EXPERIMENTAL EVALUATION OF HEAT TRANSFER IMPACTS OF TUBE PITCH ON HIGHLY ENHANCED SURFACE TUBE BUNDLE

by

EVRAAM GORGY

M.S., Kansas State University, 2008

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Mechanical and Nuclear Engineering
College of Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2011

Abstract

The current research presents the experimental investigation of the effect of tube pitch on enhanced tube bundles' performance. The typical application of this research is flooded refrigerant evaporators. Boosting evaporator's performance through optimizing tube spacing reduces cost and energy consumption. R-134a with the enhanced tube Turbo BII-HP and R-123 with Turbo BII-LP were used in this study. Three tube pitches were tested P/D 1.167, P/D 1.33, and P/D 1.5. Each tube bundle includes 20 tubes (19.05 mm outer diameter and 1 m long each) constructed in four passes. The test facility's design allows controlling three variables, heat flux, mass flux, and inlet quality.

The type of analysis used is local to one location in the bundle. This was accomplished by measuring the water temperature drop in the four passes. The water-side pressure drop is included in the data analysis. A new method called the EBHT (Enthalpy Based Heat Transfer) was introduced, which uses the water-side pressure drop in performing the heat transfer analysis.

The input variables ranges are: 15-55 $kg/m^2.s$ for mass flux, 5-60 kW/m^2 for heat flux, and 10-70% for inlet quality. The effect of local heat flux, local quality, and mass flux on the local heat transfer coefficient was investigated. The comparison between the bundle performance and single tube performance was included in the results of each tube bundle. The smallest tube pitch has the lowest performance in both refrigerants, with a significantly lower performance in the case of R-134a. However, the two bigger tube pitches have very similar performance at low heat flux. Moreover, the largest tube pitch performance approaches that of the single tube at medium and high heat fluxes.

For the R-123 study, the smallest tube bundle experienced quick decease in performance at high qualities, exhibiting tube enhancement dry-out at certain flow rates and high qualities. The flow pattern effect was demonstrated by the dry-out phenomena. At medium and high heat fluxes, as the tube pitch increases, the performance approaches that of the single tube. All tube bundles experience quick decrease in performance at high qualities. Evidently, P/D 1.33 is the optimum tube pitch for the studied refrigerants and enhanced tubes combinations.

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Acknowledgements

I want to start my acknowledgement with the biblical verse "The Lord has done great things for us, and we are glad" Psalm 126:3. Truly, the Lord has done great things throughout the difficult time of this project and I am very pleased and thankful. Firstly, I would like to thank Dr. Steve Eckels who has been a great teacher and advisor. I actually learned from the way Dr. Eckels deals with students and people in general. He is patient and forgiving and these are two great virtues. This also makes me responsible for following his example.

Secondly, I would like to thank my committee members Dr. Larry Glasgow, Dr. Terry Beck, and Dr. Don Fenton for their guidance. I learned from them that to be a faculty member is to be a giving person; and indeed they gave a lot of their time and knowledge. Many thanks for Dr. Medhat Morcos for his support and his kind heart. I am appreciative of ASHRAE RP-1316 supervisory committee and to Wolverine Tube Inc. for donating the enhanced tubes to the project.

Special thanks to David Huddleston of K-State's EDL for his diligent work and brilliant ideas in manufacturing the thermistors. This research would not have been possible without the hard work of Luke Schooler, whose skills and talents helped solving the construction problems of the complicated test facility. I am indebted also to Jacob Wagner who is a talented and bright engineer; it was a pleasure working with him. I am grateful for Eric Waters' skills and experience. Thanks to all the current and past IER students, among those Bill Sharp, Greg May, Mathew Kluitenberg, Andrew Featherstone. For all the engineering graduates who helped me and I have forgotten to mention their names I say, many thanks and please forgive my weak memory. Thanks to all IER staff, it has been a pleasure working with you.

Thanks to my dad who implanted in me the value of science and its positive impact on humanity. I am grateful for my family and friends for their support and prayers. Thanks for St. Mary Magdalene for being a strong intercessor during the hard times of this project. Finally, thanks to K-State; I had a wonderful time there and it will always be in my memory. I have to say that my almost six years at K-State have gone by fast.

Dedication

I decided to dedicate this work to someone who had a significant impact on my life. Although God has blessed me with a lot of good examples, I cannot think of anyone better than my beloved mother. My mother departed this life on February 23rd, 2009 after a battle with cancer. Her life and her death have an impact on my life; she lived and died in Egypt. I was working on this research during the time of her sickness and death. I was with her about a month before she departed this world. May God repose her soul.

