bar °C mm mm 19,0 IE 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D steel - Type Single V-bend	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type	1 4 1 4 2Cr,5Ni,3I mm CC	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	<u>ch</u>
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, y 22Cr,5Ni, - 316L	bar °C mm mm 19,0 IE	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D steel - Type Single V-bend	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance	1 4 1 4 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, - - 316L - - 13	bar °C mm mm 19,0 IE 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D steel - Type Single V-bend	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type	1 4 1 4 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp.	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	<u>ch</u>
$\begin{array}{c} 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 2316L	bar °C mm 19,0 IE 33Mo s 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 01100 OD steel steel S U-bend Bunc	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance	1 4 1 4 2Cr,5Ni,31 mm CCr,5Ni,31 mm CC	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch 23,81 mm 0 200 mm 536,48 kg/(m s²)
$\begin{array}{c} 32\\ 33\\ 3\\ 4\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 13 14 14 14 14 14 14 14 14 14 14 14 14 14	bar °C mm 19,0 [[] 33Mo s 33Mo s 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 254/ / 5 Tks-Avg #/m 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 100 0 100 0 0 0 0 0	NE SHELL Side / - - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance Tube S	1 4 1 4 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 2Cr,5Ni,	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch 23,81 mm 0 200 mm 536,48 kg/(m s²) herry service
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 13 14 14 14 14 14 14 14 14 14 14 14 14 14	bar °C mm 19,0 IE 33Mo s 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 254/ / 5 Tks-Avg #/m 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 100 0 100 0 0 0 0 0	NE SHELL Side / / - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance	1 4 1 4 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 2Cr,5Ni,	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch 23,81 mm 0 200 mm 536,48 kg/(m s²)
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 13 14 14 14 14 14 14 14 14 14 14 14 14 14	bar °C mm 19,0 [[] 33Mo s 33Mo s 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D Steel steel Steel S U-bend Bunc 45	NE SHELL Side / - - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance Tube S	1 4 1 4 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 2Cr,5Ni,	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch 23,81 mm 0 200 mm 536,48 kg/(m s²) herry service
$\begin{array}{c} 32\\ 33\\ 3\\ 3\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 1624 Tube type Plain Shell 22Cr,5Ni,3M Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	C sure:g shell In Out Intermediate OD o steel 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 22Cr,5Ni, 13 14 14 14 14 14 14 14 14 14 14 14 14 14	bar °C mm 19,0 [[] 33Mo s 33Mo s 33Mo s	TRUCTION OF Of Shell S 21/ 180 1 0 1 304,8/ 1 254/ / 5 Tks-Avg #/m 0 0 1100 0D Steel steel Steel S U-bend Bunc 45	NE SHELL Side / - - - - 1,24 laterial 22 1118 segmental eal type Tube-tu Type Ile entrance Tube S	1 4 1 4 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 mm 2Cr,5Ni,31 2Cr,5Ni,	Tube Side / / 180 1 0 406,4/ - 457,2/ - Length 7000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type joint Exp. Fla	mm Pitch Tube pattern 30 - - - - - - - - - - - - - - - - - - -	ch 23,81 mm 0 200 mm 536,48 kg/(m s²) herry service

1	Size 1100 x	7000	mm	Тур	e BEM	Hor		Connected in	1	parallel	1 series
2	Surf/Unit (gross/eff/fir	nned)	680),3 /	668 /	m²		Shells/unit	1	l	
3 4	Surf/Shell (gross/eff/f	inned)	680),3 /	668 /	m²					
5	Design				PERFORM	ANCE OF ON	E UNIT				
6			Shel	l Side		Side	1	ansfer Param	eters		
7	Process Data		In	Out	In	Out	Total he	at load		kW	14161,9
8	Total flow	kg/s	86	,8636	316	6,2758	Eff. MT	D/ 1 pass MTD		°C 3	7,73 / 37,71
9	Vapor	kg/s	0	0	0	0	Actual/F	Regd area ratio	o - fouled/cle	ean C	,88 / 0,88
10	Liquid	kg/s	86,8636	86,8636	316,2758	316,2758					
11	Noncondensable	kg/s		0		0	Coef./R	esist. V	V/(m² K)	m² K/W	%
12	Cond./Evap.			0		0	Overall	fouled	495,1	0,00202	
13	Temperature	°C	8	45,34	75,1	54,9	Overall	clean	495,1	0,00202	
14	Dew / Bubble point	°C					Tube si	de film	581	0,00172	85,21
15	Quality		0	0	0	0	Tube si	de fouling		0	0
16	Pressure (abs)	bar	10	9,36757	7,5	7,36364	Tube wa	all	12128,5	0,0008	4,08
17	Delta P allow/calc	bar	1	0,63243	1	0,13636	Outside	fouling		0	0
18	Velocity	m/s	2,19	2,24	1,12	1,11	Outside	film	4622,9	0,00022	10,71
19											
20	Liquid Properties						Shell S	de Pressure I	Drop	bar	%
21	Density	kg/m³	1020	1002,29	810,1	812,5	Inlet no:	zzle		0,00895	1,42
22	Viscosity	mPa s	1,375	0,881	3,092	3,3291	Inlet spa	ace Xflow		0,02613	4,13
23	Specific heat kJ	/(kg K)	4,45	4,437	2,23	2,219	Baffle X	flow		0,47971	75,88
24	Therm. cond. W	//(m K)	0,5834	0,6177	0,1171	0,1174	Baffle w	indow		0,08006	12,66
25	Surface tension	N/m					Outlet s	pace Xflow		0,02514	3,98
26	Molecular weight						Outlet n	ozzle		0,0122	1,93
27	Vapor Properties						Interme	diate nozzle			
28	Density	kg/m³					Tube Si	de Pressure [Drop	bar	%
29	Viscosity	mPa s					Inlet no:	zzle		0,03412	25,02
30	Specific heat kJ	/(kg K)					Entering	g tubes		0,00243	1,78
31	Therm. cond. W	//(m K)					Inside tu	ubes		0,08335	61,12
32	Molecular weight						Exiting t	ubes		0,00328	2,41
33	Two-Phase Propertie						Outlet n	ozzle		0,0132	9,68
34	Latent heat	kJ/kg					Interme	diate nozzle			
35											
36	Heat Transfer Param	neters					Velocity		2	m/s	kg/(m s²)
37	Reynolds No. vapor							zzle inlet		1,17	1389
38	Reynolds No. liquid		30893,27	48215,32	4842,5	4497,58		Indle Xflow	2,		
39	Prandtl No. vapor							ffle window	1,7	,	
40	Prandtl No. liquid		10,49	6,33	58,88	62,91		zzle outlet		1,7	2909
41	Heat Load			kW		kW	Shell no	zzle interm			
42	Vapor only			0		0				m/s	kg/(m s²)
43	2-Phase vapor			0		0		zzle inlet		3,31	8892
44	Latent heat			0		0	Tubes		1,1	12 1,11	
45	2-Phase liquid			0		0		zzle outlet		2,58	5415
46	Liquid only		14	161,9	-14	4161,9	Tube no	zzle interm			
47	- 1				D. (1)		1	N			
48	Tubes				Baffles	0. 1		Nozzles: (N			Tube Of L
49	Type			Plain	Туре	Single s	egmental	la la t		hell Side	Tube Side
50	ID/OD mr			9,05	Number	10	30	Inlet		/ 323,85	1 / 406,4
51	Length act/eff mr	m 70	00 / 6		Cut(%d)	10		Outlet	1	/ 273,05	1 / 457,2
52	Tube passes			1	Cut orientation		Н	Other		/	/
53	Tube No.			1624	Spacing: c/c	mm	200	Impingemer	nt protection	1	None
54	Tube pattern		-	30	Spacing at inle		536,48				
55	Tube pitch mr	m	2	23,81	Spacing at out	let mm	536,48				
56	Insert			None			Dh. Ma	1-4			N
57	Vibration problem		I	No / No			RhoV2 vio	Diation			No



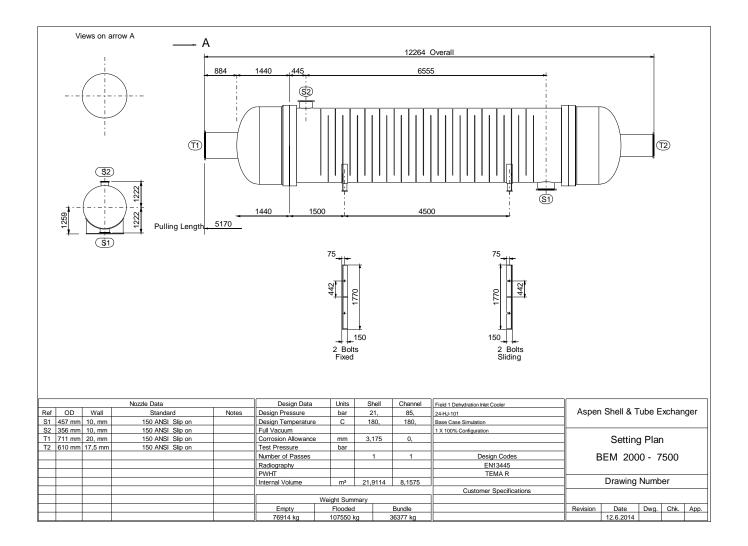


7.5 Thermal Calculations of Field 1 & 2 Dehydration Inlet Coolers (24-HJ-101 & 24-HJ-201)

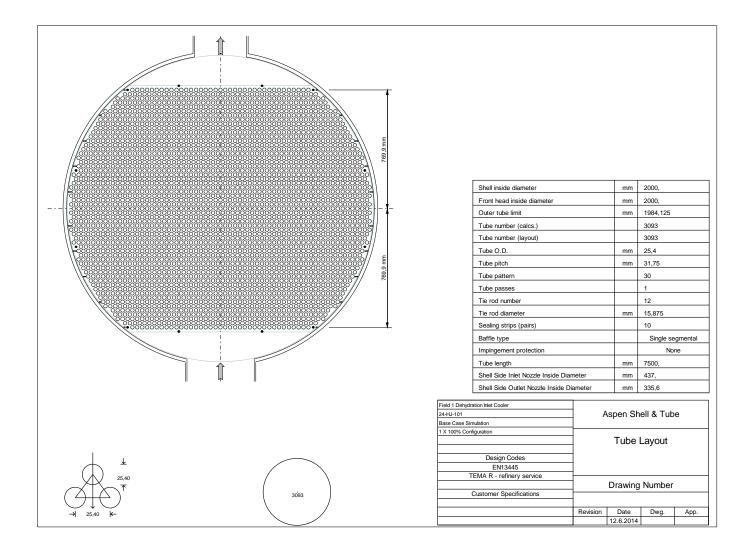
This section contains the thermal design calculations of the relevant heat exchangers in Case Study III.

7.5.1 Thermal Calculations of the 24-HJ-101 & 24-HJ-201 – Base Case Design

1	Field 1 Dehydration	Inlat Coolar							
2	24-HJ-101								
3	Base Case Simulation								
4	1 X 100% Configura	uon							
	Size 2000	7500			Hor	Connect	od in	2 parall	el 1 series
7	Surf/unit(eff.)	2512.1		ype BEM		Connect		2 parall	
8									
	Fluid allocation		FENF		Shell			г	Tube Side
	Fluid allocation			Cooling Medium Inlet 4				Inlet to 24-HJ-101	
-	Fluid quantity, Total kg/s				446,1111			268,2778	
12	Vapor (In/Out) kg/s			0 0		268,2778 268,2778			
13	Liquid				111	446,111	11	0	0
14	Liquid kg/s Noncondensable kg/s			0		0		0	0
15	Honoondonodolo		Kg/3						Ŭ
	Temperature (In/Out)	0°	20)	80		135	25,81
17	Dew / Bubble poir		<u>ວ</u> ວ°	-				100	20,01
	Density	Vapor/Liquid	kg/m³		1127	/	1072	30,19 /	41,38 /
	Viscosity		mPa s	<u> </u>	17,13	/	3,715	0.0157 /	0,0156 /
	Molecular wt, Vap			, , , , , , , , , , , , , , , , , , ,	,		-,	20,37	20,37
	Molecular wt, NC								
22	Specific heat		kJ/(kg K)	/	2,65	/	2,93	2,55 /	2,547 /
23	Thermal conductivity	,	W/(m K)	/	0,2165	/ (0,2274	0,0501 /	0,0494 /
24	Latent heat		kJ/kg		-,		- /	- ,	
25	Pressure (abs)		bar	10)	9		50,3	50,25467
26	Velocity		m/s		3,0	02			3,74
27	Pressure drop, allow	/calc.	bar	1		1,7070	1	1	0,04533
28	Fouling resist. (min)		m² K/W		0			0	0 Ao based
	Heat exchanged	74540,9	kW				MTD	corrected	21,93 ° C
30	Transfer rate, Service 967,6 Dirty 349,3 Clean 349,3 W/(m ² k								W///m2 K)
00									W/(III~ K)
31				-		Clean	543,5		Sketch
				NE SHELL		Tube Side	543,5		
31 32	Design/vac/test pres	CON	STRUCTION OF ON Shell S	NE SHELL	85	Tube Side	<u> </u>		
31 32 33		CON	STRUCTION OF ON Shell S Ir 21/ /	NE SHELL	85	Tube Side		°	
31 32 33 34	Design/vac/test pres	CON sure:g ba	STRUCTION OF ON Shell S r 21/ /	NE SHELL	85	Tube Side			
31 32 33 34 35	Design/vac/test pres Design temperature	CON sure:g ba °(shell	STRUCTION OF ON Shell S ur 21/ C 180 1	NE SHELL ide /	85	Tube Side / / 180		∘∟	
31 32 33 34 35 36 37	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections	CON sure:g ba °(shell In mr	STRUCTION OF ON Shell S Ir 21/ C 180 1 3,18 n 3,18 n 450/	NE SHELL ide /	85	Tube Side / / 180 1 0 700/ -			
31 32 33 34 35 36 37	Design/vac/test pres Design temperature Number passes per Corrosion allowance	CON sure:g ba °(shell mr	STRUCTION OF ON Shell S Ir 21/ C 180 1 0 3,18	NE SHELL		Tube Side / / 180 1 0		•	
31 32 33 34 35 36 37 38 39	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	CON sure:g ba °(shell In mr Out Intermediate	STRUCTION OF ON Shell S ir 21/ C 180 1 3,18 n 3,18 n 450/ 1 350/ / /	NE SHELL		Tube Side / / 180 1 0 700/ -		• 	
31 32 33 34 35 36 37 38 39 40	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093	CON sure:g ba °(shell In mr Out	STRUCTION OF ON Shell S ir 21/ C 180 n 3,18 n 450/ 1 350/ / / 4 Tks-Avg	NE SHELL iide / - - 1,65	1 1 1 mm	Tube Side / / / 180 1 0 700/ - 600/ - (- Length)			Sketch
31 32 33 34 35 36 37 38 39 40 41	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain	CON sure:g ba shell mr In mr Out Intermediate OD 25	STRUCTION OF ON Shell S ur 21/ C 180 n 3,18 n 450/ 1 350/ / / .4 Tks-Avg #/m M	NE SHELL iide / - - 1,65 laterial 22	1	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel		• C M F mm F Tube pattern	Sketch
31 32 33 34 35 36 37 38 39 40 41 42	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel	CON sure:g ba shell In mr Out Intermediate OD 25,	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 450/ 1 350/ 4 Tks-Avg #/m M ID 2000 OD	NE SHELL iide / - - 1,65	1 1 1 mm	Tube Side / / 180 1 0 - 700/ - 600/ - / - Length - Shell cover -	7500		Sketch
31 32 33 34 35 36 37 38 39 40 41 42 43	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc	STRUCTION OF ON Shell S ir 21/ C 180 n 3,18 n 450/ 1 350/ / / .4 Tks-Avg #/m M ID 2000 OD o steel	NE SHELL iide / - - 1,65 laterial 22	1 1 mm 2Cr,5Ni,3I	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Wo steel Shell cover Channel cov	7500 ver		Sketch
31 32 33 34 35 36 37 38 39 40 41 42 43 44	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc / 22Cr,5Ni,3Mc	STRUCTION OF ON Shell S ir 21/ C 180 n 3,18 n 450/ 1 350/ / / .4 Tks-Avg #/m M ID 2000 OD o steel	NE SHELL iide / - - 1,65 laterial 22	1 1 mm 2Cr,5Ni,3I	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Wo steel Shell cover Channel cov Tubesheet-f	7500 ver loating	Tube pattern - - -	Sketch
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc / 22Cr,5Ni,3Mc -	STRUCTION OF ON Shell S ir 21/ C 180 1 1 n 3,18 n 1 4 Tks-Avg #/m M ID 2000 OD o steel -	NE SHELL iide / - 1,65 laterial 22 2044	1 1 2Cr,5Ni,31 mm	Tube Side / / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen	7500 ver loating nt protec	Tube pattern - - - tion None	Sketch Image: Sketch in the second
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc / 22Cr,5Ni,3Mc -	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 1 1 350/ / / 4 Tks-Avg #/m M ID 2000 OD o steel - o steel - Type Single	NE SHELL iide / - 1,65 aterial 22 2044 segmental	1 1 2Cr,5Ni,31 mm	Tube Side / / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f	7500 ver loating nt protec	Tube pattern - - tion None H Spacing: c/	Sketch Image: Sketch image:
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc / 22Cr,5Ni,3Mc -	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 450/ I 350/ / / 4 Tks-Avg #/m M ID 2000 OD o steel - Type Single Single Single	NE SHELL iide / - 1,65 laterial 22 2044	1 1 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10	7500 ver loating nt protec	Tube pattern - - - tion None	Sketch Image: Sketch in the second
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc / 22Cr,5Ni,3Mc -	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 1 1 350/ / / 4 Tks-Avg #/m M ID 2000 OD o steel - o steel - Type Single	NE SHELL iide / - - 1,65 2044 segmental eal type	1 1 2Cr,5Ni,31 mm	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver loating	Tube pattern - - tion None H Spacing: c/	Sketch Image: Sketch image:
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 450/ I 350/ / / 4 Tks-Avg #/m M ID 2000 OD o steel - Type Single Single Single	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu	1 1 2Cr,5Ni,3I mm C C	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver loating nt protec	Tube pattern - - tion None H Spacing: c/	Sketch Image: Sketch image:
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 1.450/ 1 350/ / / 4 Tks-Avg #/m M ID 2000 OD p steel - p steel - Type Single U-bend Si	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3I mm C C besheet j None	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver loating ht protec	Tube pattern - - tion None H Spacing: c/ Inlet	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 1.450/ 1 350/ / / 4 Tks-Avg #/m M ID 2000 OD p steel - p steel - Type Single U-bend Si	NE SHELL iide / - 1,65 laterial 22 2044 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Ccr,5Ni,3I mm Ccr,5Ni,3I mm	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver iloating ht protec	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 15	Sketch Pitch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²)
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc 316L - 316L - 1962 -	STRUCTION OF ON Shell S Ir 21/ C 180 n 3,18 n 1.450/ 1 350/ / / 4 Tks-Avg #/m M ID 2000 OD p steel - o steel - Type Single U-bend Si	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3I mm Ccr,5Ni,3I mm Ccr,5Ni,3I mm	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver iloating ht protec	Tube pattern - - tion None H Spacing: c/ Inlet	Sketch Pitch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²)
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc - 22Cr,5Ni,3Mc - 316L - - 1962 - ead -	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 450/ I 350/ / / 4 Tks-Avg #/m M ID 2000 OD o steel - o steel - Type Single U-bend Bund	NE SHELL iide / - 1,65 laterial 22 2044 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Ccr,5Ni,3I mm Ccr,5Ni,3I mm	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type	7500 ver loating nt protec Exp. Flat	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²)
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CON sure:g ba shell In mr Out Intermediate OD 25 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L - 1962 - ead - EN13	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 350/ I 350/ I 350/ I 0 </td <td>NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S</td> <td>1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide</td> <td>Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint</td> <td>7500 ver loating nt protec l Exp. Flat</td> <td>Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F</td> <td>Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service</td>	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S	1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint	7500 ver loating nt protec l Exp. Flat	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	CON sure:g ba shell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mc - 22Cr,5Ni,3Mc - 316L - - 1962 - ead -	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 350/ I 350/ I 350/ I 0 </td <td>NE SHELL iide / - 1,65 laterial 22 2044 segmental eal type Tube-tu Type le entrance</td> <td>1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide</td> <td>Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint</td> <td>7500 ver loating nt protec l Exp. Flat</td> <td>Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F</td> <td>Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²)</td>	NE SHELL iide / - 1,65 laterial 22 2044 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint	7500 ver loating nt protec l Exp. Flat	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²)
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	CON sure:g ba shell or In mr Out Intermediate OD 25 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L - 1962 - ead - EN13	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 350/ I 350/ I 350/ I 0 </td <td>NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S</td> <td>1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide</td> <td>Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint</td> <td>7500 ver loating nt protec l Exp. Flat</td> <td>Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F</td> <td>Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service</td>	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S	1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint	7500 ver loating nt protec l Exp. Flat	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service
$\begin{array}{c} 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Design/vac/test pres Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	CON sure:g ba shell or In mr Out Intermediate OD 25 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc 22Cr,5Ni,3Mc - 316L - 1962 - ead - EN13	STRUCTION OF ON Shell S Ir 21/ C 180 I 1 I 350/ I 350/ I 350/ I 0 </td <td>NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S</td> <td>1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide</td> <td>Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint</td> <td>7500 ver loating nt protec l Exp. Flat</td> <td>Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F</td> <td>Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service</td>	NE SHELL iide / - - 1,65 laterial 22 2044 segmental eal type Tube-tu Type Ile entrance Tube S	1 1 2Cr,5Ni,31 mm C besheet j None 1501 ide	Tube Side / / 180 1 0 700/ - 600/ - 600/ - Length Mo steel Shell cover Channel cov Tubesheet-f Impingemen ut(%d) 10 Type oint	7500 ver loating nt protec l Exp. Flat	Tube pattern - - tion None H Spacing: c/ Inlet Bundle exit 150 t Metal Jacket F	Sketch Ditch 31,75 mm 30 /c 200 mm 657,48 mm 66 kg/(m s²) ibe - refinery service



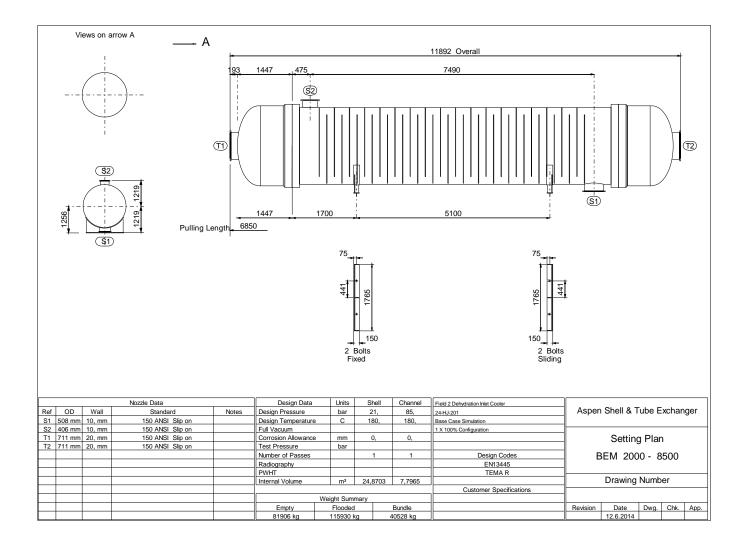
Tube Layout



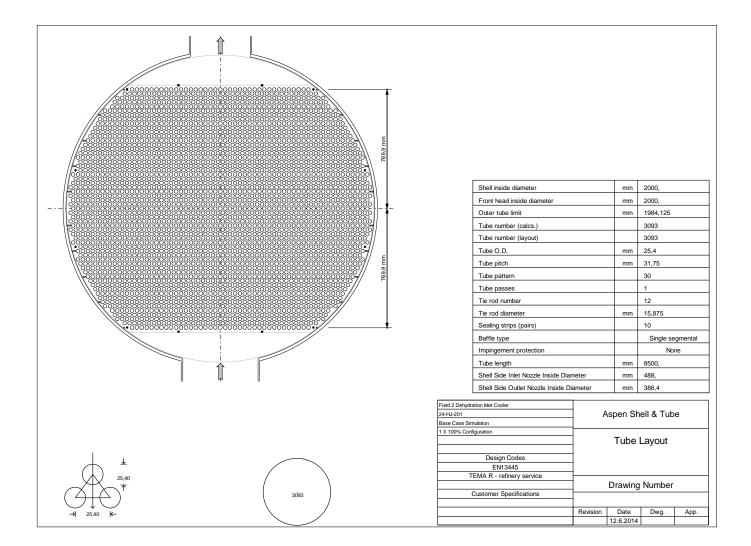
Heat Exchanger Specification Sheet

	Field 2 Debydration I	alat Caalar						
	Field 2 Dehydration In	niet Cooler						
	24-HJ-201							
3	Base Case Simulation							
4	1 X 100% Configurat	ion						
5	<u>c:</u>	0500		DEM		0 6 1	0 "	
_		8500		ype BEM	Hor	Connected in	2 paralle	
7	Surf/unit(eff.)	3998,8		/unit 2			/shell (eff.)	<u> 1999,4 m²</u>
8			PERF					
-	Fluid allocation				Shell			ibe Side
	Fluid name					lium Inlet 8		24-HJ-201
	Fluid quantity, Total		kg/s		545,5)3,8889
12	Vapor (In/Out)		kg/s			0	303,8889	303,8889
13	Liquid		kg/s			545,5555	0	0
14	Noncondensable		kg/s	0		0	0	0
15								
	Temperature (In/Out)		°C	20)	80	142	25,98
17	Dew / Bubble poin		°C	ļ,		1		
	Density	Vapor/Liquid	kg/m³	<u>├</u> ,	1127	/ 1072	32,51 /	45,35 /
	Viscosity		mPa s	/	17,13	/ 3,715	0,016 /	0,0159 /
	Molecular wt, Vap						20,33	20,33
_	Molecular wt, NC			ļ		,	,	,
22	Specific heat		kJ/(kg K)	<u> </u>	2,65	/ 2,92	2,58 /	2,578 /
-	Thermal conductivity		W/(m K)	/ /	0,2165	/ 0,2274	0,0515 /	0,0508 /
24	Latent heat		kJ/kg					
25	Pressure (abs)		bar	10)	9	55,2	55,15403
	Velocity		m/s		3,	7		3,94
27	Pressure drop, allow./	calc.	bar	1		2,71438	1	0,04598
28	Fouling resist. (min)		m² K/W		0		0	0 Ao based
29	Heat exchanged	90985,3	1-14/					
23	Tieat excitatiged	90905,5	kW			MID	corrected	24,03 ° C
30	Transfer rate, Service	e 947	Dirty	389,6		Clean 389,6	corrected	24,03 °C W/(m² K)
30 31	· · · · ·	e 947		NE SHELL		Clean 389,6		· · · · · · · · · · · · · · · · · · ·
30	· · · · ·	e 947	Dirty	NE SHELL				W/(m² K)
30 31 32	· · · · ·	e 947 CONS sure:g ba	Dirty STRUCTION OF ON Shell S r 21/ /	NE SHELL	85,	Clean 389,6 Tube Side		W/(m² K)
30 31 32 33 34	Transfer rate, Service Design/vac/test press Design temperature	e 947 CONS sure:g bai	Dirty STRUCTION OF ON Shell S r 21/ /	NE SHELL	85,	Clean 389,6 Tube Side		W/(m² K)
30 31 32 33 34	Transfer rate, Service Design/vac/test press	e 947 CONS sure:g bai	Dirty STRUCTION OF ON Shell S r 21/ /	NE SHELL	85,	Clean 389,6 Tube Side /		W/(m² K)
30 31 32 33 34	Transfer rate, Service Design/vac/test press Design temperature	e 947 CONS sure:g bai	Dirty STRUCTION OF ON Shell S r 21/ / 180	NE SHELL	85,	Clean 389,6 Tube Side / / / 180		W/(m² K)
30 31 32 33 34 35 36 37	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections	947 CONS ure:g bai °C hell mm In mm	Dirty STRUCTION OF ON Shell S 1 2 1 1 1 1 1 1 1 1	NE SHELL	85,	Clean 389,6 Tube Side / / / 180 1 0 700/ -		W/(m² K)
30 31 32 33 34 35 36 37	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections	e 947 CONS sure:g bai °C hell mm	Dirty STRUCTION OF ON Shell S 1 2 1 1 1 0	IE SHELL ide		Clean 389,6 Tube Side / / 180 1 0		W/(m² K)
30 31 32 33 34 35 36 37 38	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating	947 CONS ure:g bai °C hell mm In mm	Dirty STRUCTION OF ON Shell S 1 2 1 1 1 1 1 1 1 1	IE SHELL ide		Clean 389,6 Tube Side / / / 180 1 0 700/ -		W/(m² K)
30 31 32 33 34 35 36 37 38 39	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating	e 947 CONS sure:g bar °C hell In mm Out	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 1 0 1 500/ 1 400/ /	IE SHELL ide / - - - -		Clean 389,6 Tube Side / / / 180 1 0 700/ -		W/(m² K)
30 31 32 33 34 35 36 37 38 39 40	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal	e 947 CONS sure:g bar °C hell In mr Out Intermediate	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 1 1 500/ 1 400/ 4 Tks-Avg	IE SHELL ide - - - - 1,65	1	Clean 389,6 Tube Side / 180 / 180 / 1 - 700 / - 700 / - / - / - Length 8500		W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093	e 947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 180 1 500/ 1 400/ 4 Tks-Avg #/m M	IE SHELL ide - - - - 1,65	1 1 2 2 Cr,5Ni,31	Clean 389,6 Tube Side / 180 / 180 / 1 - 700 / - 700 / - / - / - Length 8500	mm Pit	W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain	e 947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,	Dirty STRUCTION OF ON Shell S r 21/ / 2 180 1 21/ 1 400/ 4 Tks-Avg #/m M ID 2000 OD	IE SHELL ide - - - 1,65 aterial 22	1 1 2 2 Cr,5Ni,31	Clean 389,6 Tube Side / / / 180 ////////////////////////////////////	mm Pit	W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41 42 43	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel	e 947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,	Dirty TRUCTION OF ON Shell S 21/ / 2 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 1D 2000 OD 3 steel	IE SHELL ide - - - 1,65 aterial 22	1 1 2 2 Cr,5Ni,31	Clean 389,6 Tube Side / / / 180 ////////////////////////////////////	mm Pit	W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet	e 947 CONS sure:g bar °C hell In mr Out Intermediate OD 25, 22Cr,5Ni,3Mo	Dirty TRUCTION OF ON Shell S 21/ / 2 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 1D 2000 OD 3 steel	IE SHELL ide - - - 1,65 aterial 22	1 1 2 2 Cr,5Ni,31	Clean 389,6 Tube Side / / / 180 ////////////////////////////////////	mm Pit Tube pattern - - -	W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	947 CONS uure:g bar °C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD 5 steel steel -	IE SHELL ide - - - 1,65 aterial 22	1 1 2Cr,5Ni,37 mm	Clean 389,6 Tube Side / / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	mm Pit Tube pattern - - - - -	W/(m ² K) Sketch
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	947 CONS uure:g bar °C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel - Type Singles	IE SHELL ide / - - 1,65 aterial 22 2038	1 1 2Cr,5Ni,37 mm	Clean 389,6 Tube Side / / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	mm Pir Tube pattern - - - - -	W/(m ² K) Sketch
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	947 CONS uure:g bar °C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel - Type Singles	IE SHELL ide - - 1,65 aterial 22 2038 segmental	1 1 2Cr,5Ni,37 mm	Clean 389,6 Tube Side / / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	mm Pit mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	947 CONS uure:g bar °C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD steel steel - Type Single s	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type	1 1 2Cr,5Ni,37 mm	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pit mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	947 CONS uure:g bar °C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD steel steel - Type Single s	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type	1 1 2Cr,5Ni,31 mm	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pit mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long Supports-tube Bypass seal	947 CONS aure:g bar c'C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel steel - Type Singles Steel Steel	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type Tube-tu	1 1 2Cr,5Ni,3I mm Cr besheet j	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	mm Pit mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm 585,2 mm
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	947 CONS aure:g bar c'C hell In mr Out Intermediate OD 25, 0D 25, 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel steel - Type Singles Steel Steel	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type	1 1 2Cr,5Ni,31 mm Cr besheet j None 2834	Clean 389,6 Tube Side / / / 180 1 0 700/ 700/ - / - Length 8500 Mo steel Shell cover Channel cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp.	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm 585,2 mm 7 kg/(m s ²)
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25, OD 25, 0 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 1887 -	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel steel - Type Singles Steel Steel	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm Cr besheet j None 2834	Clean 389,6 Tube Side / / / 180 1 0 700/ 700/ - / - Length 8500 Mo steel Shell cover Channel cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp.	mm Pir mm Pir Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm 585,2 mm 7 kg/(m s ²)
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25, OD 25, 0 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 1887 -	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M 10 2000 OD steel steel steel - Type Singles Se U-bend Bund	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm Cr besheet j None 2834	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m ² K) Sketch tch 31,75 mm 30 200 mm 585,2 mm 7 kg/(m s ²) pe
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 50\\ 51\\ 52\\ 53\\ 54\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,- 1 22Cr,5Ni,3Mo - 316L - 1887 - 287 - 284 -	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD 3 steel steel steel - Type Single 3 Se U-bend Bund	IE SHELL ide - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance	1 1 2Cr,5Ni,31 mm Cr besheet j None 22334 ide	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m² K) Sketch Sketch Image: second
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,- 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 1887 - 2ad - EN134	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD steel steel steel - Type Singles Se U-bend Bund	IE SHELL ide - - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm Cr besheet j None 22334 ide	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m² K) Sketch Sketch Image: second
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head Code requirements Weight/Shell	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,- 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 1887 - 2ad - EN134	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD steel steel steel - Type Singles Se U-bend Bund	IE SHELL ide - - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm Cr besheet j None 22334 ide	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m² K) Sketch Sketch Image: second
$\begin{array}{c} 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55\\ 55$	Transfer rate, Service Design/vac/test press Design temperature Number passes per s Corrosion allowance Connections Size/rating Nominal Tube No. 3093 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating head Code requirements Weight/Shell	947 CONS sure:g bar °C hell In mr Out Intermediate OD 25,- 1 22Cr,5Ni,3Mo 22Cr,5Ni,3Mo - 316L - 1887 - 2ad - EN134	Dirty STRUCTION OF ON Shell S r 21/ / 180 1 10 1 500/ 1 400/ 4 Tks-Avg #/m M D 2000 OD steel steel steel - Type Singles Se U-bend Bund	IE SHELL ide - - - 1,65 aterial 22 2038 segmental eal type Tube-tu Type le entrance Tube S	1 1 2Cr,5Ni,31 mm Cr besheet j None 22334 ide	Clean 389,6 Tube Side / / 180 1 0 700/ - 700/ - Length 8500 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	mm Pit Tube pattern - - - - - - - - - - - - - - - - - - -	W/(m² K) Sketch Sketch Image: second