To my beloved mother Victoria

Nomenclature

A	Area	Pr	Prandtl number
C	Constant	q''	Heat flux
C_i	Internal correction factor	Q	Total heat transfer
C_o	External correction factor	ρ	Density
C_p	Specific heat at constant pressure	Re	Reynolds number
Cap	Capillary number	R	Electrical resistance
D	Diameter	R_{wall}	Wall thermal resistance
D_h	Hydraulic diameter	R'_{wall}	Modified wall thermal resistance
ε	Void fraction	Ri	Richardson number
f	Friction factor	σ	Surface tension
g	Gravitational acceleration	T	Temperature
G	Mass flux	T_{sat}	Saturation temperature
h	Heat transfer coefficient	T_∞	Fluid temperature
h_{fg}	Specific heat of vaporization	U	Overall heat transfer coefficient
i	Enthalpy	u	Uncertainty
k	Thermal conductivity	V	Voltage
k_c	Copper thermal conductivity	v	Specific volume
L	Length	x	Quality
L_c	Characteristic length		
L_T	Test section length		
μ_L	Liquid viscosity		
$\dot{m}$	Mass flow rate		
Nu	Nusselt number		
P	Pressure		
P/D	Pitch to diameter ratio		

Subscripts

c	Cold-side
CB	Convective boiling
G	Gas or vapor
h	Hot-side
i	Inside or internal
L	Liquid
LQ	Liquid phase
NB	Nucleate boiling
o	Outside or outer
r	Refrigerant-side
ref	Refrigerant
w	Water-side

Chapter 1 Introduction

1.1 Background

The current document presents experimental research for investigating the heat transfer effect of tube pitch on enhanced tube bundles. This research project is funded by ASHRAE (RP-1316), and supervised by TC 8.5 “Liquid to Refrigerant Heat Transfer” under the chairmanship of Dr. Petur Thors. The application of this research is flooded refrigerant evaporators, which have wide application in the HVAC&R industry, for example in high capacity centrifugal chillers.

A flooded evaporator is a shell and tube heat exchanger in which a fluid circulates inside the tube bundle and is cooled by a refrigerant circulating in the shell and over the tube bundle. Cooling takes place through boiling (phase change) of the refrigerant. In flooded evaporators, the refrigerant flows over the tube bundle from the bottom up; it enters the shell at a quality of about 10%, due to the expansion device, and leaves at 100% quality (saturated vapor). This application is usually called “shell boiling.” The tube bundles used in this application can be smooth or enhanced.

The current enhanced copper tubes have been introduced to increase evaporator efficiency by providing active vapor traps. Numerous studies have focused on developing and evaluating enhanced tubes for shell boiling. Since boiling over a tube bundle represents a very complex two-phase flow problem, such phenomenon is often understood through experimental investigation. However, the goal of bundle studies is to introduce a predictive model for designing flooded evaporators.

Studying shell boiling involves examining the effect of different variables on the bundle performance: fluid properties, saturation pressure, mass flux, heat flux, etc. In particular, enhanced tubes are considered a modern development in flooded evaporators and although were included in several shell boiling studies, the influence of tube pitch on the bundle performance has not been examined in depth.

1.2 The significance of the research

Striving for energy resources in a troubled economy raises even more awareness of energy conservation, and in some cases, energy conservation is mandatory. This is becoming a challenging problem for the HVAC&R community (and for cooling applications in particular). All possible solutions to reduce energy consumption and initial cost are being considered, including better design tools for large cooling systems such as centrifugal chillers. In 2004, the market size of centrifugal chillers with cooling capacities exceeding 500 tons approximated $390 million and was shared by both the manufacturer and the customer.

Such a high cost scale leads to demand for all possible solutions to reduce both initial and running costs. While the flooded refrigerant evaporator is only one component of the chiller system or other cooling application, maximizing the knowledge and the development of this one component is important. Increasing the evaporator heat transfer efficiency leads to less required compressor work and a lighter weight shell and tube heat exchanger. Therefore, studying the effect of tube pitch along with expanding the database of flow boiling in flooded evaporators is worthwhile.

1.3 Objective

The goal of the current study is to investigate the effect of tube pitch on the heat transfer performance of flooded refrigerant evaporators that utilize highly enhanced tubes. This includes testing both high and low pressure refrigerants; however, boiling of low pressure refrigerants (high specific volume) over enhanced tubes can lead to dry-out. Therefore, using investigating the effect of tube pitch using low pressure refrigerant could help with researching this phenomenon.

Accordingly this research is accomplished by investigating the change of the heat transfer coefficient with respect to three variables: heat flux, mass flux, and quality, each to be controlled one at a time. In addition, the study provides an experimental database to expand the understanding of shell boiling on enhanced tubes and to produce evaporator models.

1.4 Scope of work

The project includes testing three tube pitches for two refrigerants using the staggered bundle arrangement (equilateral triangles). The three tube pitches are P/D 1.167 (commonly used in industry), P/D 1.33, and P/D 1.5. The test section can accommodate the three tube pitches and employs 20 tubes, each with a 0.01905 m (0.75 inch) outer diameter. The type of enhanced tube used is Turbo BII, which includes two versions one tailored for high and one for low pressure refrigerants. The tubes were manufactured and donated by Wolverine Tube, Inc.

The test section has sight glasses for flow visualization extending from the bottom to the top of the test section to show the full tube bundle and the inlet ports. Pure refrigerant (oil free) was used in testing, which was conducted at a saturation temperature of 4.44 °C (40 °F) for R-134a and 14.44 °C (58 °F) for R-123.

A test matrix is composed for each tube bundle, and testing is conducted according to three controlling variables in the test matrix: heat flux, mass flux, and inlet quality. Table 1-1 below shows the general range of these input variables. The type of data analysis used is local to one location in the bundle. Additionally, a new method, the research introduces the Enthalpy Based Heat Transfer analysis or "EBHT", to determine the heat transfer analysis as a function of the tube-side pressure drop. This method is particularly useful in heat exchangers that experience large tube-side pressure drop.

Table 1-1 Test matrix inputs

Mass flux (kg/s.m²)	15	20	25	35	45	55
Heat flux (kW/m²)	5	15	30	45	60	
Inlet Quality	0.10	0.35	0.55	0.70		

Pool boiling study of the two tube-refrigerant combinations is presented as part of this study, and each tube bundle result is compared to the single tube performance. This comparison is an important tool in clarifying the convective effect in enhanced tube bundles. It is also useful for investigating the effect of tube pitch compared to the single tube performance.

1.5 Document organization

This document is divided into eight chapters and five appendices. The current chapter is the research introduction. The second chapter presents the literature review of enhanced tubes, enhanced tube bundles, effect of tube pitch on bundle performance, and bundle modeling. Chapter three presents the test facility's test section, refrigerant and water loops, and instruments.

Chapter 4 presents the data reduction, including the equations and methods to determine the local and tube-average heat transfer coefficients, local heat flux, the EBHT, and the uncertainty analysis.

Chapters 5, 6, and 7 present the research results specifically Chapter 5 is a general introduction to the results, dealing with the common results of the two refrigerants as well as presenting the pool boiling results. Chapters 6 and 7 present the results for R-134a and R-123, respectively. Each chapter presents the result of each tube pitch, from the smallest to the largest, and each ends with a comparison of the three tube pitches and the effect of tube pitch on tube bundle performance.

Chapter 8 presents the discussion of the different trends of the boiling curves and a comparison between the two refrigerants in light of different tube pitches. It also present a recommendation based on the experimental data. Finally, Chapter 9 presents the conclusion of the research and the appendices present test section drawings, visuals of the test facility, boiling visuals, an example of a MathCad worksheet, and the data tables, respectively.

Chapter 2 Literature Review

2.1 Introduction

Boiling on a tube bundle has been in use for decades and has many applications: fire tube steam boilers, kettle re-boilers, waste heat boilers, and flooded refrigerant evaporators. The focus of this study is flooded refrigerant evaporators, which are widely used in centrifugal chillers, a high capacity cooling application. In flooded evaporators, refrigerant enters the tube bundle as a two phase mixture (approximately 10% quality) due to the expansion device effect, and refrigerant typically leaves the bundle as saturated vapor. The possible heat transfer regimes of the flooded evaporator from bottom to top are as follows: convective heat transfer, sub-cooled boiling, nucleate boiling, sliding bubbles evaporation, and film boiling. In some cases, the top tubes may experience dry-out.

The types of tubes used in flooded refrigerant evaporators are smooth, integral fin, and enhanced. Recently, enhanced tubes have been the focus of many research projects because of their high efficiency. Furthermore, enhanced tube technology has been on the rise as machining techniques continue to advance, previously an obstacle to developing these tubes.

The following sub-sections discuss: an overview of enhanced tubes and their advancement, enhanced tube bundles studies, effect of tube pitch, available bundle models, and general conclusion.

2.2 Enhanced tubes advancement

In the early 1960s, chiller manufacturers used integral fin tubes (for the refrigerant side) to increase heat transfer performance by increasing surface area, hence offering better heat transfer. This concept, however, is different from that of enhanced tubes, as the main focus of enhanced tubes is creating nucleation sites.

Enhanced surfaces used in boiling applications are, concisely, surfaces that contain artificial nucleation sites, unlike smooth surfaces that gain their nucleation sites from natural surface imperfections. The purpose of an enhanced surface then is to create stable vapor traps. Therefore, as the area density of nucleation sites increases, the onset of boiling occurs at a lower wall superheat.

Webb (2004) gives an excellent discussion of the development of enhanced surfaces reporting that it started in 1960 when researchers investigated the development of reentrant cavities after proving that a reentrant cavity provides a stable vapor trap. In spite of this discovery, machining tubes that contain reentrant cavities was still an obstacle. In his patent in 1970, Webb suggested creating nucleation sites on integral fin tubes by simply warping a wire at the base of the fins.

Continuing with developing tubes with artificial nucleation sites on integral fin tubes, Webb considered bending the tube fins to create a cavity with an opening on the tip of the fin. This tube was called the "bent fin" tube, and was first produced by Trane. Some consider the configuration of the bent fin as a cavity with pores design. Developing such enhanced tubes flourished among researchers and manufacturers. They even started working on enhancing the inside of the tubes (the water side). Well-known tube manufacturers making enhanced tubes included Hitachi (introduced Thermoexcel-E tube), Wieland (GEWA-T), Furukawa (ECR-40), and Wolverine (Turbo-B). The Turbo-B family evolved to what is now known as the Turbo-BIII tube. The current research uses one of the tubes in this family, the Turbo-BII.