Setting Plan



Tube Layout

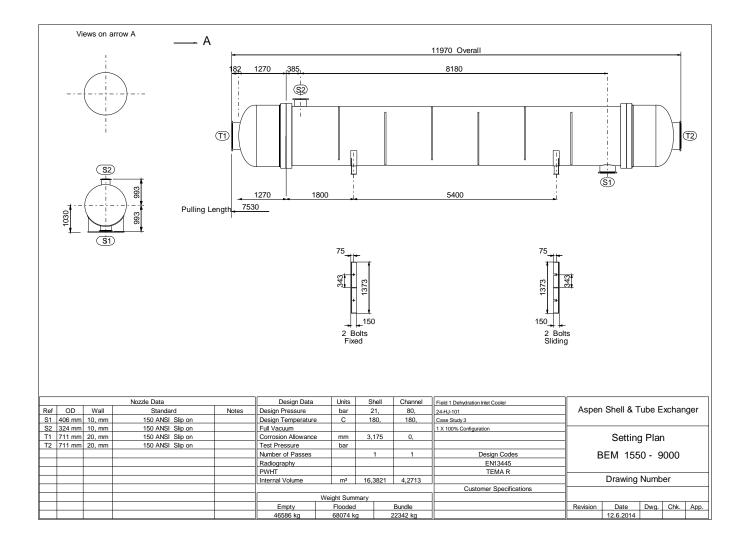


7.5.2 Thermal Calculations of the 24-HJ-101 & 24-HJ-201 – Case Study III

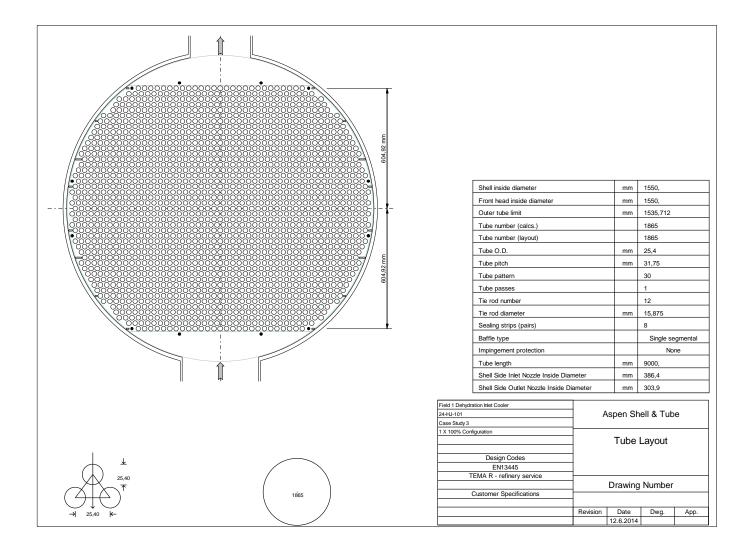
Heat Exchanger Specification Sheet

B PERFORMANCE 0F ONE UNIT 9 Fluid allocation Shell Side Tube Side 10 Fluid quantity, Total kg/s 342,2222 268,25 12 Vapor (MrOut) kg/s 342,2222 342,2222 0 0 12 Vapor (MrOut) kg/s 0 0 268,25 268,25 13 Liquid kg/s 0 0 0 0 14 Nencondensable kg/s 0 0 0 0 16 Tomperature (In/Out) *C 20 80,67 136 51,12 17 Dow / Bubbe point *C 120 Molecular wt, Vap 20,37 20,37 20,37 20 Molecular wt, Vap 1127 / 110,912 30,19 0 0,4044/ 22 Specific heat KJ/kg K / 2,255 / 2,738 2,55 / 2,543 / 23 Thermal conductivity W(m K K / 0,22165 0,22 0,0501 0,0494	1	Field 1 Debydration	nlet Cooler						
3 Case Study 3 4 1 X 100% Configuration 5 Size 1500-9000 mm Type BEM Hor Connected in 2 parallel 1 series 6 Size 1500-9000 mm Type BEM Hor Connected in 2 parallel 1 series 7 Buff with 1 2 Stall Size Tube Side Tube Side 10 Fluid name Cooling Medium Indel 4 Initit 2+U-101 Initit 2 268,25 268,25 11 Fluid name Cooling Medium Indel 4 Initit 2+U-101 1 268,25 268,25 268,25 268,25 1 2 <th2< th=""> 2 2 <th2< th=""></th2<></th2<>									
4 14 11 200% Configuration 5 5 5 7 Surfunt[eft] 2580.6 m* Shelbunit 2 Surfuhelt (eft) 1294.3 m 8 Indiancetton Shelbunit 2 Surfuhelt (eft) 1294.3 m 9 Fuid allocation Shelbunit 2 Surfuhelt (eft) 1294.3 m 9 Fuid allocation Shelbunit 2 Surfuhelt (eft) Tube Side 1016 to 24+tU-101 11 Fuid quantity, Total kg/s 342,2222 342,2222 0 0 0 12 Vapor (InOu) kg/s 342,2222 342,2222 0 0 0 14 Neocodensable kg/s 0 0 0 0 0 15 Tomerature (In/Ou) *C 2.0 80.67 135 51.12 19 Vapor/Liquid kg/m / 11/27 / 1109.12 30.15/ 0.0157/ 0.0156 / 20 Maccular vi, No 2.2 2.5 / 2.2,37 2.5 / 2.2,543 / / 10 <td< th=""><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></td<>									
S mm Type EEM Hor Connected in 2 parallel 1 series S Sturfunit(efL) 2588.6 m* Shellslunit 2 Surfushell (efL) 1294.3 m B Fuld allocation PERFORMANCE OF ONE UNIT Surfushell (efL) 1294.3 m B Fuld allocation Coloing Medium Initial 4 Initial 24.11/101 1 ID Fuld automative Ecoloing Medium Initial 4 Initial 24.11/101 288.25 12 Vapor (In/Out) kg/s 0 0 0 0 13 Liquid kg/s 0 0 0 0 0 16 Temperature (In/Out) *C 2.0 80.67 135 51.12 17 Dew / Bubble point kg/rs / 117.13 / 12.77.86 0.0157 0.0157 18 Dersity Vapor/Liquid kg/rs / 0.22.57 2.56.3 2.56.3 2.56.3 2.63.4 19 Visoosity mp as <th></th> <th></th> <th>tion</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>			tion						
Image: Size 1550-9000 mm Type BEM Hor Connected in 2 parallel 1 series 7 Surfurnt(eff.) 2588.6 m* Shellwini 2 Surfurshell (eff.) 1294.3 m 8 Indi allocation Shell Side Tube Side Tube Side Tube Side 10 Fluid quantity, Total kg/s 342,2222 268,25 288,25 11 Fluid quantity, Total kg/s 0 0 288,25 288,25 12 Vapor (inOut) kg/s 0 0 0 0 0 14 Noncondensable kg/s 0 0 0 0 0 16 Teperature (in/Out) *C 20 80.67 135 51.12 19 Vapor/Liquid kg/met / 112.7 / 110.912 30.19 / 38.31 / 1 1 0.0156 / 20.37 20 Molecular wit, Vap 2.0.57 2.55 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.543 / 2.55 / 2.543 / 2.543 / 2.543 / 2.543 /		T X 100 % Configura							
Image: Total status Speak Strukturit	-	Size 1550	9000	mm T	ne BEM	Hor	Connected in	2 narallel	1 series
B PERFORMANCE OF ONE UNIT 9 Fluid allocation Shell Side Tube Side 10 Fluid allocation Shell Side Tube Side 11 Fluid quantity, Total kg/s 342,2222 268,25 268,25 12 Vapor (IrrOut) kg/s 0 0 0 0 13 Liquid kg/s 0 0 0 0 0 14 Noncondensale kg/s 0 0 0 0 0 16 Temperature (In/Out) *C 20 80,67 135 51,12 19 Viscosity mPa / 17.3 /21,268 0,0157 0,0155 / 18 Density Wapor/Liquid kg/kg / 2,25 / 2,637 20,37 20 Molecular wit, NG / 0,2465 / 2,243 50,24669 21 Molecular wit, NG / 0,2465 6,21 0,0494 / 22						1101		•	
Image: Second			2000,0						
I T Full quantity. Total kg/s 342.2222 268.25 12 Vapor (In:Out) kg/s 0 0 268.25 268.25 12 Liquid kg/s 0 0 0 0 14 Noncondensable kg/s 0 0 0 0 15 Imparture (In:Out) *C 20 80.67 135 51.12 16 Temperature (In:Out) *C 20 80.67 135 51.12 16 Temperature (In:Out) *C 20 80.67 135 51.12 11 Dew / Bubble point *C 20.37 20.37 20.37 20 Molecular wit, Ng / 12.786 0.0157 0.0156 / 21 Specific hest kul/kg K / 2.85 / 2.284 / 23 Specific hest kul/kg K / 0.265 / 0.0501 0.0494 24 Latert hest kul/kg K / 0 0 0 0 25 Pressure (abc) bar 1 0.32511 1 0.05932 25 Pressure (abc) bar 1 0.32511 1 0.05	9	Fluid allocation						Tub	be Side
12 Vapor (In/Out) kg/s 0 0 268.25 268.25 13 Liquid kg/s 342.2222 342.2222 0 0 14 Noncondensable kg/s 0 0 0 0 15	10	Fluid name			Co	oling Med	lium Inlet 4	Inlet to	 24-HJ-101
12 Vapor (In/Out) kg/s 0 0 268,25 268,25 13 Liquid kg/s 342,2222 342,2222 0 0 14 Noncondensable kg/s 0 0 0 0 15	11	Fluid quantity, Total		kq/s					
13 Liquid kg/s 342,222 342,222 0 0 14 Noncondensable kg/s 0 0 0 0 15 Temperature (in/Out) *C 20 80,67 135 51,12 16 Temperature (in/Out) *C 20 80,67 135 51,12 16 Temperature (in/Out) *C 20 80,67 135 51,12 17 Dew/ Subole point *C 20,37 <th>12</th> <td>Vapor (In/Out)</td> <td></td> <td></td> <td>0</td> <td></td> <td>0</td> <td>268,25</td> <td>268,25</td>	12	Vapor (In/Out)			0		0	268,25	268,25
15 0 0 135 51.12 16 Temperature (In/Qut) 10 20 80.67 135 51.12 17 Dew /P Bubble point 10 120 80.67 135 51.12 18 Density Vapor/Liquid kg/m² / 1127 / 1109.12 30.19 38.11 0.0156 20.37 20.3	13				342,2	222	342,2222	0	0
16 Temperature (In/Out) *C 20 80.67 135 51.12 17 Dew / Bubble point *C *C 112 112 30.19 38.11 38.11 18 Density Vapor/Liquid kg/m² / 1127 / 1109.12 30.19 38.11 / 19 Viscosity mPa s / 17.13 / 12.7686 0.0157 0.0156 / 20.37 20.37 21 Molecular wt, NC 20.355 / 2.55 / 2.543 / 30.949 / 0.0494 / 40.414 Later theat kJ/kg / 0.22 0.0501 0.0494 / 40.414 1 0.05932 0.0593 0.0494 / 1 0.05932 2.55 / 2.543 / 30.24069 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.24069 50.3 50.3 50.24069 <th>14</th> <td>Noncondensable</td> <td></td> <td>kg/s</td> <td>0</td> <td></td> <td>0</td> <td>0</td> <td>0</td>	14	Noncondensable		kg/s	0		0	0	0
17 Dew / Bubble point *C /1127 / 1109,12 30,19 / 38,11 / 18 Density Vapor/Liquid kg/m² / 1127 / 1109,12 30,19 / 38,11 / 19 Viscosity mPa s / 17,13 / 12,7686 0,0157 / 0,0166 / 20 Molecular wt, NQ 20,37 20,37 20,37 20,37 21 Molecular wt, NC 22 20,55 / 2,543 / 0,0157 / 0,0166 / 23 Specific heat kJ/(kg K) / 2,655 / 2,738 2,55 / 2,543 / 23 Thermal conductivity W/(m K) / 0,2165 / 0,22 0,0501 / 0,0494 / 24 Latern heat kJ/kg 50.3 50.24069 50.3 50.24069 26 Velocity m/s 1,62 6,21 2 7 27 Pressure drop, allow./calc. bar 1 0,32511 1 0,05332 28 Fouling resist. (min) m/ KW 0 0 0 A based 30 Transfer rate, Service 531,7	15								
18 Density Vapor/Liquid kg/m² / 1127 / 1109,12 30,19 / 38,11 / 19 Viscosity mPa s / 17,13 / 12,7666 0,0157 / 0,0156 / 0,0157 / 0,0156 / 20 Molecular wt, NC 20,37 20,37 20,37 21 Molecular wt, NC 20,37 20,37 20,37 21 Thermal conductivity W/(m K) / 2,65 / 2,738 2,55 / 2,543 / 23 Thermal conductivity W/(m K) / 0,2165 / 0,220,37 20,371 0,0494 / 24 Latent heat kJ/(kg K) / 2,65 / 2,738 2,55 / 2,543 / 0,0494 / 24 Latent heat kJ/kg K) mm 1,62 6,21 0,7489 50,3 50,24069 20,24069 20,37 20,501 / 0,0492,3 20,4069 20,4069 20,4069 20,4069 20,4069 20,4069 20,4069 20,4069 20,4069 20,4069	16	Temperature (In/Out)		°C	20		80,67	135	51,12
19 Viscosity mPa s / 17,13 / 12,7886 0,0157 / 0,0156 / 20 Molecular wt, Vap 20,37 20,37 20,37 20,37 20,37 21 Molecular wt, NC 20,37 20,37 20,37 20,37 20,37 22 Specific heat k.J/(kg K) / 2,65 / 2,738 2,55 / 2,543 / 23 Thermal conductivity W/(m K) / 0,2166 / 0,22 0,0501 / 0,0444 / 24 Latent heat k.J/(kg K) / 0,2166 / 0,22 6,21 25 Pressure (abs) bar 10 9,67489 50,3 50,24069 26 Velocity m% 1,62 6,21 1 0,05932 28 Fouling resist. (min) m* KW 0 0 0 A based 29 Transfer rate. Service 531.7 Dirty 392.3 Clean 392.3 W/(m* K 31 Construction FO ME SHELL Sketch Sketch 3 Sketch 30 32 Conscionallowance mm 3.18 0 1<	17	Dew / Bubble poir	nt	ς					
20 Molecular wt, Vap 20,37 20,37 21 Molecular wt, NC 20,37 20,37 23 Specific heat kJ/(kg) / 2,55 23 Thermal conductivity W/(m K) / 2,65 / 2,543 23 Thermal conductivity W/(m K) / 0,2165 / 0,22 0,0501 0,0494 24 Latent heat kJ/kg 1 0,32511 1 0,05932 27 Pressure drop, allow./calc. bar 1 0,32511 1 0,05932 28 Fouling resist. (min) m* YW 0 0 0 Abased 30 Transfer rate, Service 531,7 Diriy 392,3 Clean 392,3 W/(m* K) 31 CONSTRUCTION OF ONE SHELL Sketch Sketch 3 Sketch 32 Design temperature *C 1800 180 1 1 36 Number passes par shell 1 1 1	18	Density	Vapor/Liquid	kg/m³	/	1127	/ 1109,12	30,19 /	38,11 /
21 Molecular wt, NC 22 Specific heat kJ/(kg K) / 2,65 / 2,738 2,55 / 2,543 / 23 Thermal conductivity W/(m K) / 0,2165 / 0,22 0,0501 0,0494 24 Latent heat kJ/kg 9 0 0,0494 0 0 0,0494 25 Pressure (abs) bar 10 9,67489 50,3 50,24069 26 Velocity m/% 1,62 6,21 6,21 2 27 Pressure drop, allow,/calc. bar 1 0,32511 1 0,05932 28 Fooling resist. (min) m² KW 0 0 0 A based 30 Transfer rate, Service 531,7 Dirty 392,3 Clean 392,3 W/(m² k 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch 33 Design temperature *C 180 1 1 1 36 Corrosion allowance mm 3,18 0 0 mm 10,15	19	Viscosity		mPa s	/	17,13	/ 12,7686	0,0157 /	0,0156 /
22 Specific heat kJ/(kg K) / 2,65 / 2,738 2,55 / 2,643 / 23 Thermal conductivity W/(m K) / 0,2165 / 0,221 0,0501 0,0494 / 24 Latent heat kJ/kg 1 9,67489 50.3 50,24069 26 Velocity m/s 1,62 6,21 1 0,05932 27 Pressure drop, allow/calc. bar 1 0,32511 1 0,05932 28 Fouling resist. (min) m² K/W 0 0 0 A based 30 Transfer rate, Service 531.7 Dirty 392.3 Clean 392.3 W/(m² K 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch 1 32 Design/vachest pressure:g bar 21/ 80/ 1 1 1 36 Corrosion allowance mm 3.18 0 - - - - -<	20	Molecular wt, Vap						20,37	20,37
23 Thermal conductivity W(m K) / 0,2165 / 0,22 0,0501 / 0,0494 / 24 Latent heat KJ/Kg -	21	Molecular wt, NC							
24 Latent heat kJ/kg 10 9,67489 50,3 50,24069 26 Velocity m/s 1,62 6,21 6,21 27 Pressure (abs) bar 1 0,32511 1 0,05932 26 Velocity m² KW 0 0 0 Abased 27 Pressure drop, allow./calc. bar 1 0,32511 1 0,05932 28 Fouling resist. (min) m² KW 0 0 Abased 30 Transfer rate, Service 531,7 Ditty 392,3 Clean 392,3 W/(m² K 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch 32 basign temperature °C 180 180 1 34 Design temperature °C 180 180 1	22	Specific heat		kJ/(kg K)	/	2,65	/ 2,738	2,55 /	2,543 /
25 Pressure (abs) bar 10 9,67489 50,3 50,24069 26 Velocity m/s 1 0,32511 1 0,05932 27 Pressure drop, allow./calc. bar 1 0,32511 1 0,05932 28 Fouling resist. (min) m² KW 0 0 0 Ao based 29 Heat exchanged 57144,2 KW MTD corrected 41,52 % 30 Transfer rate, Service 531.7 Dirty 392,3 Clean 392,3 W/(m² K 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch Sketch 32 Design temperature °C 180 180 1 1 36 Corrosion allowance mm 3,18 0 . . . 37 Connections In mm 1.400/ . 1.700/ . . 38 Size/rating Out 1.300/ <	23	Thermal conductivity		W/(m K)	/	0,2165	/ 0,22	0,0501 /	0,0494 /
26 Velocity m/s 1, 2 6, 21 27 Pressure drop, allow./calc. bar 1 0, 32511 1 0, 0.6932 28 Fouling resist. (min) m² KW 0 0 0 A based 29 Heat exchanged 57144,2 KW 0 0 0 A based 30 Transfer rate, Service 531,7 Dirty 392,3 Clean 392,3 W/(m² K 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch 30 32 Size/ating bar 21/ / 80/ / / 34 Design temperature °C 180 180 35 Number passes per shell 1 1 1 . <th>24</th> <td>Latent heat</td> <td></td> <td>kJ/kg</td> <td></td> <td></td> <td></td> <td></td> <td></td>	24	Latent heat		kJ/kg					
27 Pressure drop, allow./calc. bar 1 0,32511 1 0,05932 28 Fouling resist. (min) m² K/W 0	25	Pressure (abs)		bar	10		9,67489	50,3	50,24069
28 Fouling resist. (min) m² K/W 0 0 0 0 Ab based 29 Heat exchanged 57144,2 kW MTD corrected 41,52 * 30 Transfer rate, Service 531,7 Dirty 392,3 Clean 392,3 W/(m² k 31 CONSTRUCTION OF ONE SHELL Sketch Sketch Sketch 32 Design/vac/test pressure: bar 21/ / 80/ / 34 Design temperature *C 180 180 -		,		m/s		1,0	62	6	,21
29 Heat exchanged 57144,2 kW MTD corrected 41,52 41,53 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,52 41,55 41,55 41,55 41,55 41,55 41,55 <th>27</th> <td>Pressure drop, allow.</td> <td>/calc.</td> <td>bar</td> <td>1</td> <td></td> <td>0,32511</td> <td>1</td> <td>0,05932</td>	27	Pressure drop, allow.	/calc.	bar	1		0,32511	1	0,05932
30 Transfer rate, Service 531,7 Dirty 392,3 Clean 392,3 W/(m² k 31 CONSTRUCTION OF ONE SHELL Sketch 32 Shell Side Tube Side Sketch 33 Design/vac/test pressure:g bar 21/ / 80/ / 34 Design/vac/test pressure:g bar 21/ / 80/ / 34 Design/vac/test pressure:g bar 21/ / 80/ / 35 Number passes per shell 1 1 1 0 <t< th=""><th></th><td></td><td></td><td>m² K/W</td><td></td><td>0</td><td></td><td>0</td><td></td></t<>				m² K/W		0		0	
31 CONSTRUCTION OF ONE SHELL Sketch 32 Shell Side Tube Side	29		,	kW				corrected	,
32 Shell Side Tube Side 33 Design/vac/test pressure:g bar 21/ / 80/ / 34 Design temperature °C 180 180 1 1 35 Number passes per shell 1 0 1 700/ - 1 700/ - 1 700/ - 1 700/ - 1 700/ - 1 100 1 700/ - 1 700/ - 1 100 1 700/ - 1 100 1 700/ - 1 100 1 700/ - 1 100 1 100 1 100 1 100 1 100 10 10 100 10 100		Transfer rate, Servic		,	-		Clean 392,3		W/(m² K)
33 Design /vac/test pressure:g bar 21/ / 80/ / 34 Design temperature °C 180 180 180 35 Number passes per shell 1 1 1 1 36 Corrosion allowance mm 3,18 0	++		CONS				T I O I	SI	<u>ketch</u>
34 Design temperature °C 180 180 35 Number passes per shell 1 1 1 36 Corrosion allowance mm 3,18 0 37 Connections In mm 400/ - 1 700/ - 38 Size/rating Out 1 300/ - 1 700/ - 38 Naminal Intermediate / - / - 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Shell cover - 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel Tubesheet-floating - - 45 Floating head cover - Impingement protection None -		Designation		,	Ide	00			
3 Number passes per shell 1 1 36 Corrosion allowance mm 3,18 0 37 Connections In mm 1 700/ 38 Size/rating Out 1 300/ 1 700/ 39 Nominal Intermediate / / / 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel - Tubesheet-floating - - - - - - - - - - - -		• · ·				80			
36 Corrosion allowance mm 3,18 0 37 Connections In mm 1 400/ 1 700/ 38 Size/rating Out 1 300/ 1 700/ - 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - - 45 Floating head cover - - Impingement protection None 46 Baffle-crossing S3 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 49 Bypass seal Tube-tubesheet joint Exp.	$ \rightarrow $	0 1	-						
37 Connections In mm 1 400/ 1 700/ - 38 Size/rating Out 1 300/ - 1 700/ - 39 Nominal Intermediate / - / - - 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - - 45 Floating head cover - Inlighte-crossing S 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 46 Baffle-crossing S 316L								• • 🌔 🗍	
38 Size/rating Out 1 300/ - 1 700/ - 39 Nominal Intermediate / - // - 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - - 43 Channel or bonnet 22Cr,5Ni,3Mo steel - Tubesheet-floating - - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - </th <th></th> <td></td> <td></td> <td></td> <td></td> <td>1</td> <td>-</td> <td></td> <td></td>						1	-		
39 Nominal Intermediate / / / - 40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mr 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - - - - - 43 Channel or bonnet 22Cr,5Ni,3Mo steel - Channel cover -					-	1			
40 Tube No. 1865 OD 25,4 Tks-Avg 1,65 mm Length 9000 mm Pitch 31,75 mm 41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel Channel cover - - 45 Floating head cover - Impingement protection None - 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type - - - - 49 Bypass seal Tube-tubesheet joint Exp. - - - - - - 50 Expansion joint - Type						•	/ -		
41 Tube type Plain #/m Material 22Cr,5Ni,3Mo steel Tube pattern 30 42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - 45 Floating head cover - Impingement protection None - 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type None - </th <th></th> <td></td> <td></td> <td>/ Tks-Ava</td> <td>1.65</td> <td>mm</td> <td>length 9000</td> <td>mm Pito</td> <td>h 31,75 mm</td>				/ Tks-Ava	1.65	mm	length 9000	mm Pito	h 31,75 mm
42 Shell Carbon Steel ID 1550 OD 1586 mm Shell cover - 43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - 45 Floating head cover - Impingement protection None 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type None -			00 20,1	ů.					
43 Channel or bonnet 22Cr,5Ni,3Mo steel Channel cover - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - 44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - 45 Floating head cover - Impingement protection None 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type Vene			IC					-	
44 Tubesheet-stationary 22Cr,5Ni,3Mo steel - Tubesheet-floating - 45 Floating head cover - Impingement protection None 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type Tube-tubesheet joint Exp. 50 50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m si 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - - - - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks - - - - - 57								-	
45 Floating head cover Impingement protection None 46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type Type 10 H Spacing: c/c 1240 mr 49 Bypass seal Tube-tubesheet joint Exp. 50 Expansion joint - Type None 50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m si 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 53 Floating head - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 56 57 57 57 <td< th=""><th></th><td></td><td></td><td></td><td></td><td></td><td></td><td>-</td><td></td></td<>								-	
46 Baffle-crossing SS 316L Type Single segmental Cut(%d) 10 H Spacing: c/c 1240 mr 47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type 49 Bypass seal Tube-tubesheet joint Exp. 50 50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m si 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 57 57	45							tion None	
47 Baffle-long - Seal type Inlet 1248,47 mr 48 Supports-tube U-bend Type Type 1248,47 mr 49 Bypass seal Tube-tubesheet joint Exp. 50 Expansion joint - Type None 50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m si 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 57 57 57			316L	Type Single	segmental	С			1240 mm
49 Bypass seal Tube-tubesheet joint Exp. 50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m sit 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - - - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks - - - - - - 57 -	47	Baffle-long -		Se	eal type		·	Inlet	1248,47 mm
50 Expansion joint - Type None 51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m site) 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - - - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 - - - - -	48	Supports-tube		U-bend			Туре		
51 RhoV2-Inlet nozzle 1889 Bundle entrance 390 Bundle exit 407 kg/(m site 52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 - - - - -	49	Bypass seal			Tube-tu	besheet j	oint Exp.		
52 Gaskets - Shell side - Tube Side Flat Metal Jacket Fibe 53 Floating head - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 - - - - -	50	Expansion joint	-		Туре	None			
53 Floating head - 54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57 - - - -	51	RhoV2-Inlet nozzle	1889	Bundl	e entrance	390		Bundle exit 407	kg/(m s²)
54 Code requirements EN13445 TEMA class R - refinery service 55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57	52	Gaskets - Shell side	-		Tube Si	de	Fla	t Metal Jacket Fibe	÷
55 Weight/Shell 46586,1 Filled with water 68074,3 Bundle 22341,7 k 56 Remarks 57	53	Floating h	ead -						
56 Remarks 57	54	Code requirements	EN1344	5			TE	MA class R - re	efinery service
57		v	46586,1	Filled	with water	68074,3	Bu	ndle 2234	1,7 kg
		Remarks							
58									
	58								