All the previously mentioned tubes use the idea of cavities with pores, or rather tunnels with pores, and they are what is now known as "enhanced tubes"; some also call the concept structured tubes. Although some of those tube configurations are available in literature, the detailed configuration and methods of manufacturing remain proprietary.

Nakayama et al. (1982) studied the tunnel with pores configuration and came up with an explanation of evaporation modes at different heat flux ranges. They also developed a semi-analytical model to predict the heat transfer performance. Chien and Webb (1998) Part I and Part II presented a parametric study of the effect of tunnel and pore dimensions on tube performance, studying the flow visualization and presenting an enhanced version of Nakayama's model. Notably, the previously mentioned studies and model are for single tube pool boiling. Consequently, studying enhanced tube performance in a tube bundle became imperative since enhanced tubes are produced mainly for tube bundles of shell and tube heat exchangers.

2.3 Boiling over enhanced tube bundles

Studying convective boiling over a tube bundle is relatively difficult compared to studying pool boiling. First, pool boiling experimental setup normally utilizes one tube in a pool of liquid, often driven by natural circulation. Also, pool boiling measurements are relatively simple. On the other hand, in a tube bundle experiment, the test section employs a bundle of tubes where the shell fluid is usually driven by a pump. The experiment setup also includes multiple and sophisticated measurements. Therefore, tube bundle studies are few compared to those for pool boiling.

Researchers have used different approaches in assessing bundle performance. Some focused their work on studying the effect of tube position within the tube bundle, bundle height, static pressure, saturation temperature, and so forth. Additionally, often, bundle studies compare convective boiling and single tube pool boiling; this comparison is known as “bundle effect” or “bundle factor.” Among those who provided tube bundle reviews are Ribatski and Thome (2007), Webb (2005), Casciaro and Thome (2001) Part 1, Browne and Bansal (1999), Thome (1998), Thome (1996), Collier and Thome (1994), Thome (1990), Jensen and Hsu (1988).

This section of the literature review focuses only on enhanced tube bundles studies and on local analysis because this is the best method to clarify tube bundle behavior as well as provide data useful for producing flooded evaporator models. Three variables have the most significant effect on the heat transfer coefficient (often referred to as “bundle performance”): heat flux, quality, and mass flux. Those variables are also the center of the analysis of the current study. Notably, Fujita et al. (1986), Memory et al. (1992), and Memory et al. (1994) studied boiling over smooth and enhanced tube bundles in a pool of liquid. However, this is considered a different application than that in the current study, since it does not present the effect of mass velocity on convective boiling; in some cases, the calculation of quality is not possible. Therefore, the effect of quality cannot be assessed.

The following authors reported varied enhanced tube bundle studies highlighting the effect of heat flux, quality, and mass flux. Chyu et al. (2009) studied boiling of ammonia/lubricant mixture on a horizontal enhanced tube bundle, conducting tests over a range of saturation temperatures (-13.2 to 7.2 °C). Data showed that the heat transfer coefficient increased with the increase in saturation temperature, heat flux, and from the bottom row to the top row; ultimately, the bundle effect was more significant at higher saturation temperatures. Meanwhile, the performance at the bottom row was lower than that of the single tube heat transfer coefficient at a low saturation temperature, and the opposite was true at a higher saturation temperature. Thus, saturation temperature had a more significant effect on the tube bundle performance than on the pool boiling performance.

Schafer et al. (2007) studied the effect of novel plasma-coated tubes on the bundle performance using R-134a as the working fluid. In that study, coated-tube bundle performance was compared to smooth tube bundle and single tube performances and coated tubes showed a significant increase in the bundle as well as the single tube performances. At higher heat fluxes, bundle performance approached that of a single tube.

Chien and Wu (2004) studied convective boiling of R-123 and R-134a over smooth and low fin tube bundles and conducted pool boiling tests as well. They reported that the heat transfer coefficient increased with the increase of quality (at the test range of 0-0.34) for R-134a on smooth tube, while the mass flux (10-40 $kg/m^2.s$) had small effect on performance. Also, low fin tubes showed significant performance enhancement over smooth tubes.

Robinson and Thome (2004) presented one of the most comprehensive studies on this topic, studying the local bundle heat transfer coefficient for three types of tube bundles: smooth (with R-134a), integral fin (with R-134a and R-507a), and enhanced (R-134a, R-410a, R-507a). The tube bundles were P/D 1.167. They also conducted pool boiling experiments for each set. For smooth tube bundles, they reported that the local heat transfer coefficient did show a significant change with the change of mass flux. Specifically, the bundle effect (defined as the local bundle heat transfer coefficient divided by pool boiling heat transfer coefficient) decreased with the increase of heat flux. Next, for a constant mass flux over a range of quality, the heat transfer coefficient increased with the increase of heat flux. However, for constant heat flux and mass flux, the heat transfer coefficient did not show a significant effect with the change of quality.

For the integral fin (1024 fins/m (26 fins/inch))) tube bundle study, Robinson and Thome (2004) reported that the heat transfer coefficient did not show a significant change with the change of mass flux over a range of quality and constant heat flux. In particular, the bundle effect decreased with the increase of heat flux. Meanwhile, for constant heat flux and over a range of quality, the heat transfer coefficient increased with the increase of heat flux. Finally, for constant mass flux and heat flux, the heat transfer coefficient did not show a significant change with the change of quality.

For the enhanced tube portion of the study (Turbo BII tube), and for a range of quality and constant mass flux, the heat transfer coefficient did not show a significant change with mass flux. Again, for constant mass and heat fluxes, the heat transfer coefficient did not show a significant change with quality. Meanwhile, the bundle effect ranged from 0.8 to 1.6 for R-134a, and from 0.6 to 1.2 for R-410a and R-507a.

Kim et al. (2002) presented a study of different types of enhanced tube bundles under R-134a and R-123 at different saturation temperatures. They conducted tests for smooth tube bundles as well and reported that the heat transfer coefficient was dominated by heat flux with negligible dependency on mass flux or quality. The increase in saturation temperature enhanced the heat transfer coefficient. Finally, they reported that the convective effect for R-134a was higher than for R-123 for the enhanced tubes, but the smooth tube bundle showed the opposite.

Tatara and Payvar (2000) Part I presented an experimental investigation of the effect of oil on boiling of R-123 on staggered pitch enhanced tube bundle, P/D 1.167 and calculated the local heat transfer coefficient. They conducted tests for different oil concentrations including 0% concentration and reported that the increase of oil concentration decreased tube performance.

Similar to Part I, Tatara and Payvar (2000) Part II presented an experimental investigation of the effect of oil on boiling of R-134a on a staggered pitch enhanced tube bundle, P/D 1.167 and calculated the local heat transfer coefficient. They conducted tests for different oil concentrations including 0% concentration and was reported that the increase of oil concentration decreased tube performance.

Tatara and Payvar (1999) reported the experimental work of the effect of oil concentration on an integral fin (1024 fins/m (26 fins/inch)) tube bundle under R-123 and R-134a, finding general, that the heat transfer coefficient increased with the increase of oil concentration.

Gupta and Webb (1995) Part I conducted experiments for an integral fin (1024 fins/m (26 fins/inch)) tube bundle with P/D 1.25 for R-11 at two different saturation temperatures (4.4 and 26.7 °C). They studied the effect of convective boiling and pool boiling finding that convective boiling coefficients were twice as high as pool boiling coefficients.

Similar to Part I, Gupta and Webb (1995) Part II conducted experiments for enhanced tube bundles (GEWA SE and Turbo B) with P/D 1.25 under R-11, R-123 and R-134a at 4.4 and 26.7 °C saturation temperatures. Data showed convective behavior similar to that for pool boiling data. Also, the enhanced tubes' convective effect was much less than that for integral fin tubes.

Danilova and Dyundin (1972) presented experimental work for boiling of R-12 and R-22 over smooth and finned tube bundles (registering different fin geometry). They reported that for the bigger fin spacing, the effect of the number of rows of tubes was considerable. Specifically for small fin spacing, the effect of convective boiling was more pronounced.

2.4 Effect of tube pitch

The following studies point out the effect of tube pitch, or tube spacing, on boiling performance over a tube bundle, which is the focus of the current study. This section is divided into two: studies about the effect of tube spacing in a bundle submerged in a pool of liquid at all times and the studies about the effect of tube pitch for tube bundles under forced convection.

2.4.1 Effect of tube pitch for submerged tube bundles

Liao and Liu (2007) studied boiling of water over a smooth tube bundle at atmospheric and sub-atmospheric pressures focusing on the effect of tube spacing and tube positioning on bundle performance. For sub-atmospheric pressure, the optimum tube spacing is between P/D 1.0556 and 1.0277, and when P/D reaches 1.1112, the effect of tube position becomes apparent. When P/D is less than 1.0556, tube position becomes insignificant. Also, bundle pressure has an effect on the optimum spacing.

Liu and Liao (2006) used the same test facility and test conditions as their previously mentioned study. In this study, and in the one above, they tested in-line vs. staggered tube bundle configuration. At atmospheric pressure, the in-line tube bundle had better performance than the staggered tube bundle.

Qiu and Liu (2004) studied the effect of tube spacing, tube positioning, and bundle pressure on boiling of water over a smooth tube bundle and reported that P/D 1.0166 had the best heat transfer performance at low and moderate heat fluxes. For higher tube spacing, the tube position had a significant effect on heat transfer. For the tightest tube pitch, the heat transfer performance increased with the increase of pressure. Also, Liu and Chen (2001) presented a study similar to the previously mentioned study (Qiu and Liu (2004)). In addition, they investigated the differences between falling film and flooded type evaporators, discovering that flooded evaporators show better heat transfer performance.