Setting Plan



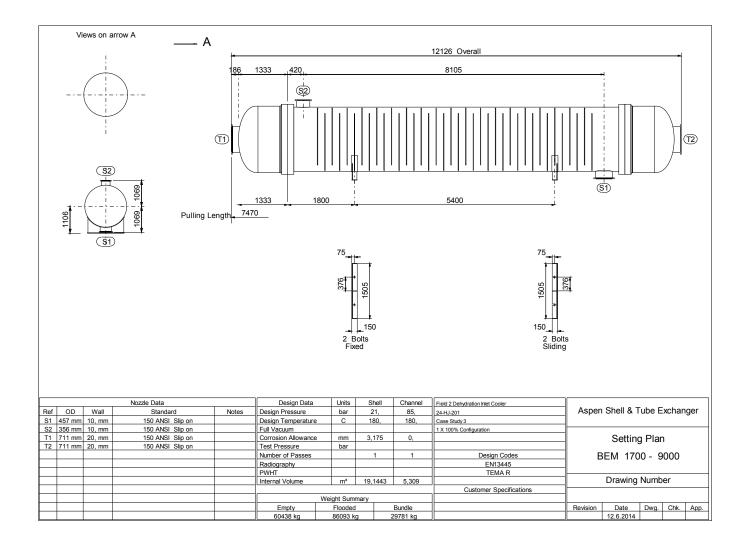
Tube Layout



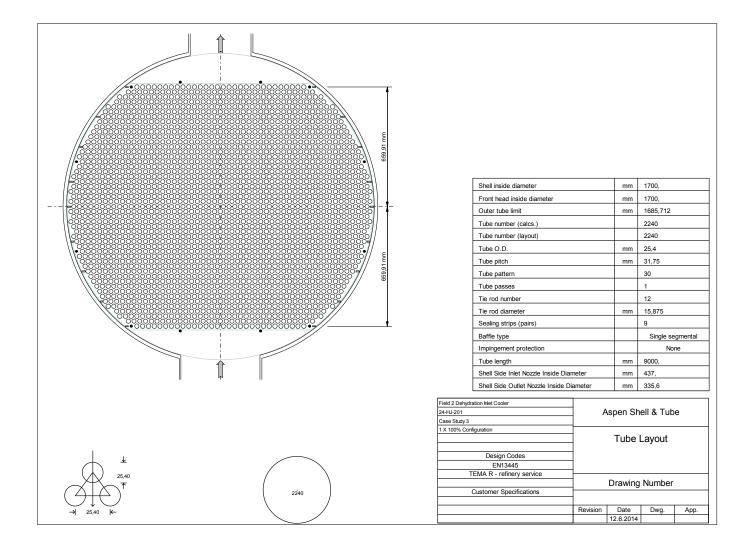
Heat Exchanger Specification Sheet

1	Field 2 Dehydration	Inlet Cooler						
2	24-HJ-201							
3	Case Study 3							
4	1 X 100% Configura	tion						
5								
6	Size 1700	9000	mm Ty	ype BEM	Hor	Connected in	2 parallel	1 series
7	Surf/unit(eff.)	3096,2	m ² Shells	/unit 2		Surf	/shell (eff.)	1548,1 m²
8			PERF	ORMANCE	E OF ON	E UNIT		
9	Fluid allocation				Shell	Side	Tu	be Side
10	Fluid name			Co	oling Mec	lium Inlet 8	Inlet to	24-HJ-201
11	Fluid quantity, Total		kg/s		418,3		30	3,8889
12	Vapor (In/Out)		kg/s	0		0	303,8889	303,8889
13	Liquid		kg/s	418,3	333	418,3333	0	0
14	Noncondensable		kg/s	0		0	0	0
15			•					
16	Temperature (In/Out)	°C	20)	80	142	52,85
17	Dew / Bubble poir		0°					- ,
18	Density	Vapor/Liquid	kg/m³	/	1127	/ 1072	32,51 /	41,55 /
19	Viscosity		mPa s	. /	17,13	/ 3,715	0,016 /	0,0159 /
20	Molecular wt, Vap			, 	,	, 0,,, 10	20,33	20,33
21	Molecular wt, Vap						20,00	20,00
22	Specific heat		kJ/(kg K)	/	2,65	/ 2,95	2,58 /	2,574 /
-	Thermal conductivity	,	W/(m K)	/	0,2165	/ 0,2274	0,0515 /	0,0507 /
24	Latent heat		kJ/kg	/	0,2100	7 0,2214	0,00107	0,0007 /
25	Pressure (abs)		bar	10	1	9,07171	55,2	55,14039
26	Velocity		m/s		3,3			5,44
	Pressure drop, allow	/calc	bar	1		0,92829	1	0.05961
	Fouling resist. (min)		m² K/W	1	0	0,02020	0	0 Ao based
	Heat exchanged	69726,1	kW		0	MTD	corrected	45,83 °C
30	Transfer rate, Servic		Dirty	465,2		Clean 465,2		W/(m ² K)
31							s	ketch
32			Shell S			Tube Side		
_			0	,				
33	Design/vac/test pres	sure:a bar	21/ /		85	/ /		
	Design/vac/test pres Design temperature		21/ /		85,	,	ø	
34	Design temperature	°C	180		85,	180		
34 35	Design temperature Number passes per	°C shell	180 1		85,	180 1	₀┫	
34 35 36	Design temperature Number passes per Corrosion allowance	°C shell mm	180 1 3,18			180 1 0		₩₩₩₩₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽
34 35 36 37	Design temperature Number passes per Corrosion allowance Connections	°C shell In mm	180 1 3,18 1 450/	- -	85, 1 1	180 1 0 700/ -		ŢŢŢŢŢŢŢŢŢŢŢŢŢŢŢŢ
34 35 36 37 38	Design temperature Number passes per Corrosion allowance Connections Size/rating	°C shell In mm Out	180 1 3,18			180 1 0	•(ŢŢŢŢŢŢŢŢŢŢŢŢŢ
34 35 36 37 38 39	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal	°C shell In mm Out Intermediate	180 1 3,18 1 450/ 1 350/ /	- - -	1	180 1 0 700/ - 700/ - /	et mm Pit	ch 31.75 mm
34 35 36 37 38 39 40	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240	°C shell In mm Out	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg	- - - 1,65	1 1 1 mm	180 1 0 700/ - 700/ - / - Length 9000		<u>ch 31,75 mm</u> 30
34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain	°C shell In mm Out Intermediate OD 25,4	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M	- - 1,65 aterial 22	1 1 mm Cr,5Ni,31	180 1 0 700/ - 700/ - / - Length 9000 Mo steel	• [] mm Pite Tube pattern	ch 31,75 mm 30
34 35 36 37 38 39 40 41 42	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel	°C shell In mm Out Intermediate OD 25,4	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M D 1700 OD	- - - 1,65	1 1 mm Cr,5Ni,31	180 1 0 700/ - 700/ - / - Length 9000 Mo steel Shell cover		
34 35 36 37 38 39 40 41	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M 0 1700 OD steel	- - 1,65 aterial 22	1 1 mm Cr,5Ni,31	180 1 0 700/ - 700/ - / - Length 9000 Mo steel Shell cover Channel cover		
34 35 36 37 38 39 40 41 42 43 44	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s	180 180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M 0 1700 OD steel	- - 1,65 aterial 22	1 1 mm Cr,5Ni,31	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating	Tube pattern - - -	
34 35 36 37 38 39 40 41 42 43 44 45	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s -	180 180 1 3,18 1 450/ 1 350/ / Tks-Avg #/m M 0 1700 OD steel steel -	- - 1,65 aterial 22	1 1 Cr,5Ni,37 mm	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern - - - tion None	30
34 35 36 37 38 39 40 41 42 43 44 45 46	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s -	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M 0 1700 OD steel steel - Type Singles	- - 1,65 aterial 22 1738 segmental	1 1 Cr,5Ni,37 mm	180 1 0 700/ - 700/ - / - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect	Tube pattern - - tion None H Spacing: c/c	30 200 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long -	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s -	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M. 0 1700 OD steel steel - Type Single s Se	- - 1,65 aterial 22	1 1 Cr,5Ni,37 mm	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10	Tube pattern - - - tion None	30
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s -	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M 0 1700 OD steel steel - Type Singles	- 1,65 aterial 22 1738 segmental eal type	1 1 Cr,5Ni,3I mm	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - tion None H Spacing: c/c	30 200 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s (22Cr,5Ni,3Mo s -	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M. 0 1700 OD steel steel - Type Single s Se	- 1,65 aterial 22 1738 segmental eal type Tube-tu	1 1 Cr,5Ni,3I mm Cr	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - tion None H Spacing: c/c	30 200 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L	180 180 1 3,18 1 450/ 1 350/ 1 350/ 1 350/ Tks-Avg #/m M 0 1700 OD steel steel - Type Single s Se U-bend	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3f mm Cc	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type	Tube pattern - - stion None H Spacing: c/c Inlet	30 200 mm 630,48 mm
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle	°C shell In mm Out Intermediate OD 25,4 II 22Cr,5Ni,3Mo s 7 22Cr,5Ni,3Mo s 7 316L - 1726	180 180 1 3,18 1 450/ 1 350/ 1 350/ 1 350/ Tks-Avg #/m M 0 1700 OD steel steel - Type Single s Se U-bend	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cr,5Ni,3I mm CC	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp.	Tube pattern - - stion None H Spacing: c/c Inlet Bundle exit 1864	30 200 mm 630,48 mm kg/(m s²)
34 35 36 37 38 39 40 41 41 42 43 44 45 46 47 48 49 50 51 52	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 -	180 180 1 3,18 1 450/ 1 350/ 1 350/ 1 350/ Tks-Avg #/m M 0 1700 OD steel steel - Type Single s Se U-bend	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type	1 1 Cr,5Ni,3I mm Cr,5Ni,3I mm CC	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp.	Tube pattern - - stion None H Spacing: c/c Inlet	30 200 mm 630,48 mm kg/(m s²)
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 - ead -	180 1 3,18 1 450/ 1 350/ 1 350/ / Tks-Avg #/m M. D 1700 OD steel steel - Type Single s Se U-bend Bundl	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cr,5Ni,3I mm CC	180 1 0 700/ - 700/ - / - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	Tube pattern - - - - -	30 200 mm 630,48 mm kg/(m s²) e
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 - ead - EN1344	180 180 1 3,18 1 450/ 1 350/ 1 3	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance Tube S	1 1 Cr,5Ni,3I mm Cr besheet j None 1787 ide	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	Tube pattern - - 	30 200 mm 630,48 mm kg/(m s²) e refinery service
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 - ead -	180 180 1 3,18 1 450/ 1 350/ 1 3	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance	1 1 Cr,5Ni,3I mm Cr besheet j None 1787 ide	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	Tube pattern - - - - -	30 200 mm 630,48 mm kg/(m s²) e refinery service
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 - ead - EN1344	180 180 1 3,18 1 450/ 1 350/ 1 3	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance Tube S	1 1 Cr,5Ni,3I mm Cr besheet j None 1787 ide	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	Tube pattern - - 	30 200 mm 630,48 mm kg/(m s²) e refinery service
$\begin{array}{c} 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 55\\ 55\\ \end{array}$	Design temperature Number passes per Corrosion allowance Connections Size/rating Nominal Tube No. 2240 Tube type Plain Shell Carbon Steel Channel or bonnet Tubesheet-stationary Floating head cover Baffle-crossing SS Baffle-long - Supports-tube Bypass seal Expansion joint RhoV2-Inlet nozzle Gaskets - Shell side Floating h Code requirements Weight/Shell	°C shell mm In mm Out Intermediate OD 25,4 IE 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s / 22Cr,5Ni,3Mo s - 316L - 1726 - ead - EN1344	180 180 1 3,18 1 450/ 1 350/ 1 3	- 1,65 aterial 22 1738 segmental eal type Tube-tu Type le entrance Tube S	1 1 Cr,5Ni,3I mm Cr besheet j None 1787 ide	180 1 0 700/ - 700/ - Length 9000 Mo steel Shell cover Channel cover Tubesheet-floating Impingement protect ut(%d) 10 Type oint Exp. Fla	Tube pattern - - 	30 200 mm 630,48 mm kg/(m s²) e refinery service

Setting Plan



Tube Layout



8.0 Discussion and Conclusions

8.1 Discussion on optimum design of heat exchangers

Optimum design of heat exchangers followed by their efficient operation is critical for the proper functioning of the entire process system. The process fluid be it either liquid or gas phase, after being heated or cooled in the heat exchangers is sent downstream to equipment units like compressors, separators or scrubbers. The outlet temperature of the process stream has a direct impact on the operation and functioning of the subsequent equipment unit. If the downstream equipment is a compressor unit and the temperature of the inlet feed gas is too high, higher energy would be required to compress the gas giving us a lower compressor efficiency value. If the downstream equipment is a 3-phase separator and the inlet stream is not heated to the right temperature, the required split between oil dominated phase, water dominated phase the gas phase will not happen. Similarly, if the inlet stream to a scrubber unit is not cooled down to the required temperature, a lesser quantity of liquid phase would be condensing out in scrubber unit. This implies that the gas phase would have a higher content of heavier hydrocarbons than specified which might result in off-spec product at the outlet of the process train.

The different scenarios explained above emphasize the fact that, for the proper operation of any oil and gas processing unit in the offshore industry, optimum design of all major equipment units especially heat exchangers is a critical factor. While optimizing the thermal design of individual heat exchanger units and also of multiple units in a heat exchanger network, L/D ratio, weight and footprint factor, effective surface area per shell and the number of shells per unit are all critical factors which need to be taken into account. Plate heat exchangers are generally the preferred choice provided the operating pressure and temperature permit the design of this type of exchanger. These exchangers provide huge savings in weight and footprint but are more expensive compared to the conventional shell and tube exchangers.

Shell and tube exchangers are comparatively cheaper than compact heat exchangers and can handle most process fluids. However the process parameters and the required heating or cooling duty can result in extreme dimensions mainly because of the low LMTD and high viscosity makes it difficult to obtain turbulent flow. In the eventuality that the designed shell and tube heat exchanger has very large dimensional features alongwith extremely high heat duty requirement and the operating parameters are beyond the range of plate exchangers, printed circuit heat exchangers would have to be preferred choice. As seen in the 3rd case study, the extreme dimensions would result in loss of available footprint which is very critical on an oil and gas platform. The PCHE's are comparatively more expensive than shell and tube exchangers but the savings due to reduced weight cost and footprint cost would compensate for the additional expense. Also changing the process parameters of the heating or cooling medium alters the heat duty requirement of the exchanger which can result in the modified exchanger having a more optimum design than the base case scenario.

8.2 Conclusions

The work done as part of this thesis involves doing the thermal design calculations of the heat exchangers based on the process parameters from the base case process design and also the thermal design calculations of the relevant heat exchangers with the modified process parameters from the case studies. The main conclusions to this thesis work regarding the optimum design of heat exchangers are as follows:

- 1. For optimum design of a shell and tube heat exchanger unit, the ratio of tube length to shell inner diameter (L/D ratio) should be in the range of 5 to 10.
- 2. If the process conditions include high design pressure, high design temperature and phase change, shell and tube exchangers is the preferred choice for such operating conditions.
- 3. When operating pressure and temperature permit, then plate frame exchangers must be the preferred choice considering the savings on weight and footprint.
- 4. When the water cut in the reservoir stream is high, like the Field 1 and Field 2 wellstream composition used as part of this thesis work, avoiding excessive surface temperature on the tube side needs to be focused on, in order to reduce the risk of scaling.
- 5. Vibration on the tube side needs to be avoided. If higher pressure drop than the allowable limit is required in order to prevent vibration then the additional pressure drop should be accepted into the process design.
- 6. As seen in Case Study I, simplifying the process design by removing an exchanger unit (20-HB-004), results in scaling up the exchanger design of 20-HA-003 and 21-HB001 in order to compensate for the additional heating and cooling duty. Since the weight saving and footprint saving is quite considerable, this options can be further analyzed in detail to be implemented into the process design.
- 7. As seen in Case Study II, increasing or decreasing the outlet temperature of the gas stream has little effect on improving the dimensions of the exchanger. Therefore for optimizing the design of the exchanger, reduction in the heating medium inlet temperature is required.
- 8. As seen in Case Study III, when the design of the shell and tube exchanger results in extreme dimensions causing very high weight and footprint factors, it is preferable to switch to printed circuit heat exchanger as the choice for that application.

9.0 References

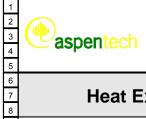
Devold, H. (2006). "Oil and gas production handbook." ABB ATPA Oil and Gas.

Jaubert, J.-N. and R. Privat (2010). "Relationship between the binary interaction parameters (< i> k </i> < sub> ij </sub>) of the Peng–Robinson and those of the Soave–Redlich–Kwong equations of state: Application to the definition of the PR2SRK model." <u>Fluid Phase Equilibria</u> **295**(1): 26-37.

Ludwig, E. E. (1997). <u>Applied Process Design for Chemical and Petrochemical Plants: Volume</u> <u>3</u>, Gulf Professional Publishing.

TEP 4185 (2012). Compendium of the Natural Gas Technology course (TEP 4185) at Norwegian University of Science and Technology. Gas Processing – Section 6.

Appendix A – Process Datasheets for Heat Exchangers in Base Case Simulation



Case Name: BASE CASE SIMULATION

Unit Set: SI

Date/Time:

Heat Exchanger: 20-HA-001

9 10				COND	TIONS				
11	Name			Field 2 Inlet	Heating	Medium Inlet 1	Field 2	to Inlet Separator	Heating Medium Outlet 1
12	Vapour			0.1643		0.0000		0.1655	0.0000
13	Temperature	(C)		44.9640		150.0000		55.0000	100.0000
14	Pressure	(kPa)		1600.0000		1100.0000	1500.0000		1000.0000
15	Molar Flow (kc	gmole/h)	3	66548.4143	24434.6310			366548.4143	24434.6310
16	Mass Flow	(kg/h)	72	51237.8039		1893301.6974	7251237.8039		1893301.6974
17	Std Ideal Lig Vol Flow	(m3/h)		9657.7878		1705.8369		9657.7878	1705.8369
18	Molar Enthalpy (kJ/	kgmole)	-	2.528e+005		-4.912e+005		-2.520e+005	-5.035e+005
19		mole-C)		79.11		172.4		81.73	141.7
20	Heat Flow	(kJ/h)	-	9.2679e+10		-1.2003e+10		-9.2380e+10	-1.2302e+10
21 22				PROPE	RTIES				
23	Name	Field	2 Inlet	Heating Medi	um Inlet 1	Field 2 to Inlet Se	parator	leating Medium Out	et 1
24	Molecular Weight		19.78		77.48		9.78	77.4	
25	Molar Density (kgmole/m3)		3.575		12.94	3	3.227	13.6	0
26	Mass Density (kg/m3)		70.72		1003	6	3.84	105	4
27	Act. Volume Flow (m3/h)	1	.025e+005		1888	1.136e-		179	
28	Mass Enthalpy (kJ/kg)		.278e+004		-6340	-1.274e	+004	-649	8
29	Mass Entropy (kJ/kg-C)		3.999		2.224	4	.131	1.82	8
30	Heat Capacity (kJ/kgmole-C)		76.57		255.2	7	6.69	234.	3
31	Mass Heat Capacity (kJ/kg-C)		3.871		3.294	3	3.877	3.02	4
32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006			1.462e+00	6
33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006			1.614e+00	6
34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+00	4
35	CO2 Loading								
36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.000	0
37	CO2 Apparent Wt. Conc. (kgmol/kg)				0.0000			0.000	0
38	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004			1.887e+00	4
39	Phase Fraction [Vol. Basis]		0.3599		0.0000	0.3	3625	0.000	0
40	Phase Fraction [Mass Basis]		0.1640		0.0000	0.1	1664	0.000	0
41	Phase Fraction [Act. Vol. Basis]		0.9392		0.0000	0.9	9449	0.000	0
42	Mass Exergy (kJ/kg)		60.70		65.58	6	62.49	25.7	5
43	Partial Pressure of CO2 (kPa)		25.59		0.0000	2	3.94	0.000	0
44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.0	0000	0.000	0
45	Act. Gas Flow (ACT_m3/h)	g	.630e+004			1.073e-	+005		
46	Avg. Liq. Density (kgmole/m3)		37.95		14.32	3	37.95	14.3	2
47	Specific Heat (kJ/kgmole-C)		76.57		255.2	7	6.69	234.	3
48	Std. Gas Flow (STD_m3/h)	8	8.667e+006	5.77	7e+005	8.667e-	+006	5.777e+00	5
49	Std. Ideal Liq. Mass Density (kg/m3)		750.8		1110	7	50.8	111	0
50	Act. Liq. Flow (m3/s)		1.731		0.5245	1	.739	0.499	2
51	Z Factor			2.41	16e-002			2.371e-00	2
52	Watson K		15.46		8.816	1	5.46	8.81	6
53	User Property								-
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	0000	0.000	0
55	Cp/(Cp - R)		1.122		1.034	1	.122	1.03	7
56	Cp/Cv		1.023		1.064	1	.022	1.06	2
57	Heat of Vap. (kJ/kgmole)	6	6.094e+004	7.24	4e+004	6.105e-	+004	7.313e+00	4
58	Kinematic Viscosity (cSt)				1.147			2.31	5
59	Liq. Mass Density (Std. Cond) (kg/m3)		822.7		1130	8	322.7	113	
60	Liq. Vol. Flow (Std. Cond) (m3/h)		8814		1676		8814	167	
61	Liquid Fraction		0.8357		1.000		8345	1.00	
62	Molar Volume (m3/kgmole)		0.2797	7.72	28e-002		3099	7.355e-00	
63	Mass Heat of Vap. (kJ/kg)		3080		934.9		3086	943.	
64	Phase Fraction [Molar Basis]		0.1643		0.0000	0.1	1655	0.000	
65	Surface Tension (dyne/cm)				35.73			40.7	
66	Thermal Conductivity (W/m-K)				0.2310			0.229	
67	Viscosity (cP)				1.150			2.43	
68	Cv (Semi-Ideal) (kJ/kgmole-C)		68.25		246.9		8.38	226.	
69	Aspen Technology Inc.		Aspen H	IYSYS Versi	ion 8.3 (2	29.0.0.8315)			Page 1 of 2



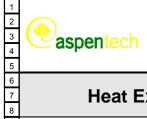
Case Name: BASE CASE SIMULATION

SI

Unit Set:

Date/Time:

5							
6 7 8	Heat Exchange	er: 20-HA-	001 (co	ontinu	ied)		
9 10			PROPE	RTIES			
11	Name	Field 2 Inlet	Heating Mediu	ım Inlet 1 F	ield 2 to Inlet Separator	eating Medium Outlet 1	
12	Mass Cv (Semi-Ideal) (kJ/kg-C)	3.450	riouting mount	3.187	3.456	2.916	
13	Cv (kJ/kgmole-C)	74.88		240.0	75.03	220.5	
14	Mass Cv (kJ/kg-C)	3.785		3.097	3.793	2.846	
15	Cv (Ent. Method) (kJ/kgmole-C)			205.9		195.1	
16	Mass Cv (Ent. Method) (kJ/kg-C)			2.657		2.517	
17	Cp/Cv (Ent. Method)			1.240		1.201	
8	Reid VP at 37.8 C (kPa)		9.84	17e-004		9.847e-004	
9	True VP at 37.8 C (kPa)			3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.425e+006		1676	1.436e+006	1676	
21	Viscosity Index	-10.86		5.070	-14.22	12.83	
22 23			DET	AILS			
24		Ove	rall/Detaile	d Perfor	mance		
25 26	Duty:		90e+08 kJ/h	UA Curv.			0.00e-01 kJ/C-h
27	Heat Leak:	0.0)00e-01 kJ/h	Hot Pinch			100.0 C
28	Heat Loss:	0.0	000e-01 kJ/h	Cold Pine	ch Temp:		44.96 C
29	UA:	4.151	e+06 kJ/C-h	Ft Factor			
30	Min. Approach:		55.04 C	Uncorrec	ted Lmtd:		73.21 C
31	Lmtd:		72.03 C				
32 33							
34							
34 35 36 37							
20							
30							
39							
38 39 40 41 42 43 44							
41							
42							
43							
44							
15							
16							
17							
18							
19							
50							
51							
52							
53							
53 54 55							
55							
6							
57							
58							
59							
60 61							
62							
63							
64							
65							
66							
67							
68					0.0.0.0045		



Case Name: BASE CASE SIMULATION

Unit Set: SI

Date/Time:

Heat Exchanger: 20-HA-002

9 10				COND	ITIONS				
11	Name			Field 1 Inlet	Heating	Medium Inlet 2	Field	1 to Inlet Seprator	Heating Medium Outlet 2
12	Vapour			0.1293		0.0000		0.1313	0.0000
13	Temperature	(C)		27.9805		150.0000		55.0000	100.0000
14	Pressure	(kPa)		1600.0000		1100.0000	1500.0000		1000.0000
15	Molar Flow (kc	mole/h)	3	33234.4142		59012.1474		333234.4142	59012.1474
16	Mass Flow	(kg/h)	65	57731.8745		4572518.3652		6557731.8745	4572518.3652
17	Std Ideal Lig Vol Flow	(m3/h)		8307.8856		4119.7715		8307.8856	4119.7715
18	Molar Enthalpy (kJ/	kgmole)	-	2.611e+005		-4.912e+005		-2.589e+005	-5.035e+005
19		mole-C)		71.06		172.4		78.03	141.7
20	Heat Flow	(kJ/h)	-	8.6999e+10		-2.8989e+10		-8.6277e+10	-2.9712e+10
21 22				PROPE	ERTIES				
23	Name	Field	1 Inlet	Heating Medi	um Inlet 2	Field 1 to Inlet Se	prator H	eating Medium Out	et 2
24	Molecular Weight		19.68		77.48	1	9.68	77.4	8
25	Molar Density (kgmole/m3)		4.717		12.94	3	.999	13.6	0
26	Mass Density (kg/m3)		92.83		1003		8.69	105	4
27	Act. Volume Flow (m3/h)		.064e+004		4561	8.333e+		434	
28	Mass Enthalpy (kJ/kg)	-1	.327e+004		-6340	-1.316e+		-649	
29	Mass Entropy (kJ/kg-C)		3.611		2.224		.965	1.82	
30	Heat Capacity (kJ/kgmole-C)		77.61		255.2		7.88	234.	
31	Mass Heat Capacity (kJ/kg-C)		3.944		3.294	3	.957	3.02	
32	LHV Molar Basis (Std) (kJ/kgmole)				2e+006			1.462e+00	
33	HHV Molar Basis (Std) (kJ/kgmole)				4e+006			1.614e+00	
34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+00	4
35	CO2 Loading								
36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.000	
37	CO2 Apparent Wt. Conc. (kgmol/kg)			4.00	0.0000			0.000	
38 39	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004	0.0		1.887e+00	
40	Phase Fraction [Vol. Basis] Phase Fraction [Mass Basis]		0.2980		0.0000		3024 1311	0.000	
41	Phase Fraction [Act. Vol. Basis]		0.9179		0.0000		9293	0.000	
42	Mass Exergy (kJ/kg)		46.84		65.58		1.44	25.7	
43	Partial Pressure of CO2 (kPa)		23.64		0.0000		2.24	0.000	
44	Cost Based on Flow (Cost/s)		0.0000		0.0000		0000	0.000	
45	Act. Gas Flow (ACT_m3/h)	6	.484e+004			7.744e+	+004		
46	Avg. Liq. Density (kgmole/m3)		40.11		14.32	4	0.11	14.3	2
47	Specific Heat (kJ/kgmole-C)		77.61		255.2	7	7.88	234.	3
48	Std. Gas Flow (STD_m3/h)	7	.879e+006	1.39	5e+006	7.879e+	+006	1.395e+00	6
49	Std. Ideal Liq. Mass Density (kg/m3)		789.3		1110	7	89.3	111	0
50	Act. Liq. Flow (m3/s)		1.611		1.267	1	.636	1.20	6
51	Z Factor			2.4	16e-002			2.371e-00	2
52	Watson K		15.11		8.816	1	5.11	8.81	6
53	User Property								
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	0000	0.000	0
55	Cp/(Cp - R)		1.120		1.034	1	.120	1.03	7
56	Cp/Cv		1.018		1.064	1	.017	1.06	2
57	Heat of Vap. (kJ/kgmole)	6	.222e+004	7.24	4e+004	6.233e+	+004	7.313e+00	4
58	Kinematic Viscosity (cSt)				1.147			2.31	
59	Liq. Mass Density (Std. Cond) (kg/m3)		857.7		1130		57.7	113	
60	Liq. Vol. Flow (Std. Cond) (m3/h)		7645		4047		7645	404	
61	Liquid Fraction		0.8707		1.000		3687	1.00	
62	Molar Volume (m3/kgmole)		0.2120	7.72	28e-002		2501	7.355e-00	
63	Mass Heat of Vap. (kJ/kg)		3162		934.9		3167	943.	
64	Phase Fraction [Molar Basis]		0.1293		0.0000	0.1	1313	0.000	
65	Surface Tension (dyne/cm)				35.73			40.7	
66	Thermal Conductivity (W/m-K)				0.2310			0.229	
67	Viscosity (cP)				1.150			2.43	
68 60	Cv (Semi-Ideal) (kJ/kgmole-C)		69.30		246.9		9.56	226.	
69	Aspen Technology Inc.		Aspen F	11515 Vers	1011 0.3 (2	29.0.0.8315)			Page 1 of 2



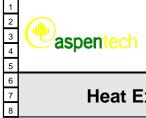
Case Name: BASE CASE SIMULATION

SI

Unit Set:

Date/Time:

5			Date/Th	ile.			
6 7	Heat Exchange	er: 20-HA-	002 (cc	ontinue	ed)		
8 9			PROPE		•		
10							
11	Name	Field 1 Inlet	Heating Mediu			Heating Medium Outlet 2	
12	Mass Cv (Semi-Ideal) (kJ/kg-C)	3.521		3.187	3.535	2.916	
13	Cv (kJ/kgmole-C)	76.25		240.0	76.55	220.5	
14 15	Mass Cv (kJ/kg-C)	3.875		3.097	3.890	2.846	
15 16	Cv (Ent. Method)(kJ/kgmole-C)Mass Cv (Ent. Method)(kJ/kg-C)			205.9 2.657		195.1 2.517	
17	Cp/Cv (Ent. Method)			1.240		1.201	
18	Reid VP at 37.8 C (kPa)		9.84	7e-004		9.847e-004	
19	True VP at 37.8 C (kPa)			3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.022e+006		4047	1.037e+006	4047	
21	Viscosity Index	-3.676		5.070	-11.75	12.83	
22			DET				
23			DEI				
24 25		Ove	rall/Detaile	d Perform	ance		
5 6	Duty:	7.2	22e+08 kJ/h	UA Curv. E	rror		0.00e-01 kJ/C-h
7	Heat Leak:		00e-01 kJ/h	Hot Pinch			100.0 C
28	Heat Loss:		00e-01 kJ/h	Cold Pinch	· · · · · · · · · · · · · · · · · · ·		27.98 C
29	UA:		e+06 kJ/C-h	Ft Factor:			
30	Min. Approach:		72.02 C	Uncorrecte	d Lmtd:		82.98 C
31	Lmtd:		80.18 C				
32							
33							
84 85							
35							
6 7							
7							
8 9							
9							
10							
+1 12							
40 41 42 43 44							
+J 14							
15							
16 17							
8							
19							
50							
18 19 50 51							
53							
54							
55							
o6							
0/ 0							
,0 59							
30							
53 54 55 56 57 58 59 50 60 61							
62							
63							
63 64 65							
66							
67							
58 59	Aspen Technology Inc		IVSVS Varei				Page 2 of 2



Case Name: BASE CASE SIMULATION MODEL.HSC

SI

Unit Set:

Date/Time: Wed Jun 04 19:32:50 2014

Heat Exchanger: 20-HA-003

Instra Instra Instra 1 Hand Heart Bedorm Orders 2 2 Vapour 0.010 0.0000 0.0227 0.0000 10 Pressee (Pr) 980.0000 1150.0000 77.6224 100.0000 10 Mars Frow (Pr) 980.0270 3335.2211 B80.0279 3335.2211 B80.0279 3335.2211 B80.0279 222.8393 101.4940.0545 222.82433 101.4940.0545 222.82433 101.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 222.8247.476 11.4940.0545 22.8247.476 11.4940.0545 22.8247.476 11.4940.0545 22.8247.476 11.4940.054 24.7247.475 11.4940.0545 22.8247.476 11.4940.054 24.7247.475 11.4940.0541 13.4178.400 14.872.4478 11.4940.0541 14.841 14.841 14.841 14.841 14.841 14.841 14.841 14.841 14.841 <th>9 10</th> <th></th> <th></th> <th></th> <th>COND</th> <th>ITIONS</th> <th></th> <th></th> <th></th> <th></th>	9 10				COND	ITIONS				
Tomesence (C) 8.3.000* 150.000* 77.8224 00.0000* 18 Pressue (PP) B00.000* 110.000* 77.8224 100.000* 18 Mass Finer (Pp) 890.0370 3335.2211 890.0379 3335.2211 890.0379 3335.2211 890.0379 2328.430 1197.9402 222.8393 1197.9402 222.8393 1197.9402 222.8393 1197.9402 222.8393 1197.9402 222.8393 1197.9402 23.937.405 4.3379.4405 4.3379.4405 4.3379.4405 4.3379.4405 4.3379.4405 4.3479.4416 1.4379.4405 4.3479.4416 1.4379.4405 4.3479.4416 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4405 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416 1.4379.4416		Name	let	o Stabiliz	ation Heater	Heating	Medium Inlet 3		21	Heating Medium Outlet 3
Image (Particle Content of Conte	12	Vapour			0.0163	Ŭ	0.0000		0.0227	0.0000
Instruction Open (stype) 3880.8370 3385.2211 8080.8370 3385.2211 Id Mass Flow (https://www.com/style) 1194940.0446 2282.4333 11184940.046 2282.4333 Id Mair Entralpy (k.J.Rgmole) -3.8458-r005 -4.9128-r005 -3.7978-r005 -4.9128-r005 Id Mair Entralpy (k.J.Rgmole) -3.4568-r00 -1.6388-r00 -3.4101-r00 -1.67722e-r09 Id Mair Entralpy (k.J.Rgmole) -3.4568-r00 -3.4101-r00 -1.67722e-r09 Id Mair Entralpy (k.J.Rgmole) -3.4568-r00 -3.4101-r00 -1.67722e-r09 Id Mair Entralpy (k.J.Rgmole) -1.748 -3.4101-r00 -1.67722e-r00 Id Mair Entralpy (k.J.Rgmole) -1.748 -3.4101-r00 -1.67722e-r00 Id Mair Entralpy (k.J.Rgmole) -2.228 -2.227 -3.640 -2.678 Id Mair Entralpy (k.J.Rgmole) -1.1622-r000 -1.1642e-r006 -1.1642e-r006 -1.1642e-r006 -1.1642e-r006 -	13	Temperature	(C)		63.0000 *		150.0000 *		77.6224 *	100.0000 *
Image Trans Depth 11148480.054 298027.4771 11148480.554 298027.4273 12 Stat Istel Live Flow (kJAgmole) -3.8439+005 -4.9129+005 -3.7767+005 -5.0528+005 13 Molar Embry (kJAgmole) -3.8439+005 -4.9129+005 -3.4767+005 -1.6729:2009 14 Mater Embry (kJAgmole) -3.8548+00 -3.34101+028 -1.6729:2009 14 Mater Embry (kJAgmole) -3.4201+024 -3.4101+026 -1.6779:2019 21 Mater Embry (kJAgmole) -1.8348+00 -3.4101+026 -1.6779:2019 22 Mater Embry (kJAgmole) -3.4201 -3.4101+026 -1.6779:2019 23 Mater Embry (kJAgmole) -1.021 -3.010 -3.6164 24 Mater Embry (kJAgmole) -2.021 -3.024 -3.024 24 Mater Embry (kJAgmole) 1.4628+006 -1.8164:008 25 Mater Embry (kJAgmole) 1.4628+006 -1.8164:008	14	Pressure	(kPa)		800.0000 *		1100.0000 *		700.0000 *	1000.0000 *
To Statusti Lissel Lis Vel Flow (m/sh) 1375.592 222.2333 1375.592 222.2333 10 Molar Encopy (k.Jkgmole-C) 2411 172.4 3.777+005 5.777+005<	15	Molar Flow (kg	gmole/h)		8980.8379		3335.2211		8980.8379	3335.2211
Image: Under Entropy (kJkgmole) -38/38+000 -4/372+005 -3/378+005 -3/359+000 Image: (kJkm) -3/3598+009 -1/5/384+09 -3/4101+09 -1/6/384+09 -3/4101+09 Image: (kJkm) -3/4598+09 -1/6/384+09 -3/4101+09 -1/6/384+09 -3/4101+09 Image: (kgm) (kgm) (kgm) -7/4 1/17 -7/4 Image: (kgm) (kgm) 6/12 -7/4 1/17 -7/4 Image: (kgm) 6/13 9 7/4 1/17 9 7/7.4 Image: (kgm) 6/13 9 7/4 1/16 7/7.4 Image: (kgm) 6/13 9 7/4 1/16 7/7.4 Image: (kgm) (kgm) -2/22 2/24 2/30 1/16/14 Image: (kJkgm) -2/22 2/24 2/30 1/16/14 1/16/14 Image: (kJkgm) 2/22 2/37 3/24	16	Mass Flow	(kg/h)	11	84949.0545		258427.4678		1184949.0545	258427.4678
Instructure Use Emory (kJh) 2241 172.4 207.4 1417. 12 Heat Flow (kJh) -3.4509e-00 -1.6384e10 -3.4101e-00 -1.6792e-00 21 FROPERTIES FROPERTIES FROPERTIES	17	Std Ideal Liq Vol Flow	(m3/h)		1376.3692		232.8393		1376.3692	232.8393
Itest Flow (LJh) -3.4509e-09 -1.6394e+09 -3.4101e+09 -1.8732e+09 Image: State	18	Molar Enthalpy (kJ/	kgmole)	-	-3.843e+005		-4.912e+005		-3.797e+005	-5.035e+005
PROPERTIES Properity Properties Pro	19	Molar Entropy (kJ/kg	mole-C)		294.1		172.4		307.4	141.7
PROPERTIES 21 Name Net to Stabilization Heat/Heating Medium Initials 21 Heating Medium Outlet 1 22 Name (kgmole/ms) 4.829 12.94 3.16 77.48 23 Molecular Weight (kgmole/ms) 4.829 12.94 3.16 13.60 24 Moles Density (kgms) 61.08 10.03 51.6.9 10.04 27 Act Volume Flow (m3h) 1940 227.8 22.92 2.45.3 26 Mass Entropy (kJkgmc) 2.92.7 3.284 2.327 3.024 28 Heast Capacity (kJkgmc) 2.227 3.284 2.327 3.024 21 HV Molar Basis (Stat) (kJkgmc) 1.614+006 1.614+006 21 HV Molar Basis (Stat) (kJkgmc) 26 C02 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000 0.0000		Heat Flow	(kJ/h)		-3.4509e+09		-1.6384e+09		-3.4101e+09	-1.6792e+09
1 Maiz-plan Weight 1319 77.46 1319 77.46 25 Maiz Density (kgmal) 4.629 12.94 3.918 13.60 26 Mass Density (kgmal) 610.8 1003 616.9 1004 27 Act. Volume Flow (m3h) 1940 257.8 2292 245.3 28 Mass Entropy (kJkg, C) 2.229 2.224 2.300 18.28 29 Mass Entropy (kJkgmde) 2.997 2.552 307.0 2.34.3 31 Mass Heat Capacity<(kJk/kgmde) - 1.462+006 1.462+006 20 LifV Mair Basis (Stit)<(kJk/gmde) 1.614+006 1.614+006 20 LifV Mair Basis (Stit)<(kJk/gmde) 1.614+006 35 C02 Apparent Wo. Conc. (kgmalkg) 0.0000 0.0000 10 2.280+004 0.8000 0.0000 10 Passe Fraction					PROPE	ERTIES				
S Meas Density (kgmolems) 4.629 11.24 3.918 13.60 25 Mass Density (kgm3) 610.8 1003 516.9 1054 24 Act Valume Flow (m3h) 1940 257.8 2202 245.3 25 Mass Enthalpy (kJkgrob) 2212 -6340 -2378 -6408 26 Mass Entracy (kJkgrob) 229 2.224 2.307 1.324 21 Mest Entracy (kJkgrob) 2.272 3.244 2.337 3.024 22 LHV Molar Basis (St) (kJkgrob) 1.462e4006 1.462e4006 23 HHV Mass Basis (St) (kJkgrob) 1.014e4400 1.614e4406 34 CO2 Apparent Mole Conc. (kgmolems) 0.0000 0.0000 35 CO2 Apparent Mole Conc. (kgmolek) 0.0000 0.0000 36 CO2 Apparent Mole Conc. (kgmolek) 0.0000 0.0000	23	Name	let to Stabiliza	ion Heate	Heating Medi	um Inlet 3	21	He	ating Medium Outle	et 3
B Mass Density (kgm) 610.8 1003 516.8 1054 27 Act. Volume Flow (m3h) 1940 257.8 2292 245.3 Mass Entrapy (kLkq) -212 -6340 -2378 6448 28 Mass Entrapy (kLkqnolc-C) 2297 2324 2307.0 234.3 31 Mass Heat Capacity (kLkgmolc-C) 2297 3.294 2.327 3.024 21 LHV Molar Basis (Std) (kLkgmolc) 1.462e+006 1.462e+006 21 LHV Molar Basis (Std) (kLkg) 1.462e+006 1.462e+006 22 LHV Masr Basis (Std) (kLkg) 1.462e+006 1.462e+006 23 HHV Masr Basis (Std) (kLkg) 0.0000 0.0000 20 20 Apparent Mic Ocnc. (kgmolem3) 0.0000 0.0000 32 Dhase Fraction (Act. Nasis) 6.474e-003 0.0000 <t< td=""><td>24</td><td>Molecular Weight</td><td></td><td>131.9</td><td></td><td>77.48</td><td>1:</td><td>31.9</td><td>77.48</td><td>3</td></t<>	24	Molecular Weight		131.9		77.48	1:	31.9	77.48	3
22 Act. Volume Flow (m3/h) 1940 257.8 2292 245.3 28 Mass Entholpy (k.lkg.) 2292 2224 2300 1428 29 Mass Entropy (k.lkg.) 2299 2224 2330 1428 30 Heat Capacity (k.lkg.) 2299 2224 2327 30.24 31 Mass Heat Capacity (k.lkg.) 2272 3.244 2.327 30.24 32 HrV Mala Basis (Std) (k.lkg.) 1.462e+006 1.462e+006 34 HrV Mass Basis (Std) (k.lkg.) 1.2082e+004 2.082e+004 35 CO2 Loading 0.0000 0.0000 0.0000 36 CO2 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 1.887e+104 0.0000 0.000	25	Molar Density (kgmole/m3)		4.629		12.94	3.	.918	13.60)
28 Mass Entrapy (kJkq-0) 2.2912 -6.340 -2.878 -6.498 20 Mass Entropy (kJkq-0) 2.229 2.224 2.330 1.828 21 Mass Entropy (kJkqmole-0) 2.997 2.56.2 30.70 2.24.3 31 Mass Heat Capacity (kJkqmole) 1.462+006 1.462+006 32 LHV Mark Basis (St) (kJkqmole) 1.462+006 1.642+006 34 HHV Mass Basis (Std) (kJkqmole) 1.662+006 0.0000 34 CO2 Apparent Mel Conc. (kgmolkq) 0.0000 0.0000 35 CO2 Apparent Mel Conc. (kgmolkq) 0.0000 0.0000 36 CO2 Apparent Mel Conc. (kgmolkq) 0.0000 0.0000	26	Mass Density (kg/m3)		610.8		1003	5	16.9	1054	4
29 Mass Entropy (kJkg-C) 2.229 2.224 2.30 1.828 20 Hear Capacity (kJkg-C) 2.997 2.55.2 307.0 2.94.3 31 Mass Hear Capacity (kJkg-C) 2.272 3.244 2.327 3.024 32 LHV Molar Basis (Std) (kJkgmole) 1.462e+006 1.162e+006 34 HV Male Basis (Std) (kJkgmole) 1.614e+006 1.614e+006 35 CO2 Loading 0.0000 36 CO2 Apparent Mole Conc. (kgmole) 1.837e+004 0.0000 36 LHV Mass Basis (Std) (kJkg) 1.887e+004 0.0000 37 CO2 Apparent Mole Conc. (kgmole) 6.474e+003 0.0000 0.32646 0.0000 38 LHV Mass Basis (Std) (kJkg) 6.758 11.19 25.75 43 Parial Pressure of CO2 (kFa) 1.755 0.0000 0.00	27	Act. Volume Flow (m3/h)		1940		257.8	2	292	245.3	3
30 Heat Capacity (kJkgmole-C) 299.7 255.2 307.0 234.3 31 Mass Heat Capacity (kJkgmole)	28	Mass Enthalpy (kJ/kg)		-2912		-6340	-2	878	-6498	3
31 Mass Heat Capacity (k/kgr-C) 2.272 3.294 2.327 3.024 21 LHV Molar Basis (Stu) (k/kgrude) 1.462e+006 1.462e+006 33 HHV Mass Basis (Stu) (k/kgrude) 1.614e+006 1.614e+006 34 HHV Mass Basis (Stu) (k/kgr) 2.083e+004 2.083e+004 35 CO2 Apparent Mole Conc. (kgrude/m3) 0.0000 0.0000 36 CO2 Apparent W. Conc. (kgrude/m3) 1.877e+004 0.0000 37 OC2 Apparent W. Conc. (kgrude/m3) 1.887e+004 1.887e+004 38 HHV Mass Basis (Stu) (k/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Vat. Vot. Basis] 0.2810-003 0.0000 0.3646 0.0000 40 Pase Fraction [Act. Vot. Basis] 0.2810-003 0.0000 0.0000 0.0000 41 Mass Evergy (k/kg) 6.525	29	Mass Entropy (kJ/kg-C)		2.229		2.224	2.	.330	1.828	3
1 LHV Molar Basis (Std) (kJkgmole) 1.462e+006 1.462e+006 33 HHV Mass Basis (Std) (kJkgmole) 2.083e+004 2.083e+004 35 CO2 Loading 2.083e+004 0.0000 35 CO2 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000 36 CO2 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000 37 Phase Fraction [Mass Basis] 6.474-003 0.0000 4.327e-003 0.0000 40 Phase Fraction [Mass Basis] 2.810e-003 0.0000 0.3646 0.0000 41 Phase Fraction [Mass Basis] 0.2890 0.0000 0.3646 0.0000 42 Mass Exergy (kJkg) 6.758 11.19 25.75 43 Partial Pressure of CO2 (PPa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (ACT_m3/h) 50.25 14.32 6.525 14.32	30	Heat Capacity (kJ/kgmole-C)		299.7		255.2	30	07.0	234.3	3
33 HHV Molar Basis (Std) (kJkgmole) 1.614e+006 2.083e+004 34 HHV Mass Basis (Std) (kJkg) 2.083e+004 2.083e+004 35 CO2 Lading 0.0000 35 CO2 Apparent Mic Conc. (kgmole/m3) 0.0000 0.0000 36 LHV Mass Basis (Std) (kJkg) 1.887e+004 0.0000 36 Phase Fraction (Mot Basis) 0.2810e-003 0.0000 0.3646 0.0000 40 Phase Fraction (Act Us Basis) 0.2799 0.0000 0.3646 0.0000 41 Phase Fraction (Act Us Basis) 0.2990 0.0000 0.0000 0.0000 42 Base Fork (kJkg) 6.796 65.58 11.19 2.575 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 0.0000 0.0000 4 Cost Based on Flow (Cost/s) 0.0000 0.0000	31	Mass Heat Capacity (kJ/kg-C)		2.272		3.294	2.	.327	3.024	4
SA HHV Mass Basis (Std) (kulkg) 2.083e+004 2.083e+004 SG CO2 Loading SG CO2 Apparent Mic Conc. (kgmolk/m) 0.0000 0.0000 GC2 Apparent Mic Conc. (kgmolk/m) 1.887e+004 1.887e+004 MHV Mass Basis (Std) (kulkg) 6.474e-003 0.0000 9.250e-003 0.0000 Mass Fraction [Vol. Basis] 0.474e-003 0.0000 0.3846 0.0000 Mass Exergy (kulkg) 6.756 6.585 11.19 25.75 Mass Exergy (kulkg) 6.756 6.585 11.19 25.75 A cott Based on Flow (Cost Based on Flow (Cost Based on Flow 0.0000 0.0000 0.0000 4 cott Based on Flow (Kulkgmole-C) 2.99.7 2.52. 307.0 2.24.3 45 Std. Gas Flow (KT_m3h) 5.02.5 14.32 6.525 14.32 46 Ast Liq, Flow (STD_m3h) 2.128	32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006			1.462e+006	3
S CO2 Loading 38 CO2 Apparent Muce Conc. (kgmole/m3) 0.0000 0.0000 39 LHV Mass Basis (Std) (kJMg) 0.0000 0.0000 39 LHV Mass Basis (Std) (kJMg) 1.887e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 6.474e+003 0.0000 9.250e+003 0.0000 41 Phase Fraction [Act. Vol. Basis] 2.810e+003 0.0000 4.327e+003 0.0000 42 Mass Exergy (kJkg) 6.766 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 16.10 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Arg. Lip. Density (kgmole/m3) 6.525 14.32 6.525 14.32 46 Std. Ideal Lip. Mass Density (kgmole/m3) 86.09 11110 86.09	33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006			1.614e+006	3
SE CO2 Apparent Wole Conc. (kgmolk(m) 0.0000 0.0000 37 CO2 Apparent W. Conc. (kgmolk(g) 0.0000 0.0000 38 LHV Mass Basis (Sid) (k.l/kg) 1.887+004 39 Phase Fraction [Vol. Basis] 6.474e-003 0.0000 9.250e-003 0.0000 40 Phase Fraction [Act. Vol. Basis] 0.2590 0.0000 0.3646 0.0000 41 Phase Fraction [Act. Vol. Basis] 0.2590 0.0000 0.3646 0.0000 42 Mass Exergy (k.l/kg) 6.6756 11.19 25.75 43 Partial Pressure of CO2 (Pa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Ary, Liq, Density (kgmole-C) 299.7 255.2 307.0 234.3 46 Std. Gas Flow (STD_m3/h) 2.128+005 7.886e+004 2.128+002 7.371e+002 <td>34</td> <td>HHV Mass Basis (Std) (kJ/kg)</td> <td></td> <td></td> <td>2.08</td> <td>3e+004</td> <td></td> <td></td> <td>2.083e+004</td> <td>4</td>	34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+004	4
57 CO2 Apparent Wt. Conc. (kgmol/kg) 1.87e-004 1.887e-004 38 LHV Mass Basis (Std) (kJ/kg) 1.887e-004 1.887e-004 39 Phase Fraction [Mass Basis] 2.810e-003 0.0000 9.256e-003 0.0000 40 Phase Fraction [Mass Basis] 2.810e-003 0.0000 4.327e-003 0.0000 41 Phase Fraction [Mass Basis] 0.2590 0.0000 0.3664 0.0000 42 Mass Every (kJ/kg) 6.796 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Art Gas Flow (KJrgmole/m3) 6.525 14.32 6.525 14.32 46 Std. Gas Flow (STD_m3/n) 2.123e+005 7.86e+004 2.133e+005 47 Specific Heat (kJ/kgmole/n) 8.60.9 1	35	CO2 Loading								-
35 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 6.474e-003 0.0000 4.207e-003 0.0000 40 Phase Fraction [Act. Vol. Basis] 2.810e-003 0.0000 0.3646 0.0000 41 Phase Fraction [Act. Vol. Basis] 0.2550 0.0000 0.3646 0.0000 42 Mass Exergy (kJ/kg) 6.765 6.65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 50.25 14.32 6.525 14.32 46 Std. Ideal Liq. Mass Density (kg/m3) 860.9 1110 860.9 1110 47 Specific Heat (kJ/kgmole) 0.3933 7.106e-002 2.371e-002 48 Std. Ideal Liq. Mass Density (kg/m3) 860.9 <t< td=""><td></td><td>CO2 Apparent Mole Conc. (kgmole/m3)</td><td></td><td></td><td></td><td>0.0000</td><td></td><td></td><td>0.0000</td><td>)</td></t<>		CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.0000)
39 Phase Fraction [Vol. Basis] 6.474e-03 0.0000 9.250e-033 0.0000 40 Phase Fraction [Mass Basis] 2.810e-03 0.0000 4.327e-03 0.0000 41 Phase Fraction [Act. Vol. Basis] 0.2590 0.0000 4.327e-03 0.0000 42 Mass Exergy (kJ/kg) 6.796 65.55 11.19 2.575 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT.ma/h) 502.5 835.7 46 Ayg. Liq. Density (kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.886e+004 2.132e+002 2.371e-002 49 Std. Ideal Liq. Mass Density (kg/m3) 86.9 1110 86.9 1110 5 51 Z Factor 2.476e-002										
40 Phase Fraction [Mass Basis] 2.810e-003 0.0000 4.327e-003 0.0000 41 Phase Fraction [Act. Vol. Basis] 0.2590 0.0000 0.3646 0.0000 42 Mass Exergy (kJ/kg) 6.796 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 16.10 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 502.5 835.7 46 Avg. Lip, Density (kgmole-C) 299.7 255.2 307.0 234.3 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.886e+004 2.122e+005 7.886e+004 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816					1.88					
41 Phase Fraction [Act. Vol. Basis] 0.2590 0.0000 0.3646 0.0000 42 Mass Exergy (kJkg) 6.796 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost%) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 502.5 835.7 46 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole/C) 299.7 255.2 307.0 234.3 48 Std. Cas Flow (STD_m3/h) 2.123e+005 7.866e+004 2.123e+005 7.866e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 860.9 11110 860.9 11110 50 Act. Liq. Flow (m3/s) 0.3993 7.160e-002 2.371e-002 51 Z Factor 2.416e-002										
42 Mass Exergy (kJ/kg) 6.796 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.55 0.0000 16.10 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 44 Cost Based on Flow (CCst/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 50.25 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Ideal Liq. Mass Density (kg/m3) 860.9 11110 860.9 11110 50 Act. Liq. Flow (m3/s) 0.3933 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property <td></td> <td>· · · ·</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		· · · ·								
43 Partial Pressure of CO2 (kPa) 17.55 0.0000 16.10 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 502.5 835.7 46 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.886e+004 2.123e+005 7.886e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq. Flow (m3/s) 0.3933 7.160e-002 2.371e-002 51 Z Factor 2.416e-002 1.02 1.061 1.02 52 Watson K 11.63 8.816 11.63 8.816 1.163 54 Partial Pressure of H2S (kPa) 0.										
44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 502.5 835.7 46 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e4005 7.886e+004 2.123e4005 7.886e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq. Flow (m3/s) 0.3993 7.160e-002 2.371e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55										
45 Act. Gas Flow (ACT_m3/h) 502.5 835.7 46 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 2234.3 48 Std. Gas Flow (SD_m3/h) 2.123e+005 7.886e+004 2.123e+005 7.886e+004 49 Std. Idea Liq. Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq. Flow (m3/s) 0.3993 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004										
46 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 14.32 47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.866+004 2.123e+005 7.886e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq. Flow (m3/s) 0.3993 7.160e-002 2.371e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cv - R) 1.022 1.034 1.028 1.037 56 Cp/CV 1.002 1.664 1.002 1.662 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 <td></td> <td>, ,</td> <td></td> <td></td> <td></td> <td>0.0000</td> <td></td> <td></td> <td>0.0000</td> <td>)</td>		, ,				0.0000			0.0000)
47 Specific Heat (kJ/kgmole-C) 299.7 255.2 307.0 234.3 48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.886e+004 2.123e+005 7.886e+004 49 Std. Ideal Liq, Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq, Flow (m3/s) 0.3993 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 51 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq, Mass										-
48 Std. Gas Flow (STD_m3/h) 2.123e+005 7.886e+004 2.123e+005 7.886e+004 49 Std. Ideal Liq, Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act, Liq, Flow (m3/s) 0.3993 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 111.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/CV 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (CSt) 1.147 2.315 59 Liq, Mass Density (Std. Cond										
49 Std. Ideal Liq, Mass Density (kg/m3) 860.9 1110 860.9 1110 50 Act. Liq, Flow (m3/s) 0.3993 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (CSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. F										
50 Act. Liq. Flow (m3/s) 0.3993 7.160e-002 0.4046 6.814e-002 51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/k) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.0			2.12		7.88					
51 Z Factor 2.416e-002 2.371e-002 52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2252 7.355e-002 63 Mass Heat of Vap. (kJ/					7.40					
52 Watson K 11.63 8.816 11.63 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (CSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ							0.4			
53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fr					2.4		4			
Fartial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 <							I			
55 Cp/(Cp - R) 1.029 1.034 1.028 1.037 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78							0.0			
56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310										
57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150										
58 Kinematic Viscosity (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438			2 00		7 24					
59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 1130 859.9 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438			2.00				2.01101			
60 Liq. Vol. Flow (Std. Cond) (m3/h) 1378 228.7 1378 228.7 61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438		· · · / /		859.9			8	59.9		
61 Liquid Fraction 0.9837 1.000 0.9773 1.000 62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438										
62 Molar Volume (m3/kgmole) 0.2160 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438										
63 Mass Heat of Vap. (KJ/kg) 1517 934.9 1526 943.9 64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438		· · · · · · · · · · · · · · · · · · ·			7.72					
64 Phase Fraction [Molar Basis] 0.0163 0.0000 0.0227 0.0000 65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438										
65 Surface Tension (dyne/cm) 35.73 40.78 66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438										
66 Thermal Conductivity (W/m-K) 0.2310 0.2295 67 Viscosity (cP) 1.150 2.438		· · · · · · · · · · · · · · · · · · ·								
67 Viscosity (cP) 1.150 2.438										
00 CV (Semi-Ideal) (KJ/Kgmole-C) 291.4 240.9 290.7 220.0	68	Cv (Semi-Ideal) (kJ/kgmole-C)		291.4		246.9	29	98.7	226.0	
Aspen Technology Inc. Aspen HYSYS Version 8.3 (29.0.0.8315) Page 1 of 2	69				IYSYS Versi					



5 6

7 8 9

10 11

12

13

14

15

16

17

18

19

20

21

22

23 24

68

NORWEGIAN UNIV OF Burlington, MA USA Unit Set:

Case Name:

BASE CASE SIMULATION MODEL.HSC

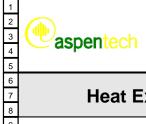
SI

Date/Time: Wed Jun 04 19:32:50 2014

Heat Exchanger: 20-HA-003 (continued) PROPERTIES let to Stabilization Heate Heating Medium Inlet 3 Name 21 Heating Medium Outlet Mass Cv (Semi-Ideal) (kJ/kg-C) 2.209 3.187 2.264 2.916 Cv (kJ/kgmole-C) 299.1 240.0 306.4 220.5 3.097 Mass Cv 2.267 2.322 2.846 (kJ/kg-C) Cv (Ent. Method) (kJ/kgmole-C) 205.9 195.1 -------(kJ/kg-C) Mass Cv (Ent. Method) 2.657 2.517 -------Cp/Cv (Ent. Method) ----1.240 1.201 ---Reid VP at 37.8 C (kPa) 153.0 9.847e-004 153.0 9.847e-004 True VP at 37.8 C (kPa) 1363 3.420 1363 3.420 Liq. Vol. Flow - Sum(Std. Cond) (m3/h) 4822 228.7 6172 228.7 Viscosity Index 16.05 5.070 13.91 12.83 DETAILS **Overall/Detailed Performance**

25				
26	Duty:	4.082e+07 kJ/h	UA Curv. Error:	0.00e-01 kJ/C-h
27	Heat Leak:	0.000e-01 kJ/h	Hot Pinch Temp:	100.0 C
28	Heat Loss:	0.000e-01 kJ/h	Cold Pinch Temp:	63.00 C
29	UA:	8.120e+05 kJ/C-h	Ft Factor:	
30	Min. Approach:	37.00 C	Uncorrected Lmtd:	52.73 C
31	Lmtd:	50.27 C		

69 Aspen Technology Inc. Licensed to: NORWEGIAN UNIV OF



Case Name: BASE CASE SIMULATION MODEL.HSC

SI

Unit Set:

Date/Time: Wed Jun 04 19:34:14 2014

Heat Exchanger: 20-HB-004

9 10				COND	TIONS				
11	Name		Inlet to Cross	Exchanger		55	let to Stab	ilization Heater	Export Oil (Hot)
12	Vapour			0.0124		0.0000		0.0163	0.0000
13	Temperature	(C)		54.9743		75.0989		63.0000 *	66.5758
14	Pressure	(kPa)		900.0000		750.0000		800.0000 *	650.0000 *
15	Molar Flow (ko	gmole/h)		8980.8379		6300.4220		8980.8379	6300.4220
16	Mass Flow	(kg/h)	11	84949.0545		1138594.4706		1184949.0545	1138594.4706
17	Std Ideal Liq Vol Flow	(m3/h)		1376.3692		1318.0673		1376.3692	1318.0673
18	•	(kgmole)	-:	3.867e+005		-4.320e+005		-3.843e+005	-4.354e+005
19		mole-C)		286.7		402.2		294.1	392.2
20	Heat Flow	(kJ/h)	-:	3.4727e+09		-2.7215e+09		-3.4509e+09	-2.7433e+09
21 22				PROPE					
22	Name	nlet to Cros	s Exchanger	55		let to Stabilization	Heate	Export Oil (Hot)	
24	Molecular Weight		131.9		180.7		31.9	180.7	
25	Molar Density (kgmole/m3)		5.106		4.483	1	629	4.524	
26	Mass Density (kg/m3)		673.7		810.2		10.8	817.5	
27	Act. Volume Flow (m3/h)		1759		1405		940	1393	
28	Mass Enthalpy (kJ/kg)		-2931		-2390	1	912	-2409	
29	Mass Entropy (kJ/kg-C)		2.173		2.225		229	2.170	
30	Heat Capacity (kJ/kgmole-C)		295.7		403.8		99.7	397.7	
31	Mass Heat Capacity (kJ/kg-C)		2.241		2.234		272	2.200	
32	LHV Molar Basis (Std) (kJ/kgmole)								
33	HHV Molar Basis (Std) (kJ/kgmole)								
34	HHV Mass Basis (Std) (kJ/kg)								
35	CO2 Loading								
36	CO2 Apparent Mole Conc. (kgmole/m3)			1 1:	20e-003			1.131e-003	
37	CO2 Apparent Wt. Conc. (kgmol/kg)				33e-006			1.383e-006	
38	LHV Mass Basis (Std) (kJ/kg)			1.00					
39	Phase Fraction [Vol. Basis]	4	.836e-003		0.0000	6.474e-	003	0.0000	
40	Phase Fraction [Mass Basis]		.020e-003		0.0000	2.810e-		0.0000	
41	Phase Fraction [Act. Vol. Basis]		0.1884		0.0000		590	0.0000	
42	Mass Exergy (kJ/kg)		5.054		9.019		796	6.364	
43	Partial Pressure of CO2 (kPa)		18.24		0.0000		7.55	0.0000	
44	Cost Based on Flow (Cost/s)		0.0000		0.0000		000	0.0000	
45	Act. Gas Flow (ACT_m3/h)		331.4				02.5		
46	Avg. Liq. Density (kgmole/m3)		6.525		4.780		525	4.780	
47	Specific Heat (kJ/kgmole-C)		295.7		403.8		99.7	397.7	
48	Std. Gas Flow (STD_m3/h)	2	.123e+005	1 49	0e+005	2.123e+		1.490e+005	
49	Std. Ideal Liq. Mass Density (kg/m3)		860.9		863.8		50.9	863.8	
50	Act. Liq. Flow (m3/s)		0.3965		0.3904		993	0.3869	
51	Z Factor					5.0			
52	Watson K		11.63		11.65	11	1.63	11.65	
53	User Property								
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	000	0.0000	
55	Cp/(Cp - R)		1.029		1.021		029	1.021	
56	Cp/Cv		1.002		1.264		002	1.265	
57	Heat of Vap. (kJ/kgmole)	1.	.986e+005	1.98	5e+005	2.001e+		1.992e+005	
58	Kinematic Viscosity (cSt)				3.818			4.521	
59	Liq. Mass Density (Std. Cond) (kg/m3)		859.9		854.3	85	59.9	854.3	
60	Liq. Vol. Flow (Std. Cond) (m3/h)		1378		1333	1	378	1333	
61	Liquid Fraction		0.9876		1.000		837	1.000	
62	Molar Volume (m3/kgmole)		0.1959		0.2231		160	0.2211	
63	Mass Heat of Vap. (kJ/kg)		1505		1098		517	1102	
64	Phase Fraction [Molar Basis]		0.0124		0.0000		163	0.0000	
65	Surface Tension (dyne/cm)								
66	Thermal Conductivity (W/m-K)				0.1172			0.1182	
67	Viscosity (cP)				3.093			3.696	
68	Cv (Semi-Ideal) (kJ/kgmole-C)		287.4		395.4	20	91.4	389.4	
69	Aspen Technology Inc.			YSYS Versi		29.0.0.8315)	- • • •	000.4	Page 1 of 2
<u> </u>					0.0 [14901012



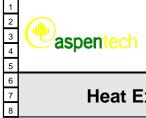
Case Name: BA

BASE CASE SIMULATION MODEL.HSC

SI

Date/Time: Wed Jun 04 19:34:14 2014

6 7	Heat Exchan	ger: 20-HB-	004 (cc	ontin	ued)		
8 9			PROPE	DTIES			
10	N			IN THE S			
11 12	Name Mass Cv (Semi-Ideal) (kJ/kg-C)	Inlet to Cross Exchanger 2.178	55	2.188	let to Stabilization Heate 2.209	Export Oil (Hot) 2.154	
12	Cv (kJ/kgmole-C)	2.178		319.3	2.209	314.3	
14	Mass Cv (kJ/kg-C)	2.236		1.767	2.267	1.739	
15	Cv (Ent. Method) (kJ/kgmole-C)						
16	Mass Cv (Ent. Method) (kJ/kg-C)						
17	Cp/Cv (Ent. Method)						
18	Reid VP at 37.8 C (kPa)	153.0		34.24	153.0	34.24	
19	True VP at 37.8 C (kPa)	1363		108.6	1363	108.6	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	4000		1322	4822	1322	
21	Viscosity Index	17.24		15.90	16.05	17.18	
22 23			DET	AILS			
24 25		Over	all/Detaile	d Perfo	ormance		
26	Duty:	2.17	79e+07 kJ/h	UA Cur	v. Error:		0.00e-01 kJ/C-h
27	Heat Leak:		00e-01 kJ/h		ch Temp:		66.58 C
28	Heat Loss:		00e-01 kJ/h		nch Temp:		54.97 C
29	UA:		e+06 kJ/C-h	Ft Fact			
30	Min. Approach:		11.60 C	Uncorre	ected Lmtd:		11.85 C
31	Lmtd:		10.81 C				
32							
33							
34							
35 36							
36 37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56 57							
57 58							
58 59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
60	Aspan Tashnalagu Ina			/	20.0.0.9215)		Daga 2 of 2



Case Name: BASE CASE SIMULATION MODEL.HSC

SI

Date/Time: Wed

Unit Set:

Wed Jun 04 19:34:50 2014

Heat Exchanger: 21-HB-001

9 10			COND	ITIONS			
11	Name		Export Oil (Hot)		Sea Water Inlet	Export Oil (Cold)	Sea Water Outlet
12	Vapour		0.0000		0.0000	0.0000	0.0000
13	Temperature	(C)	66.5758		8.0000 *	54.8057 *	45.0000 *
14	Pressure	(kPa)	650.0000 *		1000.0000 *	550.0000 *	900.0000 *
15	Molar Flow (kg	gmole/h)	6300.4220		9964.7750	6300.4220	9964.7750
16	Mass Flow	(kg/h)	1138594.4706		179516.4228	1138594.4706	179516.4228
17	Std Ideal Liq Vol Flow	(m3/h)	1318.0673		179.8787	1318.0673	179.8787
18	Molar Enthalpy (kJ/	kgmole)	-4.354e+005		-2.877e+005	-4.401e+005	-2.847e+005
19	Molar Entropy (kJ/kg	mole-C)	392.2		48.59	378.2	58.47
20	Heat Flow	(kJ/h)	-2.7433e+09		-2.8669e+09	-2.7727e+09	-2.8374e+09
21 22			PROPI	ERTIES			
23	Name	Export Oil (Hot)	Sea Wate	er Inlet	Export Oil (Cold)	Sea Water Outlet	
24	Molecular Weight	180	.7	18.02	180.7	18.02	
25	Molar Density (kgmole/m3)	4.52	24	56.63	4.580	55.09	
26	Mass Density (kg/m3)	817	.5	1020	827.7	992.4	
27	Act. Volume Flow (m3/h)	139	03	176.0	1376	180.9	
28	Mass Enthalpy (kJ/kg)	-240	9 -1.59	97e+004	-2435	-1.581e+004	
29	Mass Entropy (kJ/kg-C)	2.17		2.697	2.093	3.246	
30	Heat Capacity (kJ/kgmole-C)	397	.7	80.12	389.2	79.88	
31	Mass Heat Capacity (kJ/kg-C)	2.20	00	4.447	2.154	4.434	
32	LHV Molar Basis (Std) (kJ/kgmole)			0.0000		0.0000	
33	HHV Molar Basis (Std) (kJ/kgmole)		4.10)1e+004		4.101e+004	
34	HHV Mass Basis (Std) (kJ/kg)			2276		2276	
35	CO2 Loading						
36	CO2 Apparent Mole Conc. (kgmole/m3)	1.131e-00		0.0000	1.145e-003	0.0000	
37	CO2 Apparent Wt. Conc. (kgmol/kg)	1.383e-00		0.0000	1.383e-006	0.0000	
38	LHV Mass Basis (Std) (kJ/kg)						
39 40	Phase Fraction [Vol. Basis]	0.000		0.0000	0.0000	0.0000	
40	Phase Fraction [Mass Basis] Phase Fraction [Act. Vol. Basis]	0.000		0.0000	0.0000	0.0000	
42	Mass Exergy (kJ/kg)	6.36		3.429	3.493	3.905	
43	Partial Pressure of CO2 (kPa)	0.000		0.0000	0.0000	0.0000	
44	Cost Based on Flow (Cost/s)	0.000		0.0000	0.0000	0.0000	
45	Act. Gas Flow (ACT_m3/h)						
46	Avg. Liq. Density (kgmole/m3)	4.78	80	55.40	4.780	55.40	
47	Specific Heat (kJ/kgmole-C)	397	.7	80.12	389.2	79.88	
48	Std. Gas Flow (STD_m3/h)	1.490e+00	05 2.35	56e+005	1.490e+005	2.356e+005	
49	Std. Ideal Liq. Mass Density (kg/m3)	863	.8	998.0	863.8	998.0	
50	Act. Liq. Flow (m3/s)	0.386	69 4.8	88e-002	0.3821	5.025e-002	
51	Z Factor		7.5	54e-003		6.177e-003	
52	Watson K	11.6	65		11.65		
53	User Property						
54	Partial Pressure of H2S (kPa)	0.000		0.0000	0.0000	0.0000	
55	Cp/(Cp - R)	1.02		1.116	1.022	1.116	
56	Cp/Cv	1.20		1.130	1.265	1.153	
57	Heat of Vap. (kJ/kgmole)	1.992e+00		59e+004	1.999e+005	3.688e+004	
58 59	Kinematic Viscosity (cSt)	4.52		1.348	5.835	0.5984	
59 60	Liq. Mass Density (Std. Cond) (kg/m3) Liq. Vol. Flow (Std. Cond) (m3/h)	854		1015 176.9	854.3	1015	
61	Liquid Fraction	1.00		1.000	1.000	1.000	
62	Molar Volume (m3/kgmole)	0.22		66e-002	0.2183	1.815e-002	
63	Mass Heat of Vap. (kJ/kg)	11(2031	1106	2047	
64	Phase Fraction [Molar Basis]	0.000		0.0000	0.0000	0.0000	
65	Surface Tension (dyne/cm)			75.03		68.62	
66	Thermal Conductivity (W/m-K)	0.118		0.5834	0.1196	0.6376	
67	Viscosity (cP)	3.69		1.375	4.830	0.5939	
68	Cv (Semi-Ideal) (kJ/kgmole-C)	389	.4	71.81	380.9	71.57	
69	Aspen Technology Inc.	Aspe	n HYSYS Vers	ion 8.3 (2	29.0.0.8315)		Page 1 of 2



Case Name: Unit Set:

BASE CASE SIMULATION MODEL.HSC

SI

Date/Time: Wed Jun 04 19:34:50 2014

Heat Exchanger: 21-HB-001 (continued)

9 10				PROPERTIES			
11	Name		Export Oil (Hot)	Sea Water Inlet	Export Oil (Cold)	Sea Water Outlet	
12	Mass Cv (Semi-Ideal)	(kJ/kg-C)	2.154	3.986	2.108	3.973	
13	Cv (kJ	J/kgmole-C)	314.3	70.88	307.8	69.28	
14	Mass Cv	(kJ/kg-C)	1.739	3.935	1.703	3.846	
15	Cv (Ent. Method) (kJ	J/kgmole-C)					
16	Mass Cv (Ent. Method)	(kJ/kg-C)					
17	Cp/Cv (Ent. Method)						
18	Reid VP at 37.8 C	(kPa)	34.24	6.442	34.24	6.442	
19	True VP at 37.8 C	(kPa)	108.6	6.442	108.6	6.442	
20	Liq. Vol. Flow - Sum(Std. Co	nd) (m3/h)	1322	176.9	1322	176.9	
21	Viscosity Index		17.18	7.070	18.97	-4.906	
22 23				DETAILS			

Overall/Detailed Performance

23				
24 25		Overall/Detaile	d Performance	
25 26	Duty:	2.945e+07 kJ/h	UA Curv. Error:	0.00e-01 kJ/C-h
20 27	Heat Leak:	0.000e-01 kJ/h	Hot Pinch Temp:	0.00e-01 kJ/C-n 66.58 C
27	Heat Loss:	0.000e-01 kJ/h	Cold Pinch Temp:	45.00 C
20 29	UA:	9.774e+05 kJ/C-h	Ft Factor:	45.00 C
30	Min. Approach:	9.7740+03 K3/C-11 21.58 C	Uncorrected Lmtd:	32.58 C
31	Lmtd:	30.13 C		52.58 C
32	Linto.	30.13 C		
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				
61				
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67				
63				
64				
65				
66				
67				

68

69



5

NORWEGIAN UNIV OF Burlington, MA USA Case Name: BASE CASE SIMULATION MODEL.HSC

Unit Set:

Date/Time: Sun Jun 08 19:48:18 2014

SI

6 Heat Exchanger: 24-HA-102 7 8 9 CONDITIONS 10 11 Heating Medium Outlet 4 Name Field 1 Wet Gas Heating Medium Inlet 4 Field 1 Gas to Contactor 12 0.0000 Vapour 1.0000 0.0000 1.0000 13 Temperature 25.0000 150.0000 28.0000 100.0000 (C) 14 (kPa) 4930.0000 4830.0000 1000.0000 * Pressure 1100.0000 * 15 (kgmole/h) 48543.5903 679.5104 48543.5903 679.5104 Molar Flow 16 Mass Flow 957250.5369 52651.4266 957250.5369 52651.4266 (kg/h) 17 Std Ideal Lig Vol Flow (m3/h) 2811.6979 47.4382 2811.6979 47.4382 18 Molar Enthalpy (kJ/kgmole) -8.352e+004 -4.912e+005 -8.335e+004 -5.035e+005 19 Molar Entropy (kJ/kgmole-C) 152.6 172.4 153.3 141.7 20 Heat Flow (kJ/h) -4.0544e+09 -3.3381e+08 -4.0461e+09 -3.4212e+08 21 PROPERTIES 22 23 Name Field 1 Wet Gas Heating Medium Inlet 4 Field 1 Gas to Contactor leating Medium Outlet 24 Molecular Weight 19.72 77.48 19.72 77.48 25 Molar Density (kgmole/m3) 2.271 12.94 2.184 13.60 26 Mass Density (kg/m3) 44.78 1003 43.08 1054 27 Act. Volume Flow (m3/h) 2.138e+004 52.51 2.222e+004 49.98 28 Mass Enthalpy (kJ/kg) -4235 -6340 -4227 -6498 29 Mass Entropy (kJ/kg-C) 7.739 2.224 7.776 1.828 30 48.89 48.50 Heat Capacity (kJ/kgmole-C) 255.2 234.3 3.294 2.460 31 Mass Heat Capacity 2.479 3.024 (kJ/kg-C) LHV Molar Basis (Std) 32 1.462e+006 1.462e+006 (kJ/kgmole) ------33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e + 0.061.614e + 0.06------HHV Mass Basis (Std) 2.083e+004 2.083e+004 34 (kJ/kg) ------CO2 Loading ------------CO2 Apparent Mole Conc. (kgmole/m3) 36 0.0000 0.0000 37 CO2 Apparent Wt. Conc. (kgmol/kg) 0.0000 0.0000 LHV Mass Basis (Std) (kJ/kg) ----1.887e+004 ---1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Mass Basis] 1.000 0.0000 0.0000 1.000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy 472.8 65.58 470.6 25.75 (kJ/kg) 43 Partial Pressure of CO2 (kPa) 77.39 0.0000 75.82 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.138e+004 2.222e+004 ------46 14.32 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 47 48.89 255.2 48.50 234.3 Specific Heat (kJ/kgmole-C) 48 Std. Gas Flow (STD_m3/h) 1.148e+006 1.607e+004 1.148e+006 1.607e+004 49 Std. Ideal Liq. Mass Density 340.5 1110 340.5 1110 (kg/m3) 50 Act. Liq. Flow 0.0000 1.459e-002 1.388e-002 (m3/s) 51 Z Factor 2.416e-002 0.8831 2.371e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 Cp/(Cp - R) 55 1.205 1.034 1.207 1.037 56 Cp/Cv 1.489 1.064 1.472 1.062 57 Heat of Vap. (kJ/kgmole) 9666 7.244e+004 9771 7.313e+004 58 0.2819 0.2939 **Kinematic Viscosity** (cSt) 1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) 1.144e+006 46.60 1.144e+006 46.60 (m3/h) 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.4404 7.728e-002 0.4578 7.355e-002 (kJ/kg) 63 Mass Heat of Vap. 490.2 934.9 495.5 943.9 1.0000 0.0000 64 Phase Fraction [Molar Basis] 1.0000 0.0000 Surface Tension 40.78 65 (dyne/cm) 35.73 ------66 Thermal Conductivity 3.558e-002 0.2310 3.580e-002 0.2295 (W/m-K) Viscosity 67 1.262e-002 1.150 1.266e-002 2.438 (cP)

Aspen Technology Inc. Licensed to: NORWEGIAN UNIV OF

(kJ/kgmole-C)

Cv (Semi-Ideal)

246.9

40.19

40.57

226.0

Heat Exchanger: 24-HA-102 (continued)

1			Case Na	ame:	BASE CASE SIMULATIO	ON MODEL.HSC	
2 3	Burlington,	AN UNIV OF MA	Unit Set	:	SI		
4 5			Date/Tir	ne:	Sun Jun 08 19:48:18 201	4	
6							
7	Heat Exchange	r: 24-HA-10	02 (con	tinue	ed)		
8 9			DDODI				
10				RTIES			
11 12	Name Mass Cv (Semi-Ideal) (kJ/kg-C)	Field 1 Wet Gas 2.057	Heating Medi	<u>3.187</u>	2.038	Heating Medium Outlet 4 2.916	
13	Cv (kJ/kgmole-C)	32.82		240.0	32.94	220.5	
14	Mass Cv (kJ/kg-C)	1.665		3.097	1.671	2.846	
15 16	Cv (Ent. Method)(kJ/kgmole-C)Mass Cv (Ent. Method)(kJ/kg-C)			205.9 2.657		195.1 2.517	
17	Cp/Cv (Ent. Method) (K0/Kg-C)			1.240		1.201	
18	Reid VP at 37.8 C (kPa)		9.8	47e-004		9.847e-004	
19	True VP at 37.8 C (kPa)			3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.144e+006		46.60	1.144e+006	46.60	
21 22	Viscosity Index			5.070		12.83	
23			DET	AILS			
24 25		Ove	rall/Detaile	d Perfo	ormance		
25 26	Duty:		16e+06 kJ/h		v. Error:		0.00e-01 kJ/C-h
27	Heat Leak:		000e-01 kJ/h		ch Temp:		100.0 C
28	Heat Loss:		000e-01 kJ/h		nch Temp:		25.00 C
29	UA:	8.632	e+04 kJ/C-h	Ft Fact			
30 31	Min. Approach: Lmtd:		75.00 C 96.34 C	Uncorre	ected Lmtd:		96.60 C
32	Linta.		50.04 0				
33							
34 35							
35 36							
37 38 39							
39							
40 41							
41 42							
43							
44							
45							
46							
47 48							
49							
50							
51							
52							
53 54							
55							
56							
57							
58 50							
59 60							
61							
62							
63							
64 65							
66							
67							
68							B

69



5

NORWEGIAN UNIV OF Burlington, MA USA Case Name: BASE CASE SIMULATION MODEL.HSC

Unit Set:

SI

Date/Time: Sun Jun 08 19:49:31 2014

6 Heat Exchanger: 24-HA-202 7 8 9 CONDITIONS 10 11 Heating Medium Outlet 5 Name Field 2 Wet Gas Heating Medium Inlet 5 2 Gas to TEG Contactor 12 0.0000 Vapour 1.0000 0.0000 1.0000 13 Temperature 25.0000 150.0000 28.0000 100.0000 (C) 5420.0000 14 (kPa) 5320.0000 1000.0000 * Pressure 1100.0000 * 54998.7620 15 (kgmole/h) 786.0151 54998.7620 786.0151 Molar Flow 16 Mass Flow (kg/h) 1084637.5850 60903.8778 1084637.5850 60903.8778 17 Std Ideal Lig Vol Flow (m3/h) 3185.7806 54.8735 3185.7806 54.8735 18 Molar Enthalpy (kJ/kgmole) -8.364e+004 -4.912e+005 -8.347e+004 -5.035e+005 19 Molar Entropy (kJ/kgmole-C) 151.5 172.4 152.2 141.7 20 Heat Flow (kJ/h) -4.6001e+09 -3.8613e+08 -4.5905e+09 -3.9575e+08 21 PROPERTIES 22 23 Name Field 2 Wet Gas Heating Medium Inlet 5 Id 2 Gas to TEG Contac leating Medium Outlet 5 24 Molecular Weight 19.72 77.48 19.72 77.48 25 Molar Density (kgmole/m3) 2.530 12.94 2.437 13.60 26 Mass Density (kg/m3) 49.89 1003 48.05 1054 27 Act. Volume Flow (m3/h) 2.174e+004 60.74 2.257e+004 57.81 28 Mass Enthalpy (kJ/kg) -4241 -6340 -4232 -6498 29 7.682 Mass Entropy (kJ/kg-C) 2.224 7.719 1.828 30 50.06 Heat Capacity (kJ/kgmole-C) 255.2 49.61 234.3 3.294 2.515 31 Mass Heat Capacity 2.539 3.024 (kJ/kg-C) LHV Molar Basis (Std) 32 1.462e+006 1.462e+006 (kJ/kgmole) ------33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e + 0.061.614e + 0.06------HHV Mass Basis (Std) 2.083e+004 2.083e+004 34 (kJ/kg) ------CO2 Loading ------------CO2 Apparent Mole Conc. (kgmole/m3) 36 0.0000 0.0000 37 CO2 Apparent Wt. Conc. (kgmol/kg) 0.0000 0.0000 LHV Mass Basis (Std) 38 (kJ/kg) ----1.887e+004 ---1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy 483.1 65.58 481.1 25.75 (kJ/kg) 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 83.51 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 ------46 14.32 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 47 50.06 49.61 234.3 Specific Heat (kJ/kgmole-C) 255.2 48 Std. Gas Flow (STD_m3/h) 1.300e+006 1.858e+004 1.300e+006 1.858e+004 49 Std. Ideal Liq. Mass Density 340.5 1110 340.5 1110 (kg/m3) 50 Act. Liq. Flow 0.0000 1.687e-002 1.606e-002 (m3/s) 51 Z Factor 2.416e-002 0.8720 2.371e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 Cp/(Cp - R) 55 1.034 1.201 1.037 1.199 56 Cp/Cv 1.520 1.064 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.244e+004 9278 7.313e+004 58 0.2570 **Kinematic Viscosity** (cSt) 1.147 0.2675 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) 1.297e+006 53.90 1.297e+006 53.90 (m3/h) 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.728e-002 0.4104 7.355e-002 (kJ/kg) 63 Mass Heat of Vap. 465.1 934.9 470.4 943.9 1.0000 0.0000 64 Phase Fraction [Molar Basis] 1.0000 0.0000 Surface Tension 40.78 65 (dyne/cm) 35.73 ------66 Thermal Conductivity 3.617e-002 0.2310 3.637e-002 0.2295 (W/m-K) 67 Viscosity 1.282e-002 1.150 1.285e-002 2.438 (cP) Cv (Semi-Ideal) (kJ/kgmole-C) 246.9 41.29 226.0 41.75 Aspen HYSYS Version 8.3 (29.0.0.8315) Page 1 of 2 Aspen Technology Inc.

aspentech

8

NORWEGIAN UNIV OF Burlington, MA USA Case Name: BA

BASE CASE SIMULATION MODEL.HSC

Unit Set: SI Date/Time: Sun Jun

Sun Jun 08 19:49:31 2014

Heat Exchanger: 24-HA-202 (continued)

9 10			PROPE	ERTIES			
11	Name	Field 2 Wet Gas	Heating Media	um Inlet 5	ld 2 Gas to TEG Contac	Heating Medium Outlet 5	
12	Mass Cv (Semi-Ideal) (kJ/kg-C)	2.117	U	3.187	2.094	2.916	
13	Cv (kJ/kgmole-C)	32.94		240.0	33.06	220.5	
14	Mass Cv (kJ/kg-C)	1.670		3.097	1.676	2.846	
15	Cv (Ent. Method) (kJ/kgmole-C)			205.9		195.1	
16	Mass Cv (Ent. Method) (kJ/kg-C)			2.657		2.517	
17	Cp/Cv (Ent. Method)			1.240		1.201	
18	Reid VP at 37.8 C (kPa)		9.84	47e-004		9.847e-004	
19	True VP at 37.8 C (kPa)			3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.297e+006		53.90	1.297e+006	53.90	
21	Viscosity Index			5.070		12.83	
22 23			DET	AILS			
24 25		Ove	rall/Detaile	d Perfo	rmance		
26	Duty:		19e+06 kJ/h	UA Cur			0.00e-01 kJ/C-h
27	Heat Leak:		000e-01 kJ/h		ch Temp:		100.0 C
28	Heat Loss:		000e-01 kJ/h		nch Temp:		25.00 C
29	UA:	9.985	e+04 kJ/C-h	Ft Facto			
30	Min. Approach:		75.00 C	Uncorre	ected Lmtd:		96.60 C
31 32 33	Lmtd:		96.34 C				
34 35 36 37 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68							



Case Name: BASE CASE SIMULATION MODEL.HSC

SI

Unit Set:

Date/Time: Mon Jun 09 12:54:39 2014

LNG: 24-HJ-101

9 10				COND	TIONS			
11	Name		Inlet t	o 24-HJ-101	Cooling	Medium Inlet 4	Outlet from 24-HJ-101	Cooling Medium Outlet 4
12	Vapour			1.0000		0.0000	0.9959	0.0000
13	Temperature	(C)		135.2802		20.0000 *	25.0000	* 80.0000 *
14	Pressure	(kPa)		5030.0000		1000.0000 *	4930.0000	* 900.0000 *
15		gmole/h)		4.874e+004		2.073e+004	4.874e+004	2.073e+004
16	Mass Flow	(kg/h)		9.658e+005		1.606e+006	9.658e+005	1.606e+006
17	Std Ideal Lig Vol Flow	(m3/h)		2824		1447	2824	1447
18	· · · · ·	(kgmole)	-	7.860e+004		-5.210e+005	-8.411e+004	-5.081e+005
19	••	mole-C)		167.9		88.84	152.3	129.0
20	Heat Flow	(kJ/h)	-	3.831e+009		-1.080e+010	-4.100e+009	-1.053e+010
21				PROPE				
22 23	Name	Inlet to 2	24-HJ-101	Cooling Mediu	um Inlet 4	Outlet from 24-H	J-101 Cooling Medium Ou	itlet 4
24	Molecular Weight		19.81		77.48	19	9.81 77	.48
25	Molar Density (kgmole/m3)		1.524		14.54	2.	279 13	.84
26	Mass Density (kg/m3)		30.19		1127	45	5.15 10	172
27	Act. Volume Flow (m3/h)	3	3.199e+004		1426	2.139e+	004 14	.98
28	Mass Enthalpy (kJ/kg)		-3967		-6725	-4	245 -65	58
29	Mass Entropy (kJ/kg-C)		8.475		1.147	7.	688 1.6	65
30	Heat Capacity (kJ/kgmole-C)		50.43		205.6	49	9.17 22	6.6
31	Mass Heat Capacity (kJ/kg-C)		2.545		2.654	2.	482 2.9	25
32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006		1.462e+0	06
33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006		1.614e+0	06
34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004		2.083e+0	04
35	CO2 Loading							
36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000		0.00	00
37	CO2 Apparent Wt. Conc. (kgmol/kg)				0.0000		0.00	00
38	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004		1.887e+0	04
39	Phase Fraction [Vol. Basis]		1.000		0.0000	0.9	956 0.00	00
40	Phase Fraction [Mass Basis]		1.000		0.0000	0.9	911 0.00	00
41	Phase Fraction [Act. Vol. Basis]		1.000		0.0000	0.9	994 0.00	00
42	Mass Exergy (kJ/kg)		513.4		2.394	47	70.1 14	.86
43	Partial Pressure of CO2 (kPa)		78.72		0.0000	77	7.39 0.00	00
44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.0	000 0.00	00
45	Act. Gas Flow (ACT_m3/h)	3	3.199e+004			2.138e+	004	
46	Avg. Liq. Density (kgmole/m3)		17.26		14.32	17	7.26 14	.32
47	Specific Heat (kJ/kgmole-C)		50.43		205.6	49	9.17 22	6.6
48	Std. Gas Flow (STD_m3/h)	1	.153e+006	4.90	2e+005	1.153e+	006 4.902e+0	05
49	Std. Ideal Liq. Mass Density (kg/m3)		342.0		1110	34	12.0 11	10
50	Act. Liq. Flow (m3/s)				0.3961	3.492e-	003 0.41	61
51	Z Factor		0.9722	2.82	22e-002		2.215e-0	02
52	Watson K		17.93		8.816	17	7.93 8.8	16
53	User Property							
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	000 0.00	00
55	Cp/(Cp - R)		1.197		1.042	1.	203 1.0	38
56	Cp/Cv		1.282		1.059	1.	483 1.0	62
57	Heat of Vap. (kJ/kgmole)	1	.090e+004	7.31	3e+004	1.098e+	004 7.380e+0	04
58	Kinematic Viscosity (cSt)		0.5187		15.21		3.4	64
59	Liq. Mass Density (Std. Cond) (kg/m3)		0.8405		1130	0.8	405 11	30
60	Liq. Vol. Flow (Std. Cond) (m3/h)	1	.149e+006		1422	1.149e+	006 14	22
61	Liquid Fraction		0.0000		1.000	4.093e-	003 1.0	00
62	Molar Volume (m3/kgmole)		0.6563	6.87	77e-002	0.4	388 7.225e-0	02
63	Mass Heat of Vap. (kJ/kg)		550.2		943.9	55	54.2 95	2.5
64	Phase Fraction [Molar Basis]		1.0000		0.0000	0.9	959 0.00	00
65	Surface Tension (dyne/cm)				48.40		42	74
66	Thermal Conductivity (W/m-K)	:	5.008e-002		0.2165		0.22	74
67	Viscosity (cP)		1.566e-002		17.13		3.7	'15
68	Cv (Semi-Ideal) (kJ/kgmole-C)		42.11		197.3	40	0.86 21	8.3
69	Aspen Technology Inc.		Aspen H	IYSYS Versi	ion 8.3 (2	29.0.0.8315)		Page 1 of 2



Case Name:

Unit Set:

BASE CASE SIMULATION MODEL.HSC

Date/Time: Mon Jun 09 12:54:39 2014

SI

LNG: 24-HJ-101 (continued)

8			•			
9			PROPERTIES			
10 11	Name	Inlatte 04 11 404			Cooling Medium Outlet 4	
11	Name Mass Cv (Semi-Ideal) (kJ/kg-C)	Inlet to 24-HJ-101 2.125	2.547	2.062	2.818	
12	Cv (kJ/kgmole-C)	39.33	194.1	33.17	213.3	
14	Mass Cv (kJ/kgrC)	1.985	2.506	1.674	2.753	
14	Cv (Ent. Method) (kJ/kgmole-C)		179.3		190.6	
16	Mass Cv (Ent. Method) (kJ/kg-C)		2.314		2.460	
17	Cp/Cv (Ent. Method)		1.147		1.189	
18	Reid VP at 37.8 C (kPa)		9.847e-004		9.847e-004	
19	True VP at 37.8 C (kPa)		3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.149e+006	1422	1.144e+006	1422	
21	Viscosity Index	-34.28	25.80		16.38	
22			•			
23						
24						
25						
26						
24 25 26 27 28 29						
28						
29						
30 31						
31						
32						
33						
32 33 34 35 36 37						
35						
36						
37						
38 39						
39						
40						
40 41 42						
43						
43						
45						
45 46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						
61						
62						
63						
64						
65						
66						
67						
68						_

69



Case Name: BASE CASE SIMULATION MODEL.HSC

SI

Unit Set:

Date/Time: Mon Jun 09 12:53:25 2014

LNG: 24-HJ-201

International control Control control International control International control Control control Outlet from 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling 1 12 Vapour 1.0000 0.0000 0.0000 0.9958 1 13 Temperature (C) 142.4725 20.0000 * 25.0000 * 14 Pressure (kPa) 5520.0000 1000.0000 * 5420.0000 * 15 Molar Flow (kgmole/h) 5.523e+004 2.535e+004 5.523e+004 16 Mass Flow (kg/h) 1.094e+006 1.964e+006 1.094e+006 17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 3200 18 Molar Entropy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole/C) 167.9 88.84 151.2 20 Heat Flow (kJ/k) -4.324e+009 -1.321e+010 -4.652e+009 21 24 Molecular Weight 19.81 <th></th>	
12 Vapour 1.0000 0.0000 0.9958 13 Temperature (C) 142.4725 20.0000* 25.0000* 14 Pressure (kPa) 5520.0000 1000.000* 5420.0000* 15 Molar Flow (kgmole/h) 5.523e+004 2.535e+004 5.523e+004 16 Mass Flow (kg/h) 1.094e+006 1.964e+006 1.094e+006 17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 33200 18 Molar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/kgmole) -4.324e+009 -1.321e+010 -4.652e+009 21 22 PROPERTIES 24 Molecular Weight 19.81 77.48 19.81 77.48 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641	Medium Outlet 8
14 Pressure (kPa) 5520.000 1000.000 * 5420.000 * 15 Molar Flow (kgmole/h) 5.523e+004 2.535e+004 5.523e+004 16 Mass Flow (kg/h) 1.094e+006 1.964e+006 1.094e+006 17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 3200 18 Molar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/h) -4.324e+009 -1.321e+010 -4.652e+009 21 22 PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Enthalpy (kJ/kg) -3952 -6725 -42	0.0000
15 Molar Flow (kgmole/h) 5.523e+004 2.535e+004 5.523e+004 16 Mass Flow (kg/h) 1.094e+006 1.964e+006 1.094e+006 17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 3200 18 Molar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/h) -4.324e+009 -1.321e+010 -4.652e+009 21 22 PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 11127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 <th>80.0000 *</th>	80.0000 *
16 Mass Flow (kg/h) 1.094e+006 1.964e+006 1.094e+006 17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 3200 18 Molar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/h) -4.324e+009 -1.321e+010 -4.652e+009 21 PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kg/m3) 32.51 11127 50.30 1072 26 Mass Density (kg/m3) 32.51 11727 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -33952 -6725	900.0000 *
17 Std Ideal Liq Vol Flow (m3/h) 3200 1770 3200 18 Molar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole) -167.9 88.84 151.2 20 Heat Flow (kJ/h) -4.324e+009 -1.321e+010 -4.652e+009 21 22 PROPERTIES PROPERTIES Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004	2.535e+004
Bolar Enthalpy (kJ/kgmole) -7.830e+004 -5.210e+005 -8.423e+004 19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/k) -4.324e+009 -1.321e+010 -4.652e+009 21 PROPERTIES 22 PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Entropy (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kgrole-C) 51.08 205.6 50.34 226.6 30 Heat Capacity (kJ/kgrole) 1.462e+006 1.462e+006 31	1.964e+006
19 Molar Entropy (kJ/kgmole-C) 167.9 88.84 151.2 20 Heat Flow (kJ/h) -4.324e+009 -1.321e+010 -4.652e+009 PROPERTIES 21 PROPERTIES 22 Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kgrole, C) 51.08 205.6 50.34 226.6 <	1770
Image: Second	-5.081e+005
21 PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kg-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kgmole) 1.462e+006 1.462e+006 32 LHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mas	129.0
PROPERTIES 23 Name Inlet to 24-HJ-201 Cooling Medium Inlet 8 Outlet from 24-HJ-201 Cooling Medium Outlet 8 24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kg-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.614e+006 33 HHV Mass Basis (Std) <td< th=""><th>-1.288e+010</th></td<>	-1.288e+010
24 Molecular Weight 19.81 77.48 19.81 77.48 25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kg-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kgmole) 1.462e+006 1.462e+006 32 LHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 33 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
25 Molar Density (kgmole/m3) 1.641 14.54 2.539 13.84 26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 33.66e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kgnole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kgnole) 1.462e+006 1.462e+006 32 LHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 33 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
26 Mass Density (kg/m3) 32.51 1127 50.30 1072 27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) 3952 6725 4251 6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kgmole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
27 Act. Volume Flow (m3/h) 3.366e+004 1743 2.175e+004 1831 28 Mass Enthalpy (kJ/kg) -3952 -6725 -4251 -6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kgmole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kgmole) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
28 Mass Enthalpy (kJ/kg) 3952 6725 4251 6558 29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kgmole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
29 Mass Entropy (kJ/kg-C) 8.474 1.147 7.632 1.665 30 Heat Capacity (kJ/kgmole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
30 Heat Capacity (kJ/kgmole-C) 51.08 205.6 50.34 226.6 31 Mass Heat Capacity (kJ/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
31 Mass Heat Capacity (k/kg-C) 2.578 2.654 2.541 2.925 32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
32 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004	
35 CO2 Loading	
36 CO2 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000	
37 CO2 Apparent Wt. Conc. (kgmol/kg) 0.0000 0.0000	
38 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004	
39 Phase Fraction [Vol. Basis] 1.000 0.0000 0.9955 0.0000	
40 Phase Fraction [Mass Basis] 1.000 0.0000 0.9911 0.0000	
41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 0.9993 0.0000	
42 Mass Exergy (kJ/kg) 529.0 2.394 480.4 14.86	
43 Partial Pressure of CO2 (kPa) 86.39 0.0000 85.08 0.0000	
44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000	
45 Act. Gas Flow (ACT_m3/h) 3.366e+004 2.174e+004	
46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32	
47 Specific Heat (kJ/kgmole-C) 51.08 205.6 50.34 226.6	
48 Std. Gas Flow (STD_m3/h) 1.306e+006 5.993e+005 1.306e+006 5.993e+005	
49 Std. Ideal Liq. Mass Density (kg/m3) 342.0 1110 342.0 1110 50 Ant Lig. Flaux (m3) 342.0 1110 342.0 0.5007	
50 Act. Liq. Flow (m3/s) 0.4842 4.010e-003 0.5087 54 7. Factor 0.0725 0.0002,000 0.0452,000 0.0452,000	
51 Z Factor 0.9735 2.822e-002 2.215e-002 52 Waters K 47.02 9.940 47.02 9.940	
52 Watson K 17.93 8.816 17.93 8.816 53 User Property	
53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000	
54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.194 1.042 1.198 1.038	
56 Cp/Cv 1.194 1.042 1.196 1.036	
57 Heat of Vap. (kJ/kgmole) 1.052e+004 7.313e+004 1.059e+004 7.380e+004	
58 Kinematic Viscosity (cSt) 0.4907 15.21 3.464	
59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8405 1130 0.8405 1130	
60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.302e+006 1738 1.302e+006 1738	
61 Liquid Fraction 0.0000 1.000 4.206e-003 1.000	
62 Molar Volume (m3/kgmole) 0.6094 6.877e-002 0.3939 7.225e-002	
63 Mass Heat of Vap. (kJ/kg) 530.7 943.9 534.7 952.5	
64 Phase Fraction [Molar Basis] 1.0000 0.0000 0.9958 0.0000	
65 Surface Tension (dyne/cm) 48.40 42.74	
66 Thermal Conductivity (W/m-K) 5.146e-002 0.2165 0.2274	
67 Viscosity (cP) 1.595e-002 17.13 3.715	
68 Cv (Semi-Ideal) (kJ/kgmole-C) 42.76 197.3 42.03 218.3	
69 Aspen Technology Inc. Aspen HYSYS Version 8.3 (29.0.0.8315)	Page 1 of 2



Case Name:

Unit Set:

BASE CASE SIMULATION MODEL.HSC

Date/Time: Mon Jun 09 12:53:25 2014

SI

LNG: 24-HJ-201 (continued)

8			•	•		
9			PROPERTIES			
10 11	Name	Inlet to 24-HJ-201	Cooling Medium Inlet 8		Cooling Medium Outlet 8	
12	Mass Cv (Semi-Ideal) (kJ/kg-C)	2.158	2.547	2.121	2.818	
13	Cv (kJ/kgmole-C)	39.85	194.1	33.28	213.3	
14	Mass Cv (kJ/kg-C)	2.011	2.506	1.680	2.753	
15	Cv (Ent. Method) (kJ/kgmole-C)		179.3		190.6	
16	Mass Cv (Ent. Method) (kJ/kg-C)		2.314		2.460	
17	Cp/Cv (Ent. Method)		1.147		1.189	
18	Reid VP at 37.8 C (kPa)		9.847e-004		9.847e-004	
19	True VP at 37.8 C (kPa)		3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.302e+006	1738	1.297e+006	1738	
21	Viscosity Index	-35.39	25.80		16.38	
22						
23						
24						
25						
26						
27						
25 26 27 28 29						
29						
30						
30 31 32 33 34 35 36 37						
33						
34						
35						
36						
37						
38 39 40 41						
39						
40						
41						
42						
43						
44 45 46 47						
45						
46						
47 48						
50						
51						
49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68						
53						
54						
55						
56						
57						
58						
59						
60						
61						
62						
63						
64						
60						
67						
68						

66 67 68 69 Aspen Technology Inc. Licensed to: NORWEGIAN UNIV OF **Appendix B – Process Datasheets for Heat Exchangers in Case Study I**



5

NORWEGIAN UNIV OF Burlington, MA USA

CASE STUDY 1.HSC Case Name:

Unit Set:

SI

Date/Time: Mon Jun 09 01:34:49 2014

6 Heat Exchanger: 20-HA-003 7 8 9 CONDITIONS 10 11 let to Stabilization Heater Name Heating Medium Inlet 3 t to Secondary Separator Heating Medium Outlet 3 12 0.0000 Vapour 0.0148 0.0000 0.0228 13 Temperature 54.9165 150.0000 77.6271 100.0000 (C) 14 (kPa) 800.0000 700.0000 1000.0000 * Pressure 1100.0000 * 15 (kgmole/h) 8980.9947 5125.8344 8980.9947 5125.8344 Molar Flow 16 Mass Flow 1184961.0373 397171.9902 1184961.0373 397171.9902 (kg/h) 17 Std Ideal Lig Vol Flow (m3/h) 1376.3849 357.8461 1376.3849 357.8461 18 Molar Enthalpy (kJ/kgmole) -3.867e+005 -4.912e+005 -3.797e+005 -5.035e+005 19 Molar Entropy (kJ/kgmole-C) 286.7 172.4 307.4 20 Heat Flow (kJ/h) -3.4728e+09 -2.5180e+09 -3.4101e+09 -2.5808e+09 21 PROPERTIES 22 23 Name let to Stabilization Heate Heating Medium Inlet 3 et to Secondary Separa Heating Medium Outlet 3 24 Molecular Weight 131.9 77.48 131.9 77.48 25 Molar Density (kgmole/m3) 4.801 12.94 3.918 13.60 26 Mass Density (kg/m3) 633.4 1003 516.9 1054 27 Act. Volume Flow (m3/h) 1871 396.1 2292 377.0 28 Mass Enthalpy (kJ/kg) -2931 -6340 -2878 -6498 29 Mass Entropy (kJ/kg-C) 2.173 2.224 2.330 1.828 30 307.0 Heat Capacity (kJ/kgmole-C) 295.6 255.2 234.3 3.294 31 Mass Heat Capacity 2.241 2.327 3.024 (kJ/kg-C) LHV Molar Basis (Std) 32 1.462e+006 1.462e+006 (kJ/kgmole) ------33 HHV Molar Basis (Std) (kJ/kgmole) 1.614e + 0.061.614e + 0.06------HHV Mass Basis (Std) 2.083e+004 2.083e+004 (kJ/kg) ------CO2 Loading ------------CO2 Apparent Mole Conc. (kgmole/m3) 36 0.0000 0.0000 37 CO2 Apparent Wt. Conc. (kgmol/kg) 0.0000 ---0.0000 LHV Mass Basis (Std) (kJ/kg) ----1.887e+004 ---1.887e+004 39 Phase Fraction [Vol. Basis] 5.810e-003 0.0000 9.251e-003 0.0000 40 Phase Fraction [Mass Basis] 2.457e-003 0.0000 4.328e-003 0.0000 41 Phase Fraction [Act. Vol. Basis] 0.2376 0.0000 0.0000 0.3646 (kJ/kg) 42 Mass Exergy 4.907 65.58 11.19 25.75 43 Partial Pressure of CO2 (kPa) 17.00 0.0000 16.10 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 444.5 835.8 ------46 14.32 Avg. Liq. Density (kgmole/m3) 6.525 14.32 6.525 47 295.6 255.2 307.0 234.3 Specific Heat (kJ/kgmole-C) 48 Std. Gas Flow (STD_m3/h) 2.124e+005 1.212e+005 2.124e+005 1.212e+005 49 Std. Ideal Liq. Mass Density 860.9 1110 860.9 1110 (kg/m3) 50 Act. Liq. Flow 0.3962 0.1100 0.4046 0.1047 (m3/s) 51 Z Factor 2.416e-002 2.371e-002 ------52 Watson K 11.63 8.816 11.63 8.816 53 User Property Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 Cp/(Cp - R) 55 1.034 1.028 1.037 1.029 56 Cp/Cv 1.002 1.064 1.002 1.062 57 Heat of Vap. (kJ/kgmole) 2.001e+005 7.244e+004 2.014e+005 7.313e+004 58 **Kinematic Viscosity** (cSt) ---1.147 2.315 59 Liq. Mass Density (Std. Cond) (kg/m3) 859.9 859.9 1130 1130 60 Liq. Vol. Flow (Std. Cond) 1378 351.5 1378 351.5 (m3/h) 61 Liquid Fraction 0.9852 1.000 0.9772 1.000 62 Molar Volume (m3/kgmole) 0.2083 7.728e-002 0.2552 7.355e-002 63 Mass Heat of Vap. (kJ/kg) 1517 934.9 1526 943.9 0.0000 64 Phase Fraction [Molar Basis] 0.0148 0.0000 0.0228 35.73 40.78 65 Surface Tension (dyne/cm) ------66 Thermal Conductivity 0.2310 0.2295 (W/m-K) ------Viscosity (cP) 67 1.150 2.438 ------Cv (Semi-Ideal) (kJ/kgmole-C) 287.3 298.7 226.0 246.9

Aspen Technology Inc. Licensed to: NORWEGIAN UNIV OF 141.7

aspentech

NORWEGIAN UNIV OF Burlington, MA USA Case Name: CASE

SI

Unit Set:

CASE STUDY 1.HSC

Date/Time: Mon Jun 09 01:34:49 2014

			PROP	ERTIES			
Name		let to Stabilization Heate	Heating Medi	um Inlet 3	et to Secondary Separa	Heating Medium Outlet 3	
Mass Cv (Semi-Ideal)	(kJ/kg-C)	2.178		3.187	2.264	2.916	
Cv	(kJ/kgmole-C)	295.1		240.0	306.4	220.5	
Mass Cv	(kJ/kg-C)	2.236		3.097	2.322	2.846	
Cv (Ent. Method)	(kJ/kgmole-C)			205.9		195.1	
Mass Cv (Ent. Method	l) (kJ/kg-C)			2.657		2.517	
Cp/Cv (Ent. Method)	" (D)			1.240		1.201	
Reid VP at 37.8 C	(kPa)	153.0	9.8	47e-004	153.0	9.847e-004	
True VP at 37.8 C Liq. Vol. Flow - Sum(S	(kPa)	1363 4500		3.420	1363	3.420	
Viscosity Index	aa. Cona) (mo/n)	17.24		351.5 5.070	<u>6172</u> 13.91	351.5 12.83	
		17.24	DET	AILS	13.91	12.05	
		Over	rall/Detaile	1			
Duty:			73e+07 kJ/h	UA Curv			0.00e-01 kJ/C-
Heat Leak:			00e-01 kJ/h		ch Temp:		100.0
Heat Loss:			00e-01 kJ/h		nch Temp:		54.92
UA:		1.158	e+06 kJ/C-h	Ft Facto			
Min. Approach: Lmtd:			45.08 C 54.17 C	Uncorre	cted Lmtd:		57.66
Linita.			34.17 0				