Liu and Qiu (2004) and Liu and Qiu (2002) presented experimental results for boiling of water/salt mixture on smooth tube and roll-worked enhanced tube bundles (the latter is similar to the Wolverine Turbo B). The goals of this study, however, included the effect of tube spacing and tube position within the bundle. The smooth tube results were the same as in their study above, while for the enhanced tube bundle, tube position did not show any difference from the heat transfer perspective. Also, the tight spacing provided heat transfer enhancement for the enhanced tube bundle.

In another study by Liu and Qiu (2004) using the same test facility and methods but with R-11 as the working fluid, they reported that the P/D has an optimum value of 1.0277 (not the tightest pitch) for best performance enhancement. Liu and Tong (2002) presented similar work to Liu and Qiu (2004) in addition to producing a model for predicting the CHF, which agreed well with the experimental results.

2.4.2 Effect of tube pitch for tube bundles under forced convection

Gupta (2005) studied the effect of tube position for saturated water boiling over a 5×3 (P/D 1.5) in-line tube bundle and other tube arrangements (P/D 3.0, 4.5, and 6.0) and reported that at low heat flux, the mass flux was significant and diminished as the heat flux increased. Concerning the effect of P/D, Gupta found that the bundle heat transfer coefficient increased as the tube spacing decreased.

Fujita and Hidaka (1998) studied boiling of R-113 over in-line and staggered smooth tube bundles based on two tube pitches for each bundle configuration, P/D 1.3 and 1.5. They reported no significant effect on the heat transfer coefficient due to changing the tube pitch.

Jensen et al. (1992) conducted an experimental investigation of smooth and enhanced tube bundles. The enhanced tubes used in the analysis were smooth, Turbo B, and HIGHFLUX tubes with R-113 as the working fluid, and the two P/Ds used were 1.17 and 1.5. The effect of tube pitch on the smooth tube bundle was significant at low heat flux and high mass flux. Also, the effect of the change of mass flux and quality was negligible for the enhanced tube bundles.

Dowlati et al. (1990) studied void fraction and friction pressure drop of two phase flow of air-water across in-line tube bundles for P/D 1.3 and 1.75. This type of research is known as “adiabatic two-phase flow”. Dowlati et al. reported that void fraction does not show strong dependency on tube pitch; increasing the pitch increases two phase pressure drop. Ultimately, the presented void fraction and two-phase friction multiplier predicted the bundle pressure drop for R-113.

Jensen et al. (1989) studied the effect of tube geometry on a smooth tube bundle testing in-line and staggered tube bundles with P/D 1.3 and 1.7 for each tube bundle. They reported that at low heat flux, the higher tube pitch showed a higher heat transfer coefficient, while at medium heat flux, the heat transfer coefficient showed insignificant dependency on tube pitch.

Hsu and Jensen (1988) studied boiling of R-113 on a stainless steel smooth tube bundle testing different tube pitches to document the effect on heat transfer performance. The tube arrangement was an in-line tube bundle, with two P/Ds, 1.3 and 1.7. They reported that at high heat flux range, the high pitch bundle had the highest heat transfer coefficient while at medium heat flux range, the effect of tube pitch did not appear to be significant. Finally, the change of mass flux and saturation pressure had a negligible effect on the heat transfer coefficient for the different tube pitches.

Mueller (1986) studied boiling of R-11 over a finned tube bundle with different tube spacing and reported that tube spacing had little effect on heat transfer for the fully developed boiling regime, while tube pitch had considerable effect at the nexus between natural convection and nucleate boiling.

The above mentioned studies show that the effect of tube pitch on enhanced tubes under convective boiling has not yet been addressed. Also, for the studies focused on effect of tube pitch on submerged tube bundles, small tube spacing provided better heat transfer enhancement. Finally, for the studies of smooth tube bundles under convective boiling, results fluctuated between enhancing performance and having an insignificant effect.

2.5 Bundle models

Theoretical knowledge of boiling heat transfer in flooded refrigerant evaporator is fairly limited compared to that of in-tube boiling, which has a solid foundation of knowledge. Since mathematical and empirical models for in-tube boiling are available extensively and are well-defined in literature, researchers have made those models the starting point for working on boiling in a tube bundle. Although some might be opposed to that idea as mentioned in Casciaro and Thome (2001) Part I, others find it justifiable to apply in-tube convective boiling models to shell side boiling.

Webb (1991) defends the latter concept by explaining that convective boiling is, essentially, a combination of boiling and convection; which is further explained as a combination of nucleate (pool) boiling and single phase convection. Therefore, all convection heat transfer models can be expressed that way, whether in-tube or bundle flow boiling. He then says “there is no rational reason why one basic model should not be applicable to both flow geometries.” Hence, Chen’s model, the one developed for in-tube boiling, could be used in bundle boiling since it supports that concept.

By way of his extensive and pioneering work in developing enhanced tubes, pool boiling experiments and modeling, and tube bundle experiments (both smooth and enhanced), Webb proposed what he called “the modified model.” This model is presented in Gupte and Webb (1992) as one that can take into account the simultaneous occurrence of nucleate and convective boiling, and is presented as

$$h^n = \left(Fh_{LQ}\right)^n + \left(Sh_{NB}\right)^n, \tag{2-1}$$

where the parameters of the above equation are determined using empirical constants obtained from experimental data. Kim et al. (2002) used this model but without using the asymptotic element (the exponent n).

The previously mentioned paper presented three other models: the first model is the superposition (Chen’s model), defined as

$$h = h_{CB} + h_{NB}. \tag{2-2}$$

The second is the asymptotic model, defined as

$$h^n = h^n{}_{CB} + h^n{}_{NB}. \tag{2-3}$$

The third is the enhancement model, developed by Shah (1976), defined as

$$h = E \cdot h_{LQ}, \tag{2-4}$$

where E is the enhancement factor.

The other approach for modeling flow boiling over a tube bundle is using expanded models developed for single tube pool boiling. This approach is very useful for enhanced tubes, since enhanced tubes’ performance is dominated mainly by heat flux as studies prove. Thome and Robinson (2006) used that approach and presented a bundle model for the Turbo BII tube bundle as

$$h = F_P \cdot F_\varepsilon \cdot h_{NB}, \tag{2-5}$$

where F_P and F_ε are function of the reduced pressure and void fraction, respectively.

2.5.1 Void fraction

Boiling over a flooded tube bundle is governed by many parameters, mass velocity, heat flux, flow pattern, static pressure, friction pressure, saturation temperature, thermodynamic quality, and void fraction, to name a few. One of the complexities of two-phase flow is how to determine the void fraction, upon which the very nature of flow depends. Void fraction helps clarify other flow parameters like phase velocity, phase density, flow pattern, and pressure drop. Thome (2004) explained the different geometries used for specifying void fraction: local, chordal, cross-sectional, and volumetric void fraction.

An accurate method to predict void fraction in vertical flow in tube bundles is presented in Feenstra et al. (2000), who developed an empirical expression that is a function of quality, velocity ratio, liquid and vapor densities, tube diameter, tube pitch, mass velocity (based on the minimum area), liquid viscosity, gas velocity, and surface tension. This model was recommended by Thome and Robinson (2006), and its equations are presented as follows:

$$\varepsilon = \frac{1}{1+\left(S\left(1-x\right)/x \cdot \rho_G/\rho_L\right)}, \tag{2-6}$$

$$S = 1 + 25.7\left(Ri \cdot Cap\right)^{0.5}\left(P/D\right)^{-1}, \tag{2-7}$$

$$Ri = \frac{\left(\rho_L - \rho_G\right)^2 g \cdot \left(P/D - 1\right) D}{G^2}, \tag{2-8}$$

$$Cap = \frac{x \cdot G}{\varepsilon \cdot \rho_G} \frac{\mu_L}{\sigma}. \tag{2-9}$$

2.5.2 Flow pattern of boiling on tube bundle

Although the term “flow pattern” can be quite descriptive, it actually characterizes a complicated physical phenomenon. The meaning of flow pattern includes, for example, convective movement between liquid and bubbles. Studying flow pattern requires more than a visual of the flow or bubbles; it aims for a clear understanding of variables like the interaction of bubbles and their convection influence on tube wetting. As mentioned in the sub-section before, flow pattern is linked to void fraction. Thus, understanding flow pattern helps clarify boiling heat transfer of tube bundles. In particular, flow pattern influence becomes evident where the heat transfer coefficient has two different rates at the same heat flux, mass flux, and quality.

However, flow pattern studies of vertical flow boiling on tube bundles have been fairly limited to, for example, Casciaro and Thome (2001) Part 2, who provided a review for the two-phase pressure drop and flow pattern, and Collier and Thome (1996), who described the visual flow pattern from bottom up as single phase liquid, bubbly flow, bubble jet flow, chugging flow, and spray flow.

2.6 Conclusion

Enhanced tubes are extensively used in flooded refrigerant evaporators for their high efficiency; however, developing enhanced tubes and evaluating their performance in boiling over tube bundles has been one of the ongoing two-phase problems. Due to the complexity of experimental study of flow over a tube bundle, researchers often use pool boiling experiments to predict the behavior of enhanced tubes in tube bundles.

However, studies of enhanced tube bundles showed that there is discrepancy in the data presentation and conclusions based on a pool of information of the different aspects that can be used in evaluating the performance of enhanced tube bundles: saturation pressure, heat flux, mass flux, quality, tube arrangement, tube position, and bundle height. Most studies agreed that enhanced tubes are dominated mainly by heat flux. Mass flux and quality have little effect on the heat transfer coefficient; however, mass flux effect becomes significant at low heat flux. Moreover, some studies showed that increasing saturation pressure increases bundle performance.

Studies that documented the effect of tube pitch (tube spacing) on submerged enhanced tube bundles, showed that tight spacing provides performance enhancement. As for those with forced convection, the effect of increasing tube pitch fluctuates between enhancing performance and having no influence. In general, available bundle models are based on the in-tube superposition model introduced by Chen. Other models use a modified version of the nucleate boiling models. In all cases, experimental data must be available in order to determine the empirical constants associated with those models.