Case Name: CASE STUDY 1.HSC

Unit Set: SI

Date/Time: Mon Jun 09 01:40:16 2014

Heat Exchanger: 21-HB-001

9 10				COND	TIONS			
11	Name		H	ot Export Oil		Sea Water Inlet	Low Temp Export Oil	Sea Water Outlet
12	Vapour			0.0000		0.0000	0.0000	0.0000
13	Temperature	(C)		75.1186		8.0000 *	54.7998 *	45.0000 *
14	Pressure	(kPa)		750.0000		1000.0000 *	550.0000 *	900.0000 *
15	Molar Flow (kg	gmole/h)		6300.3826		17358.1373	6300.3826	17358.1373
16	Mass Flow	(kg/h)	11	38593.4197		312708.5873	1138593.4197	312708.5873
17	Std Ideal Liq Vol Flow	(m3/h)		1318.0638		313.3396	1318.0638	313.3396
18	Molar Enthalpy (kJ/	(kgmole)	-	4.319e+005		-2.877e+005	-4.401e+005	-2.847e+005
19	Molar Entropy (kJ/kg	mole-C)		402.2		48.59	378.2	58.47
20	Heat Flow	(kJ/h)	-	2.7214e+09		-4.9939e+09	-2.7727e+09	-4.9426e+09
21 22				PROPE	RTIES			
23	Name	Hot Ex	kport Oil	Sea Wate	r Inlet	Low Temp Export	Dil Sea Water Outlet	
24	Molecular Weight		180.7		18.02	180	.7 18.02	
25	Molar Density (kgmole/m3)		4.483		56.63	4.58	30 55.09	
26	Mass Density (kg/m3)		810.1		1020	827	.7 992.4	
27	Act. Volume Flow (m3/h)		1405		306.5	137		
28	Mass Enthalpy (kJ/kg)		-2390	-1.59	7e+004	-243		
29	Mass Entropy (kJ/kg-C)		2.225		2.697	2.09		
30	Heat Capacity (kJ/kgmole-C)		403.8		80.12	389		
31	Mass Heat Capacity (kJ/kg-C)		2.234		4.447	2.15		
32	LHV Molar Basis (Std) (kJ/kgmole)				0.0000		0.0000	
33	HHV Molar Basis (Std) (kJ/kgmole)			4.10	1e+004		4.101e+004	
34	HHV Mass Basis (Std) (kJ/kg)				2276		2276	
35	CO2 Loading							
36	CO2 Apparent Mole Conc. (kgmole/m3)	1	.120e-003		0.0000	1.144e-00	0.0000	
37	CO2 Apparent Wt. Conc. (kgmol/kg)		.383e-006		0.0000	1.383e-00		
38	LHV Mass Basis (Std) (kJ/kg)					1.0000 00		
39	Phase Fraction [Vol. Basis]		0.0000		0.0000	0.000	0.0000	
40	Phase Fraction [Mass Basis]		0.0000		0.0000	0.000		
41	Phase Fraction [Act. Vol. Basis]		0.0000		0.0000	0.000		
42	Mass Exergy (kJ/kg)		9.025		3.429	3.49		
43	Partial Pressure of CO2 (kPa)		0.0000		0.0000	0.000		
44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.000		
45	Act. Gas Flow (ACT_m3/h)		0.0000		0.0000	0.000		
46	Avg. Liq. Density (kgmole/m3)		4.780		55.40	4.78	30 55.40	
47	Specific Heat (kJ/kgmole-C)		403.8		80.12	389		
48	Std. Gas Flow (STD_m3/h)	1	490e+005	4 10	4e+005	1.490e+00		
49		1		4.10				
49 50	Std. Ideal Liq. Mass Density(kg/m3)Act. Liq. Flow(m3/s)		863.8 0.3904	0 54	998.0 14e-002	0.382		
51	Z Factor		0.3904		54e-002		6.177e-003	
52	Watson K		11.65	1.00		11.6		
53	User Property							
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.000		
54 55	Cp/(Cp - R)		1.021		1.116	1.02		
55 56	Ср/Ср - К) Ср/Сv		1.021		1.110	1.02		
56 57	Heat of Vap. (kJ/kgmole)	4	.985e+005	2 65	9e+004	1.999e+00		
	Kinematic Viscosity (cSt)	1	.985e+005 3.817	3.00	1.348	5.83		
58 59			854.3			854		
59 60	Liq. Mass Density (Std. Cond) (kg/m3)				1015 308.1			
60 61	Liq. Vol. Flow (Std. Cond) (m3/h) Liquid Fraction		1333		1.000	130		
	•			4 70		1.00		
62	Molar Volume (m3/kgmole)		0.2231	1./t	66e-002	0.218		
63	Mass Heat of Vap. (kJ/kg)		1098		2031	110		
64	Phase Fraction [Molar Basis]		0.0000		0.0000	0.000		
65 66	Surface Tension (dyne/cm)				75.03		68.62	
66	Thermal Conductivity (W/m-K)		0.1171	<u> </u>	0.5834	0.119		
67	Viscosity (cP)		3.092		1.375	4.83		
68	Cv (Semi-Ideal) (kJ/kgmole-C)		395.5		71.81	380	.9 71.57	
69	Aspen Technology Inc.		Aspen	HYSYS Versi		9.0.0.8315)		Page 1 of 2 * Specified by user

Licensed to: NORWEGIAN UNIV OF

aspentech

NORWEGIAN UNIV OF Burlington, MA USA Case Name: CASE STUDY 1.HSC

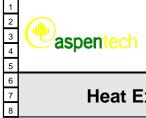
Unit Set:

SI

Date/Time: Mon Jun 09 01:40:16 2014

) 0			PROPE	RTIES			
1	Name	Hot Export Oil	Sea Wate	r Inlet	Low Temp Export Oil	Sea Water Outlet	
2	Mass Cv (Semi-Ideal) (kJ/kg-C)	2.188		3.986	2.108	3.973	
3	Cv (kJ/kgmole-C)	319.3		70.88	307.8	69.28	
4	Mass Cv (kJ/kg-C)	1.767		3.935	1.703	3.846	
5	Cv (Ent. Method) (kJ/kgmole-C)						
6	Mass Cv (Ent. Method) (kJ/kg-C)						
7	Cp/Cv (Ent. Method)						
8	Reid VP at 37.8 C (kPa)	34.23		6.442	34.23	6.442	
9	True VP at 37.8 C (kPa)	108.5		6.442	108.5	6.442	
0 1	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1322		308.1	1322	308.1	
	Viscosity Index	15.90		7.070	18.97	-4.906	
2 3			DET	AILS			
4 5		Ove	rall/Detaile	d Perfo	rmance		
6	Duty:	5.1	31e+07 kJ/h	UA Cur	v. Error:		0.00e-01 kJ/C·
7	Heat Leak:	0.0	00e-01 kJ/h		ch Temp:		75.12
8	Heat Loss:	0.0	000e-01 kJ/h	Cold Pi	nch Temp:		45.00
9	UA:	1.499	e+06 kJ/C-h	Ft Facto	or:		
0	Min. Approach:		30.12 C	Uncorre	ected Lmtd:		37.85
	Lmtd:		34.23 C				
2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9							

Appendix C – Process Datasheets for Heat Exchangers in Case Study II



Case Name: CASE STUDY 2.HSC

SI

Unit Set:

Date/Time: Mon Jun 09 13:33:25 2014

Heat Exchanger: 24-HA-102

9 10				COND	ITIONS				
11	Name		Fiel	d 1 Wet Gas	Heating	Medium Inlet 4	Field 1	Gas to Contactor	Heating Medium Outlet 4
12	Vapour			1.0000		0.0000		1.0000	0.0000
13	Temperature	(C)		25.0000		100.0000		28.0000 *	90.0000 *
14	Pressure	(kPa)		4930.0000		1000.0000		4830.0000 *	900.0000 *
15	Molar Flow (kg	gmole/h)		48543.5493		3557.8692		48543.5493	3557.8692
16	Mass Flow	(kg/h)	9	57248.8623		275679.2127		957248.8623	275679.2127
17	Std Ideal Liq Vol Flow	(m3/h)		2811.6945		248.3829		2811.6945	248.3829
18	•	(kgmole)		8.352e+004		-5.035e+005		-8.335e+004	-5.058e+005
19		mole-C)		152.6		141.7		153.3	135.4
20	Heat Flow	(kJ/h)		4.0544e+09		-1.7913e+09		-4.0461e+09	-1.7996e+09
21 22				PROPE	ERTIES				
23	Name	Field 1	Wet Gas	Heating Medi	um Inlet 4	Field 1 Gas to Co	ntactorHe	eating Medium Outle	et 4
24	Molecular Weight		19.72		77.48	1	9.72	77.48	3
25	Molar Density (kgmole/m3)		2.271		13.60	2	.184	13.72	2
26	Mass Density (kg/m3)		44.78		1054	4	3.08	1063	3
27	Act. Volume Flow (m3/h)	2	.138e+004		261.7	2.222e-	+004	259.3	3
28	Mass Enthalpy (kJ/kg)		-4235		-6498	-4	4227	-6528	8
29	Mass Entropy (kJ/kg-C)		7.739		1.828	7	.776	1.74	7
30	Heat Capacity (kJ/kgmole-C)		48.89		234.3	4	8.50	230.4	4
31	Mass Heat Capacity (kJ/kg-C)		2.479		3.024	2	.460	2.974	4
32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006			1.462e+00	6
33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006			1.614e+00	6
34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+004	4
35	CO2 Loading								-
36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.000)
37	CO2 Apparent Wt. Conc. (kgmol/kg)				0.0000			0.000)
38	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004			1.887e+004	4
39	Phase Fraction [Vol. Basis]		1.000		0.0000	1	.000	0.000	
40	Phase Fraction [Mass Basis]		1.000		0.0000	1	.000	0.000)
41	Phase Fraction [Act. Vol. Basis]		1.000		0.0000		.000	0.000	
42	Mass Exergy (kJ/kg)		472.8		25.75	4	70.6	19.80	0
43	Partial Pressure of CO2 (kPa)		77.39		0.0000	7	5.82	0.000)
44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.0	0000	0.000)
45	Act. Gas Flow (ACT_m3/h)	2	.138e+004			2.222e+			-
46	Avg. Liq. Density (kgmole/m3)		17.26		14.32	1	7.26	14.3	2
47	Specific Heat (kJ/kgmole-C)		48.89		234.3	4	8.50	230.4	4
48	Std. Gas Flow (STD_m3/h)	1	.148e+006	8.41	2e+004	1.148e+	+006	8.412e+004	4
49	Std. Ideal Liq. Mass Density (kg/m3)		340.5		1110	3	40.5	111(0
50	Act. Liq. Flow (m3/s)		0.0000	7.26	69e-002			7.204e-002	2
51	Z Factor				71e-002	0.8	3831	2.173e-002	
52	Watson K		17.97		8.816		7.97	8.810	
53	User Property								-
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	0000	0.000	0
55	Cp/(Cp - R)		1.205		1.037	1	.207	1.03	7
56	Cp/Cv		1.489		1.062		.472	1.062	
57	Heat of Vap. (kJ/kgmole)		9666	7.31	3e+004		9771	7.380e+004	4
58	Kinematic Viscosity (cSt)		0.2819		2.315	0.2	2939	2.80	7
59	Liq. Mass Density (Std. Cond) (kg/m3)		0.8365		1130		3365	1130	
60	Liq. Vol. Flow (Std. Cond) (m3/h)	1	.144e+006		244.0	1.144e+		244.0	
61	Liquid Fraction		0.0000		1.000		0000	1.000	
62	Molar Volume (m3/kgmole)		0.4404	7.35	55e-002		4578	7.289e-002	
63	Mass Heat of Vap. (kJ/kg)		490.2		943.9		95.5	952.	
64	Phase Fraction [Molar Basis]		1.0000		0.0000		0000	0.000	
65	Surface Tension (dyne/cm)				40.78			41.70	
66	Thermal Conductivity (W/m-K)		3.558e-002		0.2295	3.580e	-002	0.228	
67	Viscosity (cP)		1.262e-002		2.438	1.266e		2.984	
68	Cv (Semi-Ideal) (kJ/kgmole-C)		40.57		226.0		0.19	222.	
69	Aspen Technology Inc.			YSYS Versi		<u> </u>	0.10		Page 1 of 2
- 33			Aspent			-0.0.0.0010)			Tage TUIZ

Licensed to: NORWEGIAN UNIV OF



Case Name:

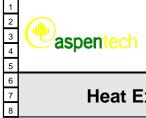
Unit Set:

CASE STUDY 2.HSC

SI

Date/Time: Mon Jun 09 13:33:25 2014

6 7 8	Heat Exchang	ger: 24-HA-	-102 (co	ontin	ued)		
9			PROPE	RTIES			
10	N	E 11 4 1 4 1 4	1				
11 12	Name Mass Cv (Semi-Ideal) (kJ/kg-C)	Field 1 Wet Gas 2.057	Heating Medi	2.916	Field 1 Gas to Contactor 2.038	Heating Medium Outlet 4 2.867	
13	Cv (kJ/kgmole-C)	32.82		220.5	32.94	216.9	
14	Mass Cv (kJ/kg-C)	1.665		2.846	1.671	2.799	
15	Cv (Ent. Method) (kJ/kgmole-C)			195.1		192.7	
16	Mass Cv (Ent. Method) (kJ/kg-C)			2.517		2.487	
17	Cp/Cv (Ent. Method)			1.201		1.196	
18	Reid VP at 37.8 C (kPa)		9.84	47e-004		9.847e-004	
19	True VP at 37.8 C (kPa)			3.420		3.420	
20	Liq. Vol. Flow - Sum(Std. Cond) (m3/h)	1.144e+006		244.0	1.144e+006	244.0	
21	Viscosity Index			12.83		14.60	
22 23			DET	AILS			
24 25		Ove	rall/Detaile	d Perfo	rmance		
26	Duty:		0.00e-01 kJ/C-h				
27	Heat Leak:		16e+06 kJ/h 000e-01 kJ/h		v. Error: ch Temp:		90.00 C
28	Heat Loss:	0.0	000e-01 kJ/h	Cold Pi	nch Temp:		25.00 C
29	UA:	1.216	6e+05 kJ/C-h	Ft Facto			
30	Min. Approach:		65.00 C	Uncorre	ected Lmtd:		68.44 C
31	Lmtd:		68.37 C				
32 33							
34 35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52 53							
54 55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69	Aspon Tochnology Inc	A 1	11/01/01/		20.0.0.8215)		Page 2 of 2



Case Name: CASE STUDY 2.HSC

SI

Unit Set:

Date/Time: Mon Jun 09 13:36:00 2014

Heat Exchanger: 24-HA-202

Insme Field 2 Wei Gas Heating Medium Units Field 2 Gas to Control Heating Medium Units 10 Trongenium (C) 25.0000 100.0000 20.0000 900.000 11 Trongenium (P) 5420.0000 100.0000 5230.0000 900.0000 15 Marg Flow (b) 5420.0000 100.0000 5330.0000 900.0000 16 Marg Flow (b) 9420.000 100.0000 100.0000 100.0000 100.0000 10 Marg Flow (b) 9400.000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.000 <td< th=""><th>9 10</th><th></th><th></th><th></th><th>COND</th><th>ITIONS</th><th></th><th></th><th></th><th></th></td<>	9 10				COND	ITIONS				
Instrument 1.000 0.000 1.000 0.000 13 Temportune (F) 25.000 900. 14 Pressure (Mai) 5498.7165 6115.511 5498.7174 3188.788 13 Maiar Envire (Wynh) 104435.7174 3188.788 207.3137 3185.7789 207.3137 3185.7789 207.3137 3185.7789 207.3137 3185.7789 207.3137 3185.7789		Name		Fiel	d 2 Wet Gas	Heating	Medium Inlet 5	Field 2	Gas to Contactor	Heating Medium Outlet 5
IP Pressure (b/a) 5420.000 100.000 5330.000 5300.	12	Vapour								0.0000
In Mass Prov (Rym) 54998.7165 4115.111 54989.7165 4115.1 ID Mass From (Rubh) 3185.7769 280 1989.3350 1094935.7174 318989.3350 1094935.7174 318989.3350 ID Mass Enthalpy (Rubhgrobe) -8.364+004 -6.0356+005 -6.397+004 -5.6569+ ID Mass Enthalpy (Rubhgrobe) -15.1 11.1 11.2 -11.2 ID Heat Flow (Rubhgrobe) -6.036+001 -2.0721+040 -4.3006+09 -2.0721+050 ID Heat Flow (Rubhgrobe) -15.1 11.17 15.2 -11 ID Heat Flow (Rubhgrobe) -15.3 11.00 2.0721+0401 -4.3006+09 -2.0871+04 ID Heat Flow (Rubhgrobe) -15.3 11.02 <td>13</td> <td>Temperature</td> <td>(C)</td> <td></td> <td>25.0000</td> <td></td> <td>100.0000 *</td> <td></td> <td>28.0000 *</td> <td>90.0000 *</td>	13	Temperature	(C)		25.0000		100.0000 *		28.0000 *	90.0000 *
In Mass Flow (rgdh) 104435.7774 31888.333 104435.7774 31888.333 18 Malar Enthalpy (kulkgmole) -8.364+004 -6.035+025 -8.347+004 -5.055e+ 19 Malar Enthalpy (kulkgmole) -8.364+004 -6.035e+025 -8.347e+004 -5.055e+ 10 Malar Enthalpy (kulkgmole) -10.5 11.1.7 102.2 1 21 Name Field 2 Wei Gas Heating Medium Weits Field 2 Gas to Constack - leasing Medium Outlet 5 23 Malar Density (kgmol) 2.632 7.748 19.72 7.744 24 Malar Density (kgmol) 2.633 13.60 2.437 13.72 25 Malar Density (kgmol) 2.174e-004 302.71 2.207e-004 300.0 26 Mass Entropy (kulkgmole) -60.066 2.243 40.61 2.2074 26 Mass Entropy (kulkgmole) -60.060 -60.0700 -60.070 27 Mass Means (Sidi)<(kulkgmole)	14	Pressure	(kPa)		5420.0000		1000.0000 *		5320.0000 *	900.0000 *
In Mass Flow (tydf) 1084435.7174 31888333 1084835.7174 3188833 10 Malar Enhicity (kJkgmathe) -5.038+005 -2.0271+006 -2.0271+010 -4.0000+000 -2.0271+010 -4.0000+00 -2.0271+010 -4.0000+00 -2.0271+010 -7.038 -1.028 -7.019 7.038 -2.027 7.748 1.972 7.744 -0.0000 -0.0000 -0.0000 -0.000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.000	15	Molar Flow (k	gmole/h)		54998.7165		4115.5191		54998.7165	4115.5191
In Mailar Entropy (kJkgmole) =3:384:404 <5:035:005 =3:377:004 <5:035:005 10 Mailar Entropy (kJkgmole) -1:0001:r09 -2:0721:e-00 -4:0002:r09 -2:0721:e-004 -2:072:e-004 -2:072:e-004	16	Mass Flow	(kg/h)	10	84635.7174		318888.3536		1084635.7174	318888.3536
19 Mailer Entropy (U,M)	17	Std Ideal Liq Vol Flow	(m3/h)		3185.7768		287.3137		3185.7768	287.3137
19 Mailer Entropy (U,M)	18	Molar Enthalpy (kJ	/kgmole)	-	8.364e+004		-5.035e+005		-8.347e+004	-5.058e+005
21 PROFERTIES 22 Name Field 2 Wei Gas Heating Medium Intel 5 Field 2 Gas to Contactol Heating Medium Outlet 5 23 Molar 19.72 77.48 19.72 77.48 24 Molar Density (kgmole/m3) 2.530 13.60 2.437 13.72 26 Mass Density (kgmole/m3) 2.174e-004 300.27 2.257e-004 300.0 27 Act. Volume Flow (kLkg-C) 7.682 1.428 7.719 1.747 34 Mess Entrapy (kLkg-C) 2.539 3.024 2.515 2.974 21 Lift Molar Basis (Std) (kLkgmole) 1.462e-006 1.462e-006 23 HMV Mara Basis (Std) (kLkgmole) 1.462e-006 1.614e-006 24 Lift Molar Basis (Std) (kLkgmole)	19	Molar Entropy (kJ/kg	gmole-C)		151.5		141.7		152.2	135.4
PROPERTIES 22 Name Field 2 Wei Gas Heating Medium Intel 5 Field 2 Gas to Contactor-Heating Medium Outlet (24 Molecular Weight (kgmole/ms) 2.530 13.60 2.437 13.72 25 Mass Density (kgmole/ms) 2.530 13.60 2.437 13.72 26 Mass Density (kgmole/ms) 2.178+004 302.7 2.557+004 300.0 27 Act Volume Flow (MAR) -4244 -6498 -4232 -6528 26 Mass Entropy (kJkgmole) -4244 -6498 -4232 -6528 26 Mass Entropy (kJkgmole) -1402 -0649 -4232 -6528 26 Heat Capacity (kJkgmole) -1.1614-066 -1.1614+066 -1.1614+066 21 HrV Molar Basis (Stat) (kJkgmole) 1.802+004 0.0000 20 Zaparent Male Conce. (kgmole/ms) 0.0000 0.0000 20 Zaparent Male Conce. (kgmole/ms)	20	Heat Flow	(kJ/h)	-	4.6001e+09		-2.0721e+09		-4.5905e+09	-2.0817e+09
Name Field 2 Wei Gas Heating Medium Intel 5 Field 2 Gas to ContactorHeating Medium Outlet 5 21 Moler Density (kgmole/m3) 2.530 13.60 2.437 13.72 25 Molar Density (kgmole/m3) 2.530 13.60 2.437 13.72 26 Mass Density (kgmole/m3) 44.89 1054 44.05 1063 27 Act. Volume Flow (m3h) 2.174e+004 302.7 2.257e+004 300.0 28 Mass Entropy (kJkgroc) 7.682 1.828 7.719 1.747 20 Mass Entropy (kJkgroc) 2.539 3.024 2.515 2.974 31 Mass Heat Capacity (kJkgroc) 2.539 3.024 2.515 2.974 32 HrW Mars Basis (Sts) (kJkgroc) 1.462e+106 1.64e+106 33 HrW Mass Basis (Sts) (kJkgroc) 0.0000 0.0000 34 HrW Mass Basis (Sts) (kJkgroc) 0.0000					PROPE	ERTIES				
Maiz Density (kgmolem3) 2.530 13.60 2.437 13.72 28 Mass Density (kgmolem3) 2.530 13.60 2.437 13.72 24 Act. Volume Flow (m3h) 2.174e-t004 300.0 300.0 28 Mass Enthalpy (kJkgr) -4.241 6498 -4232 6528 30 Mass Entropy (kJkgr) -7.682 1.828 7.719 1.747 30 Heat Capacity (kJkgr) -2.539 3.024 2.515 2.2974 31 Mass Heat Capacity (kJkgr) 1.462e1006 1.462e1006 31 HHV Mass Basis (St) (kJkgr) 1.614e1006 1.462e1006 32 HHV Mass Basis (St) (kJkg) 0.0000 0.0000 33 CO2 Loading 0.0000 0.0000 34 HHV Mass Basis (St) (kJkg) 1.887e1004 1.887e1004		Name	Field 2	Wet Gas	Heating Medi	um Inlet 5	Field 2 Gas to Co	ntactorHe	ating Medium Outle	et 5
Sec Mass Density (kg/m3) 49.80 1054 48.05 1063 22 Act. Volume Flow (m3h) 2.174e+004 302.7 2.257e+004 300.0 Mass Entholpy (kJkg) -4.241 -6.498 4.222 -6.528 20 Mass Entropy (kJkgrob) 7.782 1.828 7.719 1.747 21 Mass Heat Capacity (kJkgrob) - 1.462e+006 - 1.614e+006 21 HrV Male Basis (Std) (kJkgrob) - 1.161e+006 - 1.614e+006 31 HrV Mass Basis (Std) (kJkgrob) - 0.0000 - 0.0000 32 CO2 Langing - 0.1614e+006 - 0.1614e+006 34 HrV Mass Basis (Std) (kJkg) - 0.0000 - 0.0000 34 LrV Mass Basis (Std) (kJkg) - 1.87e+004 - 0.0000 35 CO2 Apparent Mole Conc. (kgmolekg) - 0.187e+004 - 0.87e+004	24	Molecular Weight		19.72		77.48	1	9.72	77.4	8
27 Act. Volume Flow (m3/h) 2.174e+004 302.7 2.257e+004 300.0 28 Mass Enthalpy (kJkg-C) 7.682 1.828 7.719 1.747 30 Heat Capacity (kJkg-C) 2.506 2.24.3 449.61 220.4 31 Mass Feat Capacity (kJkg-C) 2.539 3.024 2.515 2.974 32 HHV Maar Basis (Std) (kJkg-Ol) 2.539 3.024 2.515 2.974 33 HHV Maar Basis (Std) (kJkg-Ol) 1.1614e+006 1.1614e+006 34 HHV Mass Basis (Std) (kJkg) 2.083e+004 0.0000 35 CO2 Loading 0.0000 0.0000 0.0000 34 HV Mass Basis (Std) (kJkg) 1.887e+004 1.887e+004 1.887e+004 1.887e+004 1.887e+004 1.887e+004 1.887e+004 1.887e+004	25	Molar Density (kgmole/m3)		2.530		13.60	2	.437	13.7	2
28 Mass Entropy (kJkg) -4241 -6498 -4232 -66528 20 Mass Entropy (kJkgrole C) 7.782 1.828 7.719 1.1471 31 Mass Entropy (kJkgrole C) 2.508 3.024 2.515 2.974 32 LHY Mars Basis (Std) (kJkgrole) 1.462e+006 1.462e+006 33 HHY Mass Basis (Std) (kJkgrole) 1.614e+006 1.462e+006 34 HHY Mass Basis (Std) (kJkgrole) 1.614e+006 1.614e+006 34 HTY Mass Basis (Std) (kJkg) 0.0000 0.0000 35 CO2 Apparent Mb Conc. (kgmolkg) 0.0000 0.0000 36 LHV Mass Basis (Std) (kJkg) 1.867e+004 1.887e+004 37 Pasas Fraction [Xot Jaskis] 1.000 0.0000 1.000 0.0000 38 Pasas Fraction [Act Jos Basis] 1.000	26	Mass Density (kg/m3)		49.89		1054	4	8.05	106	3
22 Mass Entropy (kJkg-G) 7.882 1.828 7.719 1.747 30 Heat Capacity (kJkg-G) 50.06 234.3 49.81 220.4 31 Mass Heat Capacity (kJkg-M) 2.515 2.974 32 LHV Molar Basis (Std) (kJkg-M) 1.462e+006 1.814e+006 33 HHV Malar Basis (Std) (kJkg-M) 2.083e+004 0.0000 34 CO2 Loading 35 CO2 Apparent Mide Conc. (kgmolem3) 0.0000 0.0000 36 CO2 Apparent Mide Conc. (kgmolem3) 0.0000 0.0000 36 CO2 Apparent Mide Conc. (kgmolem3) 0.0000 0.0000 0.0000 37 CO2 Apparent Mide Conc. (kgmolem3) 1.887e+004 1.887e+004 40 Phase Fraction (Mass Basis) 1.000 0.0000 1.000 0.0000 41	27	Act. Volume Flow (m3/h)	2	.174e+004		302.7	2.257e-	+004	300.	0
20 Heat Capacity (kJkgmole-C) 50.06 234.3 49.61 230.4 31 Mass Heat Capacity (kJkgroc) 2.539 3.024 2.515 2.974 32 LHV Molar Basis (Std) (kJkgrod) 1.462e+006 1.462e+006 33 HHV Mass Basis (Std) (kJkgrod) 1.642e+006 1.462e+006 34 HHV Mass Basis (Std) (kJkgrod) 2.038e+004 34 CO2 Leading 0.0000 0.0000 35 CO2 Apparent Muc Conc. (kgmolkg) 0.0000	28	Mass Enthalpy (kJ/kg)		-4241		-6498	-4	4232	-652	8
31 Mass Heat Capacity (k/kg-C) 2.539 3.024 2.515 2.974 32 LHV Molar Basis (Std) (k/kgmole) 1.462e+006 1.462e+006 34 HHV Molar Basis (Std) (k/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (k/kg) 0.0000 35 CO2 Loading 0.0000 0.0000 0.0000 36 CO2 Apparent Mule Conc. (kgmolkg) 0.0000 0.0000 37 CO2 Apparent Mule Conc. (kgmolkg) 0.0000 1.000 0.0000 39 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 41 Mass Exergy (k/kg) 443.1 2.575 481.1 1.9.80 43 Partial Pressure of CO2 (kPa) 8.508 0.0	29	Mass Entropy (kJ/kg-C)		7.682		1.828	7	.719	1.74	7
22 LHV Molar Basis (Std) (kJ/kgmole) 1.462e+006 1.462e+006 33 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004 35 CO2 Loading 0.0000 0.0000 36 CO2 Apparent ML Conc. (kgmole/m3) 0.0000 0.0000 37 CO2 Apparent ML Conc. (kgmole/m3) 0.0000 0.0000 38 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Mass Basis] 1.000 0.0000 0.0000 0.0000 42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.06 0.0000 0.0000 0.0000 44 Cast Base on Flow (Cost/s) 0.0000 0.0000 0.0000 <td>30</td> <td>Heat Capacity (kJ/kgmole-C)</td> <td></td> <td>50.06</td> <td></td> <td>234.3</td> <td>4</td> <td>9.61</td> <td>230.4</td> <td>4</td>	30	Heat Capacity (kJ/kgmole-C)		50.06		234.3	4	9.61	230.4	4
53 HHV Molar Basis (Std) (kJ/kgmole) 1.614e+006 1.614e+006 34 HHV Mass Basis (Std) (kJ/kg) 2.083e+004 2.083e+004 35 CO2 Loading 36 CO2 Capparent Mole Conc. (kgmole/m3) 0.0000 0.0000 37 CO2 Apparent Mole Conc. (kgmole/m3) 0.0000 0.0000 38 LHV Mass Basis (Std) (kJ/kg) 1.87e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Mass Basis] 1.000 0.0000 0.0000 0.0000 42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 42 Mass Exergy (kJ/kgmole) 0.1726 1.43.2 1.726 1.43.2	31	Mass Heat Capacity (kJ/kg-C)		2.539		3.024	2	.515	2.97	4
34 HHV Mass Basis (Std) (k.l/kg) 2.083e+004 2.083e+004 35 CO2 Loading 36 CO2 Apparent Mole Conc. (kgmolem3) 0.0000 0.0000 36 CO2 Apparent Mole Conc. (kgmolem3) 0.0000 0.0000 37 LHV Mass Basis (Std) (k.l/kg) 1.887e+004 0.0000 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 0.351 0.0000 42 Mass Exargy (k.l/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000	32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006			1.462e+00	6
35 CO2 Loading 36 CO2 Apparent Mide Conc. (kgmole/m3) 0.0000 0.0000 37 CO2 Apparent Mide Conc. (kgmole/m3) 0.0000 0.0000 37 CO2 Apparent Mide Conc. (kgmole/m3) 1.887e+004 1.887e+004 39 Phase Fraction (Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Act Vol. Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act Vol. Basis] 1.000 0.0000 0.0000 0.0000 42 Mass Exergy (ku/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act Gas Flow (K/Lgmole/C) 50.06 234.3 49.61 230.4	33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006			1.614e+00	6
35 CO2 Apparent Mole Conc. (kgmol/kg) 0.0000 0.0000 37 CO2 Apparent W. Conc. (kgmol/kg) 0.0000 0.0000 38 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (KT_mxh) 2.174e+004 2.257e+004 46 Std. Gas Flow (STD_m3/h) 1.74e+004 2.81a	34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+004	4
37 CO2 Apparent Wt. Conc. (kgmol/kg) 0.0000 0.0000 38 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 8.51 0.0000 42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 8.000 0.0000 44 Cost Based on Flow (Cost's) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 4.42 45 Std. Gas Flow (StD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Idea Llq, Mass Density (kg/m	35	CO2 Loading								
3 LHV Mass Basis (Std) (kJ/kg) 1.887e+004 1.887e+004 39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 86.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost%) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole/m3) 13.00e+006 9.731e+004 8.33e+002 5 48 Std. Cas Flow (STD_m3/h) 1.300	36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.000	0
39 Phase Fraction [Vol. Basis] 1.000 0.0000 1.000 0.0000 40 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy (kJ/kg) 443.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/m) 0.174e+004 2.257e+004 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Lip. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Lip. Mass Density (kg/m3) 340.5 11110 </td <td>37</td> <td>CO2 Apparent Wt. Conc. (kgmol/kg)</td> <td></td> <td></td> <td></td> <td>0.0000</td> <td></td> <td></td> <td>0.000</td> <td>0</td>	37	CO2 Apparent Wt. Conc. (kgmol/kg)				0.0000			0.000	0
40 Phase Fraction [Mass Basis] 1.000 0.0000 1.000 0.0000 41 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy (kJkg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 0.0000 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole/C) 5.0.06 23.43 49.61 230.4 48 Std. deal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.088e-002	38	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004			1.887e+00	4
4 Phase Fraction [Act. Vol. Basis] 1.000 0.0000 1.000 0.0000 42 Mass Exergy (kJkg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 83.51 0.0000 44 Cost Based on Flow (CostVs) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJkgmole-C) 50.06 234.3 48.61 230.4 48 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816	39	Phase Fraction [Vol. Basis]		1.000		0.0000	1	.000	0.000	0
42 Mass Exergy (kJ/kg) 483.1 25.75 481.1 19.80 43 Partial Pressure of CO2 (kPa) 85.08 0.0000 83.51 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e4004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e+002 8.338e+002 51 Z Factor 2.371e+002 0.8720 2.173e+002 52 Watson K 17.97 8.816	40	Phase Fraction [Mass Basis]		1.000		0.0000	1	.000	0.000	0
41 Partial Pressure of CO2 (kPa) 85.08 0.0000 83.51 0.0000 44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property <td< td=""><td>41</td><td>Phase Fraction [Act. Vol. Basis]</td><td></td><td>1.000</td><td></td><td>0.0000</td><td>1</td><td>.000</td><td>0.000</td><td>0</td></td<>	41	Phase Fraction [Act. Vol. Basis]		1.000		0.0000	1	.000	0.000	0
44 Cost Based on Flow (Cost/s) 0.0000 0.0000 0.0000 45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (KPa) 0.0000 0.0000 0.0000 55 Cp	42	Mass Exergy (kJ/kg)		483.1		25.75	4	81.1	19.8	0
45 Act. Gas Flow (ACT_m3/h) 2.174e+004 2.257e+004 46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.338e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/Cv 1.520 1.062 1.501 1.062 56 Cp/Cv 1.520 1.662 1.501 1.062 57 <	43	Partial Pressure of CO2 (kPa)		85.08		0.0000	8	3.51	0.000	0
46 Avg. Liq. Density (kgmole/m3) 17.26 14.32 17.26 14.32 47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.33a-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 11.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cy - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. </td <td>44</td> <td>Cost Based on Flow (Cost/s)</td> <td></td> <td>0.0000</td> <td></td> <td>0.0000</td> <td>0.0</td> <td>0000</td> <td>0.000</td> <td>0</td>	44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.0	0000	0.000	0
47 Specific Heat (kJ/kgmole-C) 50.06 234.3 49.61 230.4 48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 L	45	Act. Gas Flow (ACT_m3/h)	2	.174e+004			2.257e-	+004		
48 Std. Gas Flow (STD_m3/h) 1.300e+006 9.731e+004 1.300e+006 9.731e+004 49 Std. Ideal Liq, Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq, Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.31ae+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq, Mass	46	Avg. Liq. Density (kgmole/m3)		17.26		14.32	1	7.26	14.3	2
49 Std. Ideal Liq. Mass Density (kg/m3) 340.5 1110 340.5 1110 50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 10 Higuid Fraction 0.0000 1.000 0.0000 1.000 60 Liq. Vol. Flow (Std. Cond) (m	47	Specific Heat (kJ/kgmole-C)		50.06		234.3	4	9.61	230.4	4
50 Act. Liq. Flow (m3/s) 0.0000 8.408e-002 8.333e-002 51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction <td< td=""><td>48</td><td>Std. Gas Flow (STD_m3/h)</td><td>1</td><td>.300e+006</td><td>9.73</td><td>1e+004</td><td>1.300e-</td><td>+006</td><td>9.731e+00</td><td>4</td></td<>	48	Std. Gas Flow (STD_m3/h)	1	.300e+006	9.73	1e+004	1.300e-	+006	9.731e+00	4
51 Z Factor 2.371e-002 0.8720 2.173e-002 52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis]	49	Std. Ideal Liq. Mass Density (kg/m3)		340.5		1110	3	40.5	111	0
52 Watson K 17.97 8.816 17.97 8.816 53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap.	50	Act. Liq. Flow (m3/s)		0.0000	8.40	08e-002			8.333e-00	2
53 User Property 54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5	51	Z Factor			2.37	71e-002	0.8	3720	2.173e-00	2
54 Partial Pressure of H2S (kPa) 0.0000 0.0000 0.0000 0.0000 55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.00000 1.0000 0.0000 <td>52</td> <td>Watson K</td> <td></td> <td>17.97</td> <td></td> <td>8.816</td> <td>1</td> <td>7.97</td> <td>8.81</td> <td>6</td>	52	Watson K		17.97		8.816	1	7.97	8.81	6
55 Cp/(Cp - R) 1.199 1.037 1.201 1.037 56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76	53	User Property								-
56 Cp/Cv 1.520 1.062 1.501 1.062 57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.63	54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	0000	0.000	0
57 Heat of Vap. (kJ/kgmole) 9171 7.313e+004 9278 7.380e+004 58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	55	Cp/(Cp - R)		1.199		1.037	1	.201	1.03	7
58 Kinematic Viscosity (cSt) 0.2570 2.315 0.2675 2.807 59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	56	Cp/Cv		1.520		1.062	1	.501	1.06	2
59 Liq. Mass Density (Std. Cond) (kg/m3) 0.8365 1130 0.8365 1130 60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	57	Heat of Vap. (kJ/kgmole)		9171	7.31	3e+004	9	9278	7.380e+00	4
60 Liq. Vol. Flow (Std. Cond) (m3/h) 1.297e+006 282.2 1.297e+006 282.2 61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	58	Kinematic Viscosity (cSt)		0.2570		2.315	0.2	2675	2.80	7
61 Liquid Fraction 0.0000 1.000 0.0000 1.000 62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	59	Liq. Mass Density (Std. Cond) (kg/m3)		0.8365		1130	0.8	3365	113	0
62 Molar Volume (m3/kgmole) 0.3953 7.355e-002 0.4104 7.289e-002 63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.00000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	60	Liq. Vol. Flow (Std. Cond) (m3/h)	1	.297e+006		282.2	1.297e-	+006	282.3	2
63 Mass Heat of Vap. (kJ/kg) 465.1 943.9 470.4 952.5 64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	61	Liquid Fraction		0.0000		1.000	0.0	0000	1.00	0
64 Phase Fraction [Molar Basis] 1.0000 0.0000 1.0000 0.0000 65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	62	Molar Volume (m3/kgmole)		0.3953	7.35	55e-002	0.4	4104	7.289e-00	2
65 Surface Tension (dyne/cm) 40.78 41.76 66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	63	Mass Heat of Vap. (kJ/kg)		465.1		943.9	4	70.4	952.	5
66 Thermal Conductivity (W/m-K) 3.617e-002 0.2295 3.637e-002 0.2285	64	Phase Fraction [Molar Basis]		1.0000		0.0000	1.0	0000	0.000	0
	65	Surface Tension (dyne/cm)				40.78			41.7	6
	66	Thermal Conductivity (W/m-K)	:	3.617e-002		0.2295	3.637e	-002	0.228	5
	67	Viscosity (cP)		1.282e-002		2.438			2.98	4
68 Cv (Semi-Ideal) (kJ/kgmole-C) 41.75 226.0 41.29 222.1	68					226.0	4	1.29	222.	1
	69			Aspen H	IYSYS Versi	ion 8.3 (2	29.0.0.8315)			Page 1 of 2

Licensed to: NORWEGIAN UNIV OF



Case Name:

Unit Set:

CASE STUDY 2.HSC

SI

Date/Time: Mon Jun 09 13:36:00 2014

PROPERTIES PROPERTIES INTER STATE OF CONSTRUCTION Plating Networn Outer 5 2016 2006 2007 <th cols<="" th=""><th>6 7</th><th colspan="10"></th></th>	<th>6 7</th> <th colspan="10"></th>	6 7										
International Number (Number (N	9			PROPE	RTIES							
10 Corr C		Nama	Field 2 Wat Gas			Field 2 Cas to Contactor	Heating Medium Outlet 5					
Ib Cv (Uklgmole C) 32.44 22.05 33.06 27.19 15 Order Method) (Uklgmole C) 19.61 10.07 16 Order Method) (Uklgmole C) 24.67 24.67 24.67 24.67 24.67 24.67 24.67 24.67 24.67 34.20 34.20												
Image Cv (pulkg) (pulkg) 1.670 2.246 1.676 2.700 10 Cv(Ent. Method) (ulkgroc) 126.1 2.467 10 DepCrv(Ent. Method) (ulkgroc) 12.467 2.467 11 DepCrv(Ent. Method) (ulkgroc) 3.420 3.420 12 DepCrv(Ent. Method) (ulkgroc) 3.420 3.420 13 Teat Pr at 37.8 C (tran) 1.207+006 222.2 1.207+006 322.2 21 Visconty Index 1.283 1.480 22 Duty SetMetedS MM Uk Cur. Error 0.000-cri kUC-h 23 Duty SetMetedS MM Code Drate More Harge 29.000 C 24 Heat Laak: 0.000-cri kM Code Drate More Harge 28.000 24 Heat Laak: 0.000-cri kM Code Drate More Harge 28.000 25 Heat Laak: 0.000-cri kM Code Drate Marge												
Ins Name 2.517 2.487 CQ/Cy (Ent, Method) 1.201 1.106 IB Pred VP at 27.8 C (JP2) 3.420 3.420 ID True VP at 37.8 C (JP2) 3.420 22 3.420 ID Up (VD Invo Sun(St) Cond) (m3h) 1.2370+006 22.2 1.2370+006 22.2 14.60 ID Up (VD Invo Sun(St) Cond) (m3h) 1.2370+006 22.2 1.2370+006 22.2 14.60 ID Up (VD Invo Sun(St) Cond) (m3h) 1.2370+006 22.2 1.2370+006 22.2 14.60 ID Sun		· - · ·										
Image: Constraint of the stand of	15	Cv (Ent. Method) (kJ/kgmole-C)			195.1		192.7					
In Real VP at 37.8 C (PPa) 93.87e-004 93.87e-004 10 True VP at 37.8 C (PPa) 3.420 3.420 12 Usg Vol. Flow- Sun(Std. Cond) (mSh) 1.297e-006 228.2 1.297e-006 228.2 14.60 21 Viscotty Index 12.83 14.60 22 DetTAILS 14.00 3.420 23 0.000-01 kJL:h Molary Katteria 9.000 C 2.001 C 2.001 C 2.002 2.002 C 2.002 C 2.002 C							2.487					
Int UP Part 37 B C (PPa) 3 420 3 420 21 Us, Vol Freer-Sum(Sid. Cond) (m3kh) 1 297e-006 282.2 1 297e-006 282.2 1 22 Uscosthy Index 1 2.83 1 4.80 22 Uscosthy Index 1 2.83 1 4.80 23 DETAILS 1 4.80 24 0.000-01 MDC 0.000-01 MDC 0.000-01 MDC 0.000-01 MDC 0.000-01 MDC 0.000-01 MDC 28.00 C 0.000-01 MDC 0.000-01 MDC 29.00 C 0.000-01 MDC												
Interpretation 1287e+006 282.2 1.287e+006 282.2 Viscosity index 12.83 14.60 Viscosity index 12.83 14.60 Viscosity index Detailed Performance 2 Users 4.60 20 Users 4.60 20 Users 4.60 20 Users 20 Users 21 Heat Lask: 0.000e-01 kM Mode Price Temp: 21 Unit				9.84								
12.83 14.80 22 DETALLS 23 0.000-01 kul/betalle Verall/Detalle 24 0.000-01 kul/betalle Verall/Detalle Veralle 25 0.000-01 kul/betalle Veralle 0.000-01 kul/betalle 26 1.460: 0.000-01 kul/betalle Veralle 0.000-01 kul/betalle 21 Heat Loak: 0.000-01 kul/betalle Outeront-Temp: 28.000 C 20 U/L: 1.407e+05 kul/betalle Petale 28.000 C 20 U/L: 1.407e+05 kul/betalle Petale 28.000 C 21 U/L: 1.407e+05 kul/betalle Petale 28.000 C 23 U/L: 1.407e+05 kul/betalle Petale 28.000 C 24 U/L: 1.407e+05 kul/betalle Verale 28.000 C Verale 34 1.407e+05 kul/betalle Verale 1.407e+05 kul/betalle 28.000 C 35 Verale Verale Verale 1.407e+05 kul/betalle 1.407e+05 kul/betalle 36												
DETAILS 20 Dury: 9.6198-06 kJM UA Curv. Error: 0.000-01 kJM 0.6198-06 kJM MA Curv. Error: 0.000-01 kJM 0.6198-07 kJM 0.000-01 kJM 0.000-01 kJM 0.6198-07 kJM 0.000-01 kJM 0.6198-07 kJM 0.000-01 kJM 0.6198-07 kJM 0.000-01 kJM 0.6198-07 kJM 0.000-01 kJM 0.0												
24 Overall/Detailer 25 Duty: 9.6198+06 kJ/h UA Curv. Error: 0.006+01 kJ/C h. 27 Heat Loas: 0.000e+01 kJ/C h. CulP Pinn Temp: 250.00 C 28 Heat Loas: 0.000e+01 kJ/C h. CulP Pinn Temp: 250.00 C 29 Min. Approach: 65.00 C Uncorrected Lmid: 68.44 C 30 Innet: 68.97 C Uncorrected Lmid: 68.44 C 31 Innet: 68.97 C S S 32 Innet: 68.97 C S S 33 S S S S S 34 S S S S S 35 S S S S S 36 S S S S S 37 S S S S S 38 S S S S S 39 S S S S S	22			DET			14.00					
28. Dury: 9.619er-06 kJM UA Curv. Error. 0.00e-01 kJC-h 21. Heat Laak: 0.000e-01 kJM Hot Pinch Temp: 25.00 C 23. Heat Loss: 0.000e-01 kJM Fit Factor:	24		Ove	rall/Detaile	d Perfo	rmance						
27 Heat Leak: 0.000e-01 kJh Hot Pinch Temp: 20.00 C 28 Heat Loss: 0.000e-01 kJh Cold Finch Temp: 25.00 C 30 Min. Approach: 65.00 C Uncorrected Lind: 68.41 C 33 Min. Approach: 68.37 C 34 36 35 36 36 Min. Approach: 68.37 C 37 38 38 39 38		Duty:	9.6	319e+06 kJ/h	UA Cur	v. Error:		0.00e-01 kJ/C-h				
22 Heat Loss: 0.000e-01 kJ/h Cold Pinch Temp: 25.00 C 23 Vih. 1.407e405 kJ/ch Pt Fator: 34 0 Min. Approach: 65.00 C Uncorrected Lind: 66.44 C 32 Untd: 68.37 C Status Status Status 33 Status Status Status Status Status 34 Status Status Status Status Status Status 35 Status Status Status Status Status Status Status Status 36 Status <												
20 Min. Approach: 65.00 C Uncorrected Lintt: 68.44 C 31 Lintt: 68.37 C 68.37 C 33 33 33 33 34 34 35 36 35 37 38 36 36 36 37 38 38 36 36 36 39 36 36 36 40 41 42 43 42 43 44 44 43 44 45 46 44 45 46 47 46 46 47 48 47 48 49 49 48 49 49 49 49 49 49 49 41 49 49 49 42 49 49 49 43 49 49 49 44 49 49 49 45 49 49 49 49 49 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>												
31 Lmdt 68.37 C 32	29	UA:	1.407	7e+05 kJ/C-h								
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 46 47 48 49 50 51 52 53 56 57 58 59 50 51 52 53 56 57 58 59 50 51 52 53 54 55 56 57 58 59 50 51 52 53 54 55 56 57					Uncorre	ected Lmtd:		68.44 C				
33 34 35 36 37 38 39 41 42 43 44 46 47 48 49 41 42 43 44 45 46 47 48 49 50 50 51 52 53 54 55 56 57 58 59 50 51 52 53 54 55 56 57 58 59 50 51 52 53 54 55 56 57 58 59		Lmtd:		68.37 C								
67	$\begin{array}{c} 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 53\\ 54\\ 55\\ 56\\ 57\\ 58\\ 59\\ 60\\ 61\\ 62\\ 63\\ 64\\ 65\\ 66\\ 66\\ 66\\ 66\\ 66\\ 66\\ 66\\ 66\\ 66$											
	68 60					20.0.0.9245)		Dage 2 of 2				

Appendix D – Process Datasheets for Heat Exchangers in Case Study III



Case Name: CASE STUDY 3.HSC

SI

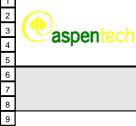
Unit Set:

Date/Time: Wed Jun 11 17:56:23 2014

LNG: 24-HJ-101

9 10			COND	ITIONS				
11	Name	Field 1 Inlet to	o 24-HJ-101	Cooling	Medium Inlet 4	Inlet to Field	1 Contactor	Cooling Medium Outlet 4
12	Vapour		1.0000		0.0000		1.0000 *	0.0000
13	1	(C)	135.2823		20.0000 *		48.8340	80.0000 *
14	Pressure (kF	(<i>)</i>	5030.0000		1000.0000 *		4930.0000 *	900.0000 *
15	Molar Flow (kgmole		4.874e+004		1.589e+004		4.874e+004	1.589e+004
16	Mass Flow (kg	,	9.657e+005		1.232e+006		9.657e+005	1.232e+006
17	Std Ideal Lig Vol Flow (m3	,	2824		1110		2824	1110
18	Molar Enthalpy (kJ/kgmo	,	7.860e+004		-5.210e+005		8.282e+004	-5.081e+005
19	Molar Entropy (kJ/kgmole-		167.9		88.84		156.5	129.0
20	Heat Flow (kJ	,	3.831e+009		-8.282e+009		4.037e+009	-8.076e+009
21	(,						
22			PROPE	ERTIES				
23	Name Field 1	Inlet to 24-HJ-101	Cooling Medi	um Inlet 4	Inlet to Field 1 Cor	ntactorCooline	g Medium Outl	et 4
24	Molecular Weight	19.81	<u> </u>	77.48		9.81	77.4	
25	Molar Density (kgmole/m3)	1.524		14.54		.026	13.8	
26	Mass Density (kg/m3)	30.19		1127		0.15	107	
27	Act. Volume Flow (m3/h)	3.199e+004		1093	2.405e+		114	
28	Mass Enthalpy (kJ/kg)	-3967		-6725		180	-655	
29	Mass Entropy (kJ/kg-C)	8.475		1.147		.898	1.66	
30	Heat Capacity (kJ/kgmole-C)	50.43		205.6		8.32	226.	
31	Mass Heat Capacity (kJ/kg-C)	2.545		2.654		.439	2.92	
32	LHV Molar Basis (Std) (kJ/kgmole)		1.46	2e+006			1.462e+00	
33	HHV Molar Basis (Std) (kJ/kgmole)			4e+006			1.614e+00	
34	HHV Mass Basis (Std) (kJ/kg)			3e+004			2.083e+00	
35	CO2 Loading							
36	CO2 Apparent Mole Conc. (kgmole/m3)			0.0000			0.000	0
37	CO2 Apparent Wt. Conc. (kgmol/kg)			0.0000			0.000	
38	LHV Mass Basis (Std) (kJ/kg)		1.88	37e+004			1.887e+00	
39	Phase Fraction [Vol. Basis]	1.000		0.0000	1	.000	0.000	
40	Phase Fraction [Mass Basis]	1.000		0.0000		.000	0.000	
41	Phase Fraction [Act. Vol. Basis]	1.000		0.0000		.000	0.000	
42	Mass Exergy (kJ/kg)	513.4		2.394		72.6	14.8	
43	Partial Pressure of CO2 (kPa)	78.72		0.0000	7	7.15	0.000	0
44	Cost Based on Flow (Cost/s)	0.0000		0.0000	0.0	0000	0.000	0
45	Act. Gas Flow (ACT_m3/h)	3.199e+004			2.405e+	-004		
46	Avg. Liq. Density (kgmole/m3)	17.26		14.32	1	7.26	14.3	2
47	Specific Heat (kJ/kgmole-C)	50.43		205.6	4	8.32	226.	6
48	Std. Gas Flow (STD_m3/h)	1.152e+006	3.75	8e+005	1.152e+	-006	3.758e+00	5
49	Std. Ideal Liq. Mass Density (kg/m3)	342.0		1110	3	42.0	111	0
50	Act. Liq. Flow (m3/s)			0.3036	0.0	0000	0.319	0
51	Z Factor	0.9722	2.82	22e-002			2.215e-00	2
52	Watson K	17.93		8.816	1	7.93	8.81	6
53	User Property							
54	Partial Pressure of H2S (kPa)	0.0000		0.0000	0.0	0000	0.000	0
55	Cp/(Cp - R)	1.197		1.042	1	.208	1.03	8
56	Cp/Cv	1.282		1.059	1	.415	1.06	2
57	Heat of Vap. (kJ/kgmole)	1.090e+004	7.31	3e+004	1.098e+	-004	7.380e+00	4
58	Kinematic Viscosity (cSt)	0.5187		15.21	0.3	304	3.46	4
59	Liq. Mass Density (Std. Cond) (kg/m3)	0.8405		1130	0.8	405	113	0
60	Liq. Vol. Flow (Std. Cond) (m3/h)	1.149e+006		1090	1.149e+	-006	109	0
61	Liquid Fraction	0.0000		1.000	0.0	0000	1.00	0
62	Molar Volume (m3/kgmole)	0.6563	6.8	77e-002	0.4	935	7.225e-00	2
63	Mass Heat of Vap. (kJ/kg)	550.2		943.9	5	54.2	952.	5
64	Phase Fraction [Molar Basis]	1.0000		0.0000	1.0	0000	0.000	0
65	Surface Tension (dyne/cm)			48.40			42.7	4
66	Thermal Conductivity (W/m-K)	5.008e-002		0.2165	3.831e-	-002	0.227	4
67	Viscosity (cP)	1.566e-002		17.13	1.327e-	-002	3.71	5
68	Cv (Semi-Ideal) (kJ/kgmole-C)	42.11		197.3	4	0.01	218.	3
69	Aspen Technology Inc.	Aspen H	YSYS Vers	ion 8.3 (2	29.0.0.8315)			Page 1 of 2

Licensed to: NORWEGIAN UNIV OF



Case Name: CASE STUDY 3.HSC SI

Wed Jun 11 17:56:23 2014

LNG: 24-HJ-101 (continued)

PROPERTIES

Unit Set:

Date/Time:

10							
11	Name		Field 1 Inlet to 24-HJ-101	Cooling Medium Inlet 4	Inlet to Field 1 Contactor	Cooling Medium Outlet 4	
12	Mass Cv (Semi-Ideal)	(kJ/kg-C)	2.125	2.547	2.019	2.818	
13	Cv	(kJ/kgmole-C)	39.33	194.1	34.16	213.3	
14	Mass Cv	(kJ/kg-C)	1.985	2.506	1.724	2.753	
15	Cv (Ent. Method)	(kJ/kgmole-C)		179.3		190.6	
16	Mass Cv (Ent. Method)	(kJ/kg-C)		2.314		2.460	
17	Cp/Cv (Ent. Method)			1.147		1.189	
18	Reid VP at 37.8 C	(kPa)		9.847e-004		9.847e-004	
19	True VP at 37.8 C	(kPa)		3.420		3.420	
20	Liq. Vol. Flow - Sum(Std	. Cond) (m3/h)	1.149e+006	1090	1.149e+006	1090	
21	Viscosity Index		-34.28	25.80		16.38	
21		, , , ,	-34.28	25.80		16.38	

68

69



Case Name: CASE STUDY 3.HSC

SI

Unit Set:

Date/Time: Wed Jun 11 17:55:09 2014

LNG: 24-HJ-201

9 10				COND	TIONS				
11	Name		Inlet to	o 24-HJ-201	Cooling	Medium Inlet 8	Inlet to Fie	eld 2 Contactor	Cooling Medium Outlet 8
12	Vapour			1.0000	0	0.0000		1.0000 *	0.0000
13	Temperature	(C)		142.4748		20.0000 *		50.4076	80.0000 *
14	Pressure	(kPa)		5520.0000		1000.0000 *		5420.0000 *	900.0000 *
15	Molar Flow (kg	gmole/h)		5.523e+004		1.944e+004		5.523e+004	1.944e+004
16	Mass Flow	(kg/h)		1.094e+006		1.506e+006		1.094e+006	1.506e+006
17	Std Ideal Liq Vol Flow	(m3/h)		3200		1357		3200	1357
18	Molar Enthalpy (kJ/	(kgmole)	-	7.830e+004		-5.210e+005		-8.285e+004	-5.081e+005
19		mole-C)		167.9		88.84		155.7	129.0
20	Heat Flow	(kJ/h)	-	4.324e+009		-1.013e+010		-4.576e+009	-9.875e+009
21 22				PROPE	RTIES				
23	Name	Inlet to 2	4-HJ-201	Cooling Mediu	um Inlet 8	Inlet to Field 2 Co	ntactorCoo	ling Medium Outle	et 8
24	Molecular Weight		19.81		77.48	1	9.81	77.48	3
25	Molar Density (kgmole/m3)		1.641		14.54	2	.232	13.84	4
26	Mass Density (kg/m3)		32.51		1127	4	4.22	1072	2
27	Act. Volume Flow (m3/h)	3	366e+004		1337	2.475e+	-004	1404	4
28	Mass Enthalpy (kJ/kg)		-3952		-6725	-4	181	-6558	8
29	Mass Entropy (kJ/kg-C)		8.474		1.147	7	.857	1.66	5
30	Heat Capacity (kJ/kgmole-C)		51.08		205.6	4	9.10	226.0	6
31	Mass Heat Capacity (kJ/kg-C)		2.578		2.654	2	.478	2.92	5
32	LHV Molar Basis (Std) (kJ/kgmole)			1.46	2e+006			1.462e+00	6
33	HHV Molar Basis (Std) (kJ/kgmole)			1.61	4e+006			1.614e+00	6
34	HHV Mass Basis (Std) (kJ/kg)			2.08	3e+004			2.083e+004	4
35	CO2 Loading								-
36	CO2 Apparent Mole Conc. (kgmole/m3)				0.0000			0.000	0
37	CO2 Apparent Wt. Conc. (kgmol/kg)				0.0000			0.000	0
38	LHV Mass Basis (Std) (kJ/kg)			1.88	7e+004			1.887e+004	4
39	Phase Fraction [Vol. Basis]		1.000		0.0000	1	.000	0.000)
40	Phase Fraction [Mass Basis]		1.000		0.0000	1	.000	0.000	0
41	Phase Fraction [Act. Vol. Basis]		1.000		0.0000	1	.000	0.000	0
42	Mass Exergy (kJ/kg)		529.0		2.394	4	83.2	14.80	5
43	Partial Pressure of CO2 (kPa)		86.39		0.0000	8	4.82	0.000	0
44	Cost Based on Flow (Cost/s)		0.0000		0.0000	0.0	0000	0.000	0
45	Act. Gas Flow (ACT_m3/h)	3	366e+004			2.475e+	-004		-
46	Avg. Liq. Density (kgmole/m3)		17.26		14.32	1	7.26	14.3	2
47	Specific Heat (kJ/kgmole-C)		51.08		205.6	4	9.10	226.0	6
48	Std. Gas Flow (STD_m3/h)	1.	306e+006	4.59	5e+005	1.306e+	-006	4.595e+00	5
49	Std. Ideal Liq. Mass Density (kg/m3)		342.0		1110	3	42.0	1110	0
50	Act. Liq. Flow (m3/s)				0.3713		0000	0.390	
51	Z Factor		0.9735	2.82	22e-002			2.215e-002	
52	Watson K		17.93		8.816	1	7.93	8.810	
53	User Property								-
54	Partial Pressure of H2S (kPa)		0.0000		0.0000	0.0	0000	0.000	0
55	Cp/(Cp - R)		1.194		1.042	1	.204	1.038	3
56	Cp/Cv		1.282		1.059	1	.430	1.062	2
57	Heat of Vap. (kJ/kgmole)	1.	051e+004	7.31	3e+004	1.059e+	-004	7.380e+004	4
58	Kinematic Viscosity (cSt)		0.4907		15.21	0.3	3047	3.464	4
59	Liq. Mass Density (Std. Cond) (kg/m3)		0.8405		1130	0.8	3405	1130	0
60	Liq. Vol. Flow (Std. Cond) (m3/h)	1.	302e+006		1333	1.302e+	-006	1333	3
61	Liquid Fraction		0.0000		1.000	0.0	0000	1.000	0
62	Molar Volume (m3/kgmole)		0.6094	6.87	7e-002	0.4	481	7.225e-002	2
63	Mass Heat of Vap. (kJ/kg)		530.7		943.9	5	34.7	952.5	5
64	Phase Fraction [Molar Basis]		1.0000		0.0000		0000	0.000	
65	Surface Tension (dyne/cm)				48.40			42.74	
66	Thermal Conductivity (W/m-K)	5	.146e-002		0.2165	3.899e	-002	0.2274	
67	Viscosity (cP)		.595e-002		17.13	1.347e		3.71	
68	Cv (Semi-Ideal) (kJ/kgmole-C)		42.76		197.3		0.79	218.3	
69	Aspen Technology Inc.			YSYS Versi		29.0.0.8315)			Page 1 of 2
للسب									

Licensed to: NORWEGIAN UNIV OF



Case Name: CASE STUDY 3.HSC

SI

Date/Time: Wed Jun 11 17:55:09 2014

LNG: 24-HJ-201 (continued)

0							
9				PROPERTIES			
10				PROPERTIES			
11	Name		Inlet to 24-HJ-201	Cooling Medium Inlet 8	Inlet to Field 2 Contactor	Cooling Medium Outlet 8	
12	Mass Cv (Semi-Ideal)	(kJ/kg-C)	2.158	2.547	2.058	2.818	
13	Cv	(kJ/kgmole-C)	39.85	194.1	34.33	213.3	
14	Mass Cv	(kJ/kg-C)	2.011	2.506	1.733	2.753	
15	Cv (Ent. Method)	(kJ/kgmole-C)		179.3		190.6	
16	Mass Cv (Ent. Method)	(kJ/kg-C)		2.314		2.460	
17	Cp/Cv (Ent. Method)			1.147		1.189	
18	Reid VP at 37.8 C	(kPa)		9.847e-004		9.847e-004	
19	True VP at 37.8 C	(kPa)		3.420		3.420	
20	Liq. Vol. Flow - Sum(Std	. Cond) (m3/h)	1.302e+006	1333	1.302e+006	1333	
21	Viscosity Index		-35.39	25.80		16.38	

Unit Set:

Appendix E – Thermal Calculations for Heat Exchangers in Base Case Design

Shell&Tube V7.3.1 CP1

Date: 4.6.2014

Time: 18:31:58

Basic Geometry

Unit Configuration							
Exchanger Type			BEM 1	Tube number (calc	s.)		1180
Position			Hor 1	Tube length actual		mm	900
Arrangement		2 par	1 ser 1	Tube passes			
Baffle type		Single	segmental	Tube type			Plai
Baffle number			8 1	Гube O.D.		mm	31,7
Spacing (center-center)		nm	850 1	Tube pitch		mm	4(
Spacing at inlet	I	nm	1332,48	Tube pattern			30
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	I	nm	1609			1715	1715
Inside Diameter	I	nm	1575			1575	1575
	_		Shell Side		Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	355,6	323,9		914	914	
Inside diameter	mm	335,6	303,9		842	842	
Height under nozzle	mm	182,73	182,73				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingement	No impingement			
Distance to tubesheet	mm	8550	430				

Heat Exchanger Thermal Design

20-HA-001 : Base Case Design

Shell&Tube V7.3.1 CP1 Date: 4.6.2014

Time: 18:31:58

Tubes

Tubes					
Туре		Plain	Total number		1180
Outside diameter	mm	31,75	Number of tubes plugged		0
Inside diameter	mm	27,53	Tube length actual	mm	9000
Wall thickness	mm	2,11	Tube length effective	mm	8615
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	189,52
Pitch	mm	40	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	16,0027
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Heat Exchanger Thermal Design

20-HA-001 : Base Case Design

Shell&Tube V7.3.1 CP1

Date: 4.6.2014

Time: 18:31:58

Baffles

Туре	Single s	egmental	Baffle cut: inner / outer / inter	m		
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		8	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	850	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	1332,48	Cut orientation			н
Spacing at outlet	mm	1332,48	Thickness		mm	12,7
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			34
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	1525	Baffle hole - tube od diam clear	ance	mm	0,79
End length at rear head	mm	1525	Shell id - baffle od diam clearar	ce	mm	7,94

mm

mm

Baffle spacing
Baffle cut percent, outer
Baffle cut percent, inner
Number of baffle spaces
Baffle region length
Baffle cut area percent, outer
Baffle cut area percent, inner

Supports Misc. Baffles

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Heat Exchanger Thermal Design

20-HA-001 : Base Case Design

Shell&Tube V7.3.1 CP1

Date: 4.6.2014

Time: 18:31:58

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		182,73	Tube pass layout	Ribbon (s	ingle band)
From bottom		182,73	Tube pass orientation	Standard	(horizontal)
From right		11,62	U-bend orientation		Undefined
From Left		11,62	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		(
Impingement plate width	mm		Outer tube limit	mm	1560,71
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	14,29
Impingement plate thickness	mm		Tie rod number		12
Gross surface area per shell	m²	1059,3	Tie rod diameter	mm	15,88
Effective surface area per shell	m²	1014	Sealing strips (pairs)		6
Bare tube area per shell	m²	1014	Tube to tubesheet joint		Exp
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Basic Geometry

Unit Configuration							
Exchanger Type			BEM 1	Tube number (calc	s.)		58
Position			Hor 1	Tube length actual		mm	740
Arrangement		2 par	1 ser 1	Tube passes			
Baffle type		Single	segmental	Tube type			Plai
Baffle number			4 1	Tube O.D.		mm	31,7
Spacing (center-center)		mm	1370 1	Tube pitch		mm	39,6
Spacing at inlet	I	mm	1500,48	Tube pattern			30
			Shell	Kettle		Front head	Rear head
Outside diameter	I	mm	1178			1254	1254
Inside Diameter	I	mm	1150			1150	1150
	-		Shell Side		— т	ube Side ——	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	610	457		914	1016	
Inside diameter	mm	590	437		842	936	
Height under nozzle	mm	181,05	181,05				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection		No impingement	No impingement	No impingement			
Distance to tubesheet	mm	6870	445				

Tubes

Tubes					
Туре		Plain	Total number		581
Outside diameter	mm	31,75	Number of tubes plugged		0
Inside diameter	mm	27,53	Tube length actual	mm	7400
Wall thickness	mm	2,11	Tube length effective	mm	7111
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	141,52
Pitch	mm	39,69	Material	22Cr,51	vi,3Mo stee
Pattern		30	Thermal conductivity	W/(m K)	15,9016
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		C
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

٦

Туре	Single s	egmental	Baffle cut: inner / outer / interm			
Tubes in window		No	Actual (% diameter)	/	12,99 /	
Number		4	Nominal (% diameter)	/	12,99 /	
Spacing (center-center)	mm	1370	Actual (% area)	/	7,63 /	
Spacing at inlet	mm	1500,48	Cut orientation			Н
Spacing at outlet	mm	1500,48	Thickness		mm	15,88
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			22
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	1645	Baffle hole - tube od diam clearance	;	mm	0,4
End length at rear head	mm	1645	Shell id - baffle od diam clearance		mm	6,35

Baffle spacing	mm
Baffle cut percent, outer	
Baffle cut percent, inner	
Number of baffle spaces	
Baffle region length	mm
Baffle cut area percent, outer	
Baffle cut area percent, inner	

Supports Misc. Baffles

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		181,05	Tube pass layout	Ribbon (s	single band)
From bottom		181,05	Tube pass orientation	Standard	(horizontal)
From right		23,34	U-bend orientation		Undefined
From Left		23,34	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1137,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	428,8	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	412,1	Sealing strips (pairs)		4
Bare tube area per shell	m²	412,1	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Basic Geometry

Unit Configuration							
Exchanger Type			BEM ⁻	Fube number (calc	s.)		798
Position			Hor [–]	Fube length actual		mm	6500
Arrangement		2 par	1 ser ⁻	Tube passes			1
Baffle type		Single	segmental	Tube type			Plair
Baffle number			8 -	Гube O.D.		mm	19,05
Spacing (center-center)		mm	730	Tube pitch		mm	23,81
Spacing at inlet		mm	644,48	Tube pattern			30
			Shell	Kettle		Front head	Rear head
Outside diameter		mm	793			789	789
Inside Diameter		mm	775			775	775
			Shell Side		— Ти	ibe Side ——	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	219,1	168,3		406,4	711	
Inside diameter	mm	203,1	154,1		386,4	691	
Height under nozzle	mm	89,26	89,26				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection		No impingement	No impingement	No impingement			
Distance to tubesheet	mm	6260	210	r 0			

Tubes

Tubes					
Туре		Plain	Total number		798
Outside diameter	mm	19,05	Number of tubes plugged		C
Inside diameter	mm	16,55	Tube length actual	mm	6500
Wall thickness	mm	1,25	Tube length effective	mm	6399
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	47,52
Pitch	mm	23,81	Material	22Cr,51	vi,3Mo stee
Pattern		30	Thermal conductivity	W/(m K)	16,201 [,]
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		(
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Single se	egmental	Baffle cut: inner / outer / interm			
	No	Actual (% diameter)	/	10 /	
	8	Nominal (% diameter)	/	10 /	
mm	730	Actual (% area)	/	5,2 /	
mm	644,48	Cut orientation			н
mm	644,48	Thickness		mm	7,94
mm		Tube rows in baffle overlap			28
mm		Tube rows in baffle window			0,5
mm	695	Baffle hole - tube od diam clearand	ce	mm	0,79
mm	695	Shell id - baffle od diam clearance		mm	4,76
mm					
m m					
	mm mm mm mm mm	8 mm 730 mm 644,48 mm 644,48 mm 695 mm 695 mm 695	NoActual (% diameter)8Nominal (% diameter)mm730Actual (% area)mm644,48Cut orientationmm644,48ThicknessmmTube rows in baffle overlapmm695Baffle hole - tube od diam clearancemm695Shell id - baffle od diam clearance	NoActual (% diameter)/8Nominal (% diameter)/mm730Actual (% area)/mm644,48Cut orientation/mm644,48Thickness/mmTube rows in baffle overlap/mm695Baffle hole - tube od diam clearancemm695Shell id - baffle od diam clearancemmfilefilemmfilefilemmfilefilemmfilefilemmfilefilefilefilefilemmfilefilemmfilefilefilefilefilemmfile <td< td=""><td>NoActual (% diameter)/10 /8Nominal (% diameter)/10 /mm730Actual (% area)/5,2 /mm644,48Cut orientationmmmm644,48ThicknessmmmmTube rows in baffle overlapmmmm695Baffle hole - tube od diam clearancemmmm695Shell id - baffle od diam clearancemmmmmm10 /mm</td></td<>	NoActual (% diameter)/10 /8Nominal (% diameter)/10 /mm730Actual (% area)/5,2 /mm644,48Cut orientationmmmm644,48ThicknessmmmmTube rows in baffle overlapmmmm695Baffle hole - tube od diam clearancemmmm695Shell id - baffle od diam clearancemmmmmm10 /mm

Supports Misc. Baffles

Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		89,26	Tube pass layout	Ribbon (s	ingle band)
From bottom		89,26	Tube pass orientation	Standard	(horizontal)
From right		8,88	U-bend orientation		Undefined
From Left		8,88	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	762,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		6
Gross surface area per shell	m²	310,4	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	305,6	Sealing strips (pairs)		5
Bare tube area per shell	m²	305,6	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Basic Geometry

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			147
Position			Hor	Tube length actual		mm	650
Arrangement		1 par	1 ser	Tube passes			
Baffle type		Singles	segmental	Tube type			Plai
Baffle number			28	Tube O.D.		mm	19,0
Spacing (center-center)	n	nm	200	Tube pitch		mm	23,8
Spacing at inlet	n	nm	488,48	Tube pattern			3
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	n	nm	1066			1066	1066
Inside Diameter	n	nm	1050			1050	1050
			Shell Side	,	— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	219,1	219,1		406,4	457	
Inside diameter	mm	203,1	203,1		386,4	437	
Height under nozzle	mm	123,65	123,65				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	ir	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	6250	245				

Tubes					
Туре		Plain	Total number		1473
Outside diameter	mm	19,05	Number of tubes plugged		0
Inside diameter	mm	16,65	Tube length actual	mm	6500
Wall thickness	mm	1,2	Tube length effective	mm	6377
Area ratio Ao/Ai		1,14	Tubesheet thickness	mm	58,52
Pitch	mm	23,81	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	16,1365
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles						
Туре	Single se	egmental	Baffle cut: inner / outer / inter	erm		
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		28	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	200	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	488,48	Cut orientation			н
Spacing at outlet	mm	488,48	Thickness		mm	6,35
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			38
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	550	Baffle hole - tube od diam clea	arance	mm	0,79
End length at rear head	mm	550	Shell id - baffle od diam cleara	ance	mm	6,35
VariableBaffles						
Baffle spacing	mm					
Baffle cut percent, outer						
Baffle cut percent, inner						
Number of baffle spaces Baffle region length	mm					

Supports Misc. Baffles

Baffle cut area percent, outer Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		123,65	Tube pass layout	Ribbon (s	ingle band)
From bottom		123,65	Tube pass orientation	Standard	(horizontal)
From right		15,41	U-bend orientation		Undefined
From Left		15,41	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1037,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	573	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	562,2	Sealing strips (pairs)		7
Bare tube area per shell	m²	562,2	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Basic Geometry

Unit Configuration							
Exchanger Type			ВЕМ Т	ube number (calc	:s.)		577
Position			Hor T	ube length actual		mm	1750
Arrangement		1 par	1 ser T	ube passes			1
Baffle type		Single	segmental T	ube type			Plair
Baffle number			6 Т	ube O.D.		mm	25,4
Spacing (center-center)		mm	175 1	ube pitch		mm	31,75
Spacing at inlet		mm	352,98 1	ube pattern			30
			Shell	Kettle	ł	Front head	Rear head
Outside diameter		mm	899			927	927
Inside Diameter		mm	875			875	875
			Shell Side		— Tu	be Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	139,7	114,3		508	508	
Inside diameter	mm	125,5	101,7		479,6	479,6	
Height under nozzle	mm	94,84	94,84				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection		No impingement	No impingement	No impingement			
		1515	215				

Tubes

Tubes					
Туре		Plain	Total number		577
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	1750
Wall thickness	mm	1,65	Tube length effective	mm	1581
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	81,53
Pitch	mm	31,75	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	15,7194
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Baffles					
Туре	Single se	egmental	Baffle cut: inner / outer / interm		
Tubes in window		No	Actual (% diameter)	′ 10 /	
Number		6	Nominal (% diameter)	′ 10 /	
Spacing (center-center)	mm	175	Actual (% area)	′ 5,2 /	
Spacing at inlet	mm	352,98	Cut orientation		н
Spacing at outlet	mm	352,98	Thickness	mm	6,35
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap		24
Spacing at center of H shell	mm		Tube rows in baffle window		0,5
End length at front head	mm	437,5	Baffle hole - tube od diam clearance	mm	0,79
End length at rear head	mm	437,5	Shell id - baffle od diam clearance	mm	4,76
VariableBaffles					
Baffle spacing	mm				

mm

Supports Misc. Baffles

Baffle cut percent, outer Baffle cut percent, inner Number of baffle spaces Baffle region length

Baffle cut area percent, outer Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		94,84	Tube pass layout	Ribbon (s	ingle band)
From bottom		94,84	Tube pass orientation	Standard	(horizontal)
From right		12,05	U-bend orientation		Undefined
From Left		12,05	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	862,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	80,6	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	72,8	Sealing strips (pairs)		5
Bare tube area per shell	m²	72,8	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Basic Geometry

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.))		57
Position			Hor	Tube length actual		mm	1750
Arrangement		1 par	1 ser	Tube passes			
Baffle type		Single s	segmental	Tube type			Plai
Baffle number			6	Tube O.D.		mm	25,
Spacing (center-center)	n	nm	175	Tube pitch		mm	31,7
Spacing at inlet	n	nm	352,98	Tube pattern			3
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	n	nm	899			927	927
Inside Diameter	n	nm	875			875	875
			Shell Side	,	— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	139,7	114,3		508	508	
Inside diameter	mm	125,5	101,7		479,6	479,6	
Height under nozzle	mm	94,84	94,84				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	ir	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	1515	215				

Tubes

Tubes					
Туре		Plain	Total number		577
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	1750
Wall thickness	mm	1,65	Tube length effective	mm	1581
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	81,53
Pitch	mm	31,75	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	15,7182
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Baffles			r			
Туре	Single segmental		Baffle cut: inner / outer / interm			
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		6	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	175	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	352,98	Cut orientation			н
Spacing at outlet	mm	352,98	Thickness		mm	6,35
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			24
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	437,5	Baffle hole - tube od diam clearance	Э	mm	0,79
End length at rear head	mm	437,5	Shell id - baffle od diam clearance		mm	4,76
VariableBaffles						
Baffle spacing	mm					

mm

Supports Misc. Baffles

Baffle cut percent, outer Baffle cut percent, inner Number of baffle spaces Baffle region length

Baffle cut area percent, outer Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle		
Supports in endspace at front head	0	Thickness	mm	
Supports in endspace at rear head	0	Window length at front head	mm	
Supports between baffles	0	Window length at center	mm	
Support blanking baffle	No	Window length at rear head	mm	
Supports at U-bend	0			
Supports at each G,H,J shell inlet and I shell outlet	0			
Supports at center of H shell	0			
Supports for K, X shells	0			
Special support at inlet nozzle	No			

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		94,84	Tube pass layout	Ribbon (s	ingle band)
From bottom		94,84	Tube pass orientation	Standard	(horizontal)
From right		12,05	U-bend orientation		Undefined
From Left		12,05	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	862,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	80,6	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	72,8	Sealing strips (pairs)		5
Bare tube area per shell	m²	72,8	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			3093
Position			Hor	Tube length actual		mm	7500
Arrangement		2 par	1 ser	Tube passes			1
Baffle type		Singles	segmental	Tube type			Plair
Baffle number			30	Tube O.D.		mm	25,4
Spacing (center-center)	n	nm	200	Tube pitch		mm	31,75
Spacing at inlet	n	nm	657,48	Tube pattern			30
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	n	nm	2044			2124	2124
Inside Diameter	n	nm	2000			2000	2000
	_		Shell Side	,	— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	457	355,6		711	610	
Inside diameter	mm	437	335,6		671	575	
Height under nozzle	mm	217,4	217,4				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	ir	No npingement	No impingeme	nt			
Distance to tubesheet	mm	7000	445				

Tubes

S					
		Plain	Total number		3093
de diameter	mm	25,4	Number of tubes plugged		0
e diameter	mm	22,1	Tube length actual	mm	7500
thickness	mm	1,65	Tube length effective	mm	7115
ratio Ao/Ai		1,15	Tubesheet thickness	mm	189,52
	mm	31,75	Material	22Cr,51	Ni,3Mo stee
rn		30	Thermal conductivity	W/(m K)	16,3173
nal enhancement			Internal enhancement		
circumferential fins			Low longitudinal fins		
ensity	#/m		Fin number		C
eight	mm		Fin thickness	mm	
ickness	mm		Fin height	mm	
root diameter	mm		Fin spacing	mm	
wall thickness under fin	mm		Cut and twist length	mm	
inside diameter under fins	mm				
wall thickness under fin	mm				

Baffles

Baffles						
Туре	Single segmental		Baffle cut: inner / outer / interm			
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		30	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	200	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	657,48	Cut orientation			н
Spacing at outlet	mm	657,48	Thickness		mm	9,52
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			56
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	850	Baffle hole - tube od diam clear	ance	mm	0,79
End length at rear head	mm	850	Shell id - baffle od diam clearar	nce	mm	9,52
VariableBaffles						
Baffle spacing	mm					
Baffle cut percent, outer						
Baffle cut percent, inner						
Number of baffle spaces						
Baffle region length	mm					
Baffle cut area percent, outer						

Supports Misc. Baffles

Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		217,4	Tube pass layout	Ribbon (s	single band)
From bottom		217,4	Tube pass orientation	Standard	(horizontal)
From right		18,92	U-bend orientation		Undefined
From Left		18,92	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1984,12
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	15,88
Impingement plate thickness	mm		Tie rod number		12
Gross surface area per shell	m²	1851,1	Tie rod diameter	mm	15,88
Effective surface area per shell	m²	1756	Sealing strips (pairs)		10
Bare tube area per shell	m²	1756	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			3093
Position			Hor	Tube length actual		mm	8500
Arrangement		2 par	1 ser	Tube passes			1
Baffle type		Single	segmental	Tube type			Plain
Baffle number			36	Tube O.D.		mm	25,4
Spacing (center-center)	r	nm	200	Tube pitch		mm	31,75
Spacing at inlet	r	nm	585,2	Tube pattern			30
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	r	nm	2038			2124	2124
Inside Diameter	r	nm	2000			2000	2000
	-		Shell Side		— Tube	Side ——	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	508	406,4		711	711	
Inside diameter	mm	488	386,4		671	671	
Height under nozzle	mm	217,4	217,4				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	7965	475				

Tubes

Tubes					
Туре		Plain	Total number		3093
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	8500
Wall thickness	mm	1,65	Tube length effective	mm	8101
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	196,52
Pitch	mm	31,75	Material	22Cr,5N	li,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	16,35
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Туре	Single se	egmental	Baffle cut: inner / outer / interm		
Tubes in window		No	Actual (% diameter)	/ 10 /	/
Number		36	Nominal (% diameter)	/ 10 /	/
Spacing (center-center)	mm	200	Actual (% area)	/ 5,2 /	/
Spacing at inlet	mm	585,2	Cut orientation		Н
Spacing at outlet	mm	515,75	Thickness	mm	9,52
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap		56
Spacing at center of H shell	mm		Tube rows in baffle window		0,5
End length at front head	mm	715,28	Baffle hole - tube od diam clearance	mm	0,79
End length at rear head	mm	784,72	Shell id - baffle od diam clearance	mm	9,52

Baffle spacing	mm
Baffle cut percent, outer	
Baffle cut percent, inner	
Number of baffle spaces	
Baffle region length	mm
Baffle cut area percent, outer	
Baffle cut area percent, outer Baffle cut area percent, inner	

Supports Misc. Baffles

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		217,4	Tube pass layout	Ribbon (s	ingle band)
From bottom		217,4	Tube pass orientation	Standard	(horizontal)
From right		18,92	U-bend orientation		Undefined
From Left		18,92	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1984,12
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	15,88
Impingement plate thickness	mm		Tie rod number		12
Gross surface area per shell	m²	2097,9	Tie rod diameter	mm	15,88
Effective surface area per shell	m²	1999,4	Sealing strips (pairs)		10
Bare tube area per shell	m²	1999,4	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Appendix F – Thermal Calculations for Heat Exchangers in Case Study I

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)		1290
Position			Hor	Tube length actual		mm	6500
Arrangement		2 par	1 ser	Tube passes			
Baffle type		Single	segmental	Tube type			Plair
Baffle number			8	Tube O.D.		mm	19,0
Spacing (center-center)	r	nm	700	Tube pitch		mm	23,8
Spacing at inlet	r	nm	742,48	Tube pattern			30
			Shell	Kettle	Fre	ont head	Rear head
Outside diameter	r	nm	999			993	993
Inside Diameter	r	nm	975			975	975
	_		Shell Side		— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	273	219,1		406,4	457	
Inside diameter	mm	253	203,1		386,4	437	
Height under nozzle	mm	106,78	106,78				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	6225	240				

Tubes

Tubes				
Туре	Plain	Total number		1290
Outside diameter mm	19,05	Number of tubes plugged		0
Inside diameter mm	16,65	Tube length actual	mm	6500
Wall thickness mm	1,2	Tube length effective	mm	6385
Area ratio Ao/Ai	1,14	Tubesheet thickness	mm	54,52
Pitch mm	23,81	Material	22Cr,5N	li,3Mo steel
Pattern	30	Thermal conductivity	W/(m K)	16,138
External enhancement		Internal enhancement		
Low circumferential fins		Low longitudinal fins		
Fin density #/m		Fin number		0
Fin height mm		Fin thickness	mm	
Fin thickness mm		Fin height	mm	
Tube root diameter mm		Fin spacing	mm	
Tube wall thickness under fin mm		Cut and twist length	mm	
Tube inside diameter under fins mm				

Baffles

Baffles					
Туре	Single se	egmental	Baffle cut: inner / outer / interm		
Tubes in window		No	Actual (% diameter)	/ 10 /	
Number		8	Nominal (% diameter)	/ 10 /	
Spacing (center-center)	mm	700	Actual (% area)	/ 5,2 /	
Spacing at inlet	mm	742,48	Cut orientation		н
Spacing at outlet	mm	742,48	Thickness	mm	9,52
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap		36
Spacing at center of H shell	mm		Tube rows in baffle window		0,5
End length at front head	mm	800	Baffle hole - tube od diam clearance	mm	0,79
End length at rear head	mm	800	Shell id - baffle od diam clearance	mm	4,76
VariableBaffles					
Baffle spacing	mm				

mm

Supports Misc. Baffles

Baffle cut percent, outer Baffle cut percent, inner Number of baffle spaces Baffle region length

Baffle cut area percent, outer Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		106,78	Tube pass layout	Ribbon (s	single band)
From bottom		106,78	Tube pass orientation	Standard	(horizontal)
From right		13,63	U-bend orientation		Undefined
From Left		13,63	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	962,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	501,8	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	492,9	Sealing strips (pairs)		7
Bare tube area per shell	m²	492,9	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs	.)		1624
Position			Hor	Tube length actual		mm	700
Arrangement		1 par	1 ser	Tube passes			
Baffle type		Singles	segmental	Tube type			Plai
Baffle number			30	Tube O.D.		mm	19,0
Spacing (center-center)	r	nm	200	Tube pitch		mm	23,8
Spacing at inlet	r	mm	536,48	Tube pattern			3
			Shell	Kettle	Fr	ont head	Rear head
Outside diameter	r	nm	1118			1118	1118
Inside Diameter	r	nm	1100			1100	1100
	_		Shell Side	· ·	— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	323,85	273,05		406,4	457,2	
Inside diameter	mm	304,8	254,51		387,35	438,15	
Height under nozzle	mm	128,03	128,03				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	6695	275				

Tubes

_

Tubes				
Туре	Plain	Total number		1624
Outside diameter mm	19,05	Number of tubes plugged		0
Inside diameter mm	16,56	Tube length actual	mm	7000
Wall thickness mm	1,24	Tube length effective	mm	6873
Area ratio Ao/Ai	1,15	Tubesheet thickness	mm	60,52
Pitch mm	23,81	Material	22Cr,51	Ni,3Mo steel
Pattern	30	Thermal conductivity	W/(m K)	16,1767
External enhancement		Internal enhancement		
Low circumferential fins		Low longitudinal fins		
Fin density #/m		Fin number		0
Fin height mm		Fin thickness	mm	
Fin thickness mm		Fin height	mm	
Tube root diameter mm		Fin spacing	mm	
Tube wall thickness under fin mm		Cut and twist length	mm	
Tube inside diameter under fins mm				

Baffles

Baffles						
Туре	Single se	egmental	Baffle cut: inner / outer / inter	rm		
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		30	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	200	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	536,48	Cut orientation			Н
Spacing at outlet	mm	536,48	Thickness		mm	6,35
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			40
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	600	Baffle hole - tube od diam clear	ance	mm	0,79
End length at rear head	mm	600	Shell id - baffle od diam clearar	nce	mm	6,35
VariableBaffles						
Baffle spacing Baffle cut percent, outer Baffle cut percent, inner Number of baffle spaces	mm					

mm

Supports Misc. Baffles

Baffle region length

Baffle cut area percent, outer Baffle cut area percent, inner

	Longitudinal Baffle	
0	Thickness	mm
0	Window length at front head	mm
0	Window length at center	mm
No	Window length at rear head	mm
0		
0		
0		
0		
No		
	0 0 No 0 0 0	0 Thickness 0 Window length at front head 0 Window length at center No Window length at rear head 0 0 0 0 0 0 0 0

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		128,03	Tube pass layout	Ribbon (s	ingle band)
From bottom		128,03	Tube pass orientation	Standard	(horizontal)
From right		16,6	U-bend orientation		Undefined
From Left		16,6	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1087,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	680,3	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	668	Sealing strips (pairs)		7
Bare tube area per shell	m²	668	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Appendix G – Thermal Calculations for Heat Exchangers in Case Study II

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			708
Position			Hor	Tube length actual		mm	500
Arrangement		1 par	1 ser	Tube passes			
Baffle type		Singles	segmental	Tube type			Plai
Baffle number			6	Tube O.D.		mm	24,
Spacing (center-center)	n	nm	610	Tube pitch		mm	31,7
Spacing at inlet	n	nm	876,48	Tube pattern			3
			Shell	Kettle	Fr	ont head	Rear head
Outside diameter	n	nm	1001			1033	1033
Inside Diameter	n	nm	975			975	975
			Shell Side		— Tube	Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	273	219,1		914	914	
Inside diameter	mm	253	203,1		864	864	
Height under nozzle	mm	117,8	117,8				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	ir	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	4685	280				

Tubes

Tubes					
Туре		Plain	Total number		708
Outside diameter	mm	24,5	Number of tubes plugged		0
Inside diameter	mm	21,2	Tube length actual	mm	5000
Wall thickness	mm	1,65	Tube length effective	mm	4803
Area ratio Ao/Ai		1,16	Tubesheet thickness	mm	95,52
Pitch	mm	31,75	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	15,7218
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Туре	Single se	egmental	Baffle cut: inner / outer / inte	rm		
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		6	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	610	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	876,48	Cut orientation			н
Spacing at outlet	mm	876,48	Thickness		mm	9,52
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			26
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	975	Baffle hole - tube od diam clear	ance	mm	0,79
End length at rear head	mm	975	Shell id - baffle od diam clearar	nce	mm	4,76

Baffle spacing	mm
Baffle cut percent, outer	
Baffle cut percent, inner	
Number of baffle spaces	
Baffle region length	mm
Baffle cut area percent, outer	
Baffle cut area percent, inner	

Supports Misc. Baffles

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

mm		Tube passes		1
	117,8	Tube pass layout	Ribbon (s	ingle band)
	117,8	Tube pass orientation	Standard	(horizontal)
	14,88	U-bend orientation		Undefined
	14,88	Horizontal pass lane width	mm	
	None	Vertical pass lane width	mm	
mm		Interpass tube alignment		No
mm		Deviation in tubes/pass		0
mm		Outer tube limit	mm	962,3
mm		Shell id - bundle otl diam clearance	mm	12,7
mm		Tie rod number		8
m²	272,5	Tie rod diameter	mm	12,7
m²	261,7	Sealing strips (pairs)		5
m²	261,7	Tube to tubesheet joint		Exp.
m²	0	Tube projection from front tsht	mm	3
m²	0	Tube projection from rear tsht	mm	3
	mm mm mm mm m ² m ² m ² m ² m ²	mm 117,8 117,8 14,88 14,88 None mm mm mm mm mm 272,5 m ² 272,5 m ² 261,7 m ² 261,7 m ² 0	117,8Tube pass layout117,8Tube pass orientation117,8Tube pass orientation14,88U-bend orientation14,88Horizontal pass lane widthNoneVertical pass lane widthNoneVertical pass lane widthInterpass tube alignmentInterpass tube alignmentmmDeviation in tubes/passmmOuter tube limitmmShell id - bundle otl diam clearancemmTie rod numberm2272,5Tie rod diameterm2261,7Sealing strips (pairs)m20Tube projection from front tsht	117,8Tube pass layoutRibbon (s117,8Tube pass orientationStandard14,88U-bend orientation14,8814,88Horizontal pass lane widthmmNoneVertical pass lane widthmmmmInterpass tube alignmentmmmmOuter tube limitmmmmShell id - bundle otl diam clearancemmmmTie rod numbermmm²272,5Tie rod diametermmm²261,7Sealing strips (pairs)m²0Tube projection from front tshtmm

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			73
Position			Hor	Tube length actual		mm	650
Arrangement		1 par	1 ser	Tube passes			
Baffle type		Single	segmental	Tube type			Plai
Baffle number			6	Tube O.D.		mm	25,
Spacing (center-center)	r	nm	855	Tube pitch		mm	31,7
Spacing at inlet	r	nm	1009,98	Tube pattern			3
			Shell	Kettle	F	ront head	Rear head
Outside diameter	r	nm	1026			1060	1060
Inside Diameter	r	nm	1000			1000	1000
	_		Shell Side		— Tub	e Side ——	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	323,9	273		914	914	
Inside diameter	mm	303,9	253		864	864	
Height under nozzle	mm	129,85	129,85				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	6155	310				

Tubes

Tubes					
Туре		Plain	Total number		731
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	6500
Wall thickness	mm	1,65	Tube length effective	mm	6295
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	99,52
Pitch	mm	31,75	Material	22Cr,51	vi,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	15,7206
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles

Туре	Single s	egmental	Baffle cut: inner / outer / interm			
Tubes in window		No	Actual (% diameter)	/	12,75 /	
Number		6	Nominal (% diameter)	/	12,75 /	
Spacing (center-center)	mm	855	Actual (% area)	/	7,43 /	
Spacing at inlet	mm	1009,98	Cut orientation			ŀ
Spacing at outlet	mm	1009,98	Thickness		mm	9,5
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			2
Spacing at center of H shell	mm		Tube rows in baffle window			0,
End length at front head	mm	1112,5	Baffle hole - tube od diam clearance	;	mm	0,7
End length at rear head	mm	1112,5	Shell id - baffle od diam clearance		mm	6,3

Baffle spacing	mm
Baffle cut percent, outer	
Baffle cut percent, inner	
Number of baffle spaces	
Baffle region length	mm
Baffle cut area percent, outer	
Baffle cut area percent, inner	

Supports Misc. Baffles

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		129,85	Tube pass layout	Ribbon (s	single band)
From bottom		129,85	Tube pass orientation	Standard	(horizontal)
From right		11,05	U-bend orientation		Undefined
From Left		11,05	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	987,3
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	12,7
Impingement plate thickness	mm		Tie rod number		8
Gross surface area per shell	m²	379,2	Tie rod diameter	mm	12,7
Effective surface area per shell	m²	367,2	Sealing strips (pairs)		5
Bare tube area per shell	m²	367,2	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Appendix H – Thermal Calculations for Heat Exchangers in Case Study III

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.))		1865
Position			Hor	Tube length actual		mm	9000
Arrangement		2 par	1 ser	Tube passes			1
Baffle type		Single	segmental	Tube type			Plain
Baffle number			6	Tube O.D.		mm	25,4
Spacing (center-center)	r	nm	1240	Tube pitch		mm	31,75
Spacing at inlet	r	nm	1248,47	Tube pattern			30
			Shell	Kettle	I	Front head	Rear head
Outside diameter	r	nm	1586			1642	1642
Inside Diameter	r	nm	1550			1550	1550
	_		Shell Side		— Tu	be Side	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	406,4	323,9		711	711	
Inside diameter	mm	386,4	303,9		671	671	
Height under nozzle	mm	157,38	157,38				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	nt			
Distance to tubesheet	mm	8565	385				

Tubes

Tubes					
Туре		Plain	Total number		1865
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	9000
Wall thickness	mm	1,65	Tube length effective	mm	8697
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	148,52
Pitch	mm	31,75	Material	22Cr,51	vi,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	16,4295
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles						
Туре	Single segmental		Baffle cut: inner / outer / inter	m		
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		6	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	1240	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	1248,47	Cut orientation			н
Spacing at outlet	mm	1248,47	Thickness		mm	19,05
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			44
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	1400	Baffle hole - tube od diam cleara	ance	mm	0,4
End length at rear head	mm	1400	Shell id - baffle od diam clearan	се	mm	7,94
VariableBaffles			L			
Baffle spacing	mm					
Baffle cut percent, outer						
Baffle cut percent, inner Number of baffle spaces						
Baffle region length	mm					

Supports Misc. Baffles

Baffle cut area percent, outer Baffle cut area percent, inner

	Longitudinal Baffle	
0	Thickness	mm
0	Window length at front head	mm
0	Window length at center	mm
No	Window length at rear head	mm
0		
0		
0		
0		
No		
	0 0 No 0 0 0	0 Thickness 0 Window length at front head 0 Window length at center No Window length at rear head 0 0 0 0 0 0 0 0

Bundle

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		157,38	Tube pass layout	Ribbon (s	ingle band)
From bottom		157,38	Tube pass orientation	Standard	(horizontal)
From right		16,18	U-bend orientation		Undefined
From Left		16,18	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1535,71
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	14,29
Impingement plate thickness	mm		Tie rod number		12
Gross surface area per shell	m²	1339,4	Tie rod diameter	mm	15,88
Effective surface area per shell	m²	1294,3	Sealing strips (pairs)		8
Bare tube area per shell	m²	1294,3	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3

Unit Configuration							
Exchanger Type			BEM	Tube number (calcs.)			2240
Position			Hor	Tube length actual		mm	9000
Arrangement		2 par	1 ser	Tube passes			
Baffle type		Single	segmental	Tube type			Plair
Baffle number			38	Tube O.D.		mm	25,4
Spacing (center-center)	r	nm	200	Tube pitch		mm	31,7
Spacing at inlet	r	nm	630,48	Tube pattern			30
			Shell	Kettle	Fr	ont head	Rear head
Outside diameter	r	nm	1738			1806	1806
Inside Diameter	r	nm	1700			1700	1700
	_		Shell Side	· ·	— Tube	e Side ——	
Nozzle type		Inlet	Outlet		Inlet	Outlet	
Number of nozzles		1	1		1	1	
Actual outside diameter	mm	457	355,6		711	711	
Inside diameter	mm	437	335,6		671	671	
Height under nozzle	mm	177,39	177,39				
Dome inside diameter	mm						
Vapor belt inside diameter	mm						
Vapor belt inside width	mm						
Vapor belt slot area	mm²						
Impingement protection	i	No mpingement	No impingeme	ent			
Distance to tubesheet	mm	8525	420				

Tubes

Tubes					
Туре		Plain	Total number		2240
Outside diameter	mm	25,4	Number of tubes plugged		0
Inside diameter	mm	22,1	Tube length actual	mm	9000
Wall thickness	mm	1,65	Tube length effective	mm	8661
Area ratio Ao/Ai		1,15	Tubesheet thickness	mm	166,52
Pitch	mm	31,75	Material	22Cr,51	Ni,3Mo steel
Pattern		30	Thermal conductivity	W/(m K)	16,4586
External enhancement			Internal enhancement		
Low circumferential fins			Low longitudinal fins		
Fin density	#/m		Fin number		0
Fin height	mm		Fin thickness	mm	
Fin thickness	mm		Fin height	mm	
Tube root diameter	mm		Fin spacing	mm	
Tube wall thickness under fin	mm		Cut and twist length	mm	
Tube inside diameter under fins	mm				

Baffles						
Туре	Single segmental		Baffle cut: inner / outer / interm			
Tubes in window		No	Actual (% diameter)	/	10 /	
Number		38	Nominal (% diameter)	/	10 /	
Spacing (center-center)	mm	200	Actual (% area)	/	5,2 /	
Spacing at inlet	mm	630,48	Cut orientation			Н
Spacing at outlet	mm	630,48	Thickness		mm	9,52
Spacing at central in/out for G,H,I,J shells	mm		Tube rows in baffle overlap			48
Spacing at center of H shell	mm		Tube rows in baffle window			0,5
End length at front head	mm	800	Baffle hole - tube od diam clearar	ice	mm	0,79
End length at rear head	mm	800	Shell id - baffle od diam clearance	9	mm	7,94
VariableBaffles						
Baffle spacing	mm					
Baffle cut percent, outer						
Baffle cut percent, inner						
Number of baffle spaces Baffle region length	mm					
Baffle cut area percent, outer						

Supports Misc. Baffles

Baffle cut area percent, inner

Supports-tube		Longitudinal Baffle	
Supports in endspace at front head	0	Thickness	mm
Supports in endspace at rear head	0	Window length at front head	mm
Supports between baffles	0	Window length at center	mm
Support blanking baffle	No	Window length at rear head	mm
Supports at U-bend	0		
Supports at each G,H,J shell inlet and I shell outlet	0		
Supports at center of H shell	0		
Supports for K, X shells	0		
Special support at inlet nozzle	No		

Bundle					
Shell ID to center 1st tube row	mm		Tube passes		1
From top		177,39	Tube pass layout	Ribbon (s	ingle band)
From bottom		177,39	Tube pass orientation	Standard	(horizontal)
From right		11,8	U-bend orientation		Undefined
From Left		11,8	Horizontal pass lane width	mm	
Impingement protection		None	Vertical pass lane width	mm	
Impingement distance	mm		Interpass tube alignment		No
Impingement plate diameter	mm		Deviation in tubes/pass		0
Impingement plate width	mm		Outer tube limit	mm	1685,71
Impingement plate length	mm		Shell id - bundle otl diam clearance	mm	14,29
Impingement plate thickness	mm		Tie rod number		12
Gross surface area per shell	m²	1608,7	Tie rod diameter	mm	15,88
Effective surface area per shell	m²	1548,1	Sealing strips (pairs)		9
Bare tube area per shell	m²	1548,1	Tube to tubesheet joint		Exp.
Finned area per shell	m²	0	Tube projection from front tsht	mm	3
U-bend area per shell	m²	0	Tube projection from rear tsht	mm	3