Chapter 3 Test Circuit and Equipment Description

3.1 Introduction

The test circuit was constructed to investigate the heat transfer performance for shell-side boiling of enhanced surface tube bundles. The tube bundle was set up in the test section, the main component in the test facility, which is located at the highest point of the test facility. The height of the test section was calculated to provide the required NPSH for the refrigerant pump. The NPSH was determined according to R-123 calculations, since it operates at low pressure.

Next to the test section in the refrigerant flow direction are the condenser, the refrigerant pump, and the pre-boiler as shown in Figure 3-1 below. The test section is water heated; the water circuit associated with the test section was given the name “primary test section water circuit.” In that circuit, water circulates throughout the test section and a secondary heat exchanger, the heat input to the test section.

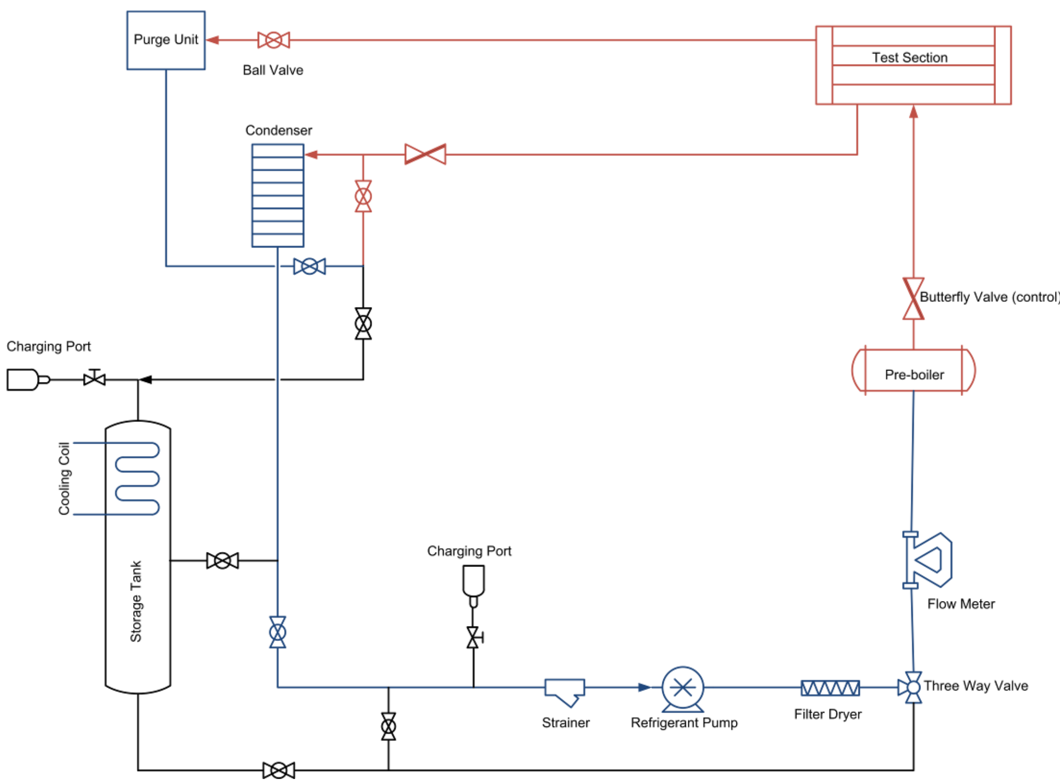

Figure 3-1 Refrigerant circuit

Tube bundle experiments entail testing at different bundle inlet vapor qualities, which are controlled by the pre-boiler. The pre-boiler, sometimes called pre-conditioner, raises the refrigerant thermodynamic quality from sub-cooled liquid to the desired bundle inlet quality. Similar to the test section, the pre-boiler is water heated; its water circuit is called “the primary pre-boiler water circuit.” The latter receives its heat input from a secondary heat exchanger.

The two secondary heat exchangers (the test section and the pre-boiler) are connected to the hot water reservoir, that part of the hot water system that uses the energy available from the building’s steam. Therefore, there are five different circuits in the test facility; the refrigerant circuit, the primary test section water circuit, the primary pre-boiler water circuit, the secondary test section water circuit, and the secondary pre-boiler water circuit. Each of these will be reviewed in the following sub-sections.

3.2 Test Section

The test section is a rectangular pressure vessel designed for high and low pressure refrigerants that is essentially a rectangular-shape shell and tube heat exchanger; the refrigerant flows across the tube bundle while water circulates in the tubes. Its inner dimensions are 0.4254 m (16.75 inch) high, 0.0984 m (3.875 inch) wide, and 1 m (39.37 inch) deep as shown in Figure 3-2; please refer to Appendix “A” for other test section drawings and dimensions. The idea behind a rectangular test section is to create symmetry boundaries for the two sides of the tube bundle. This makes the tube bundle look as if it is a 1 m long specimen taken from a large evaporator. The test section has four sight glasses, two on each side, where one side is a mirror image of the other. Each of the four sight glasses is an oblong quartz glass 0.3048 m (12 inch) high by 0.0762 m (3 inch) wide. This provided a full view of the tube bundle covering the refrigerant inlet up to the top of the tube bundle.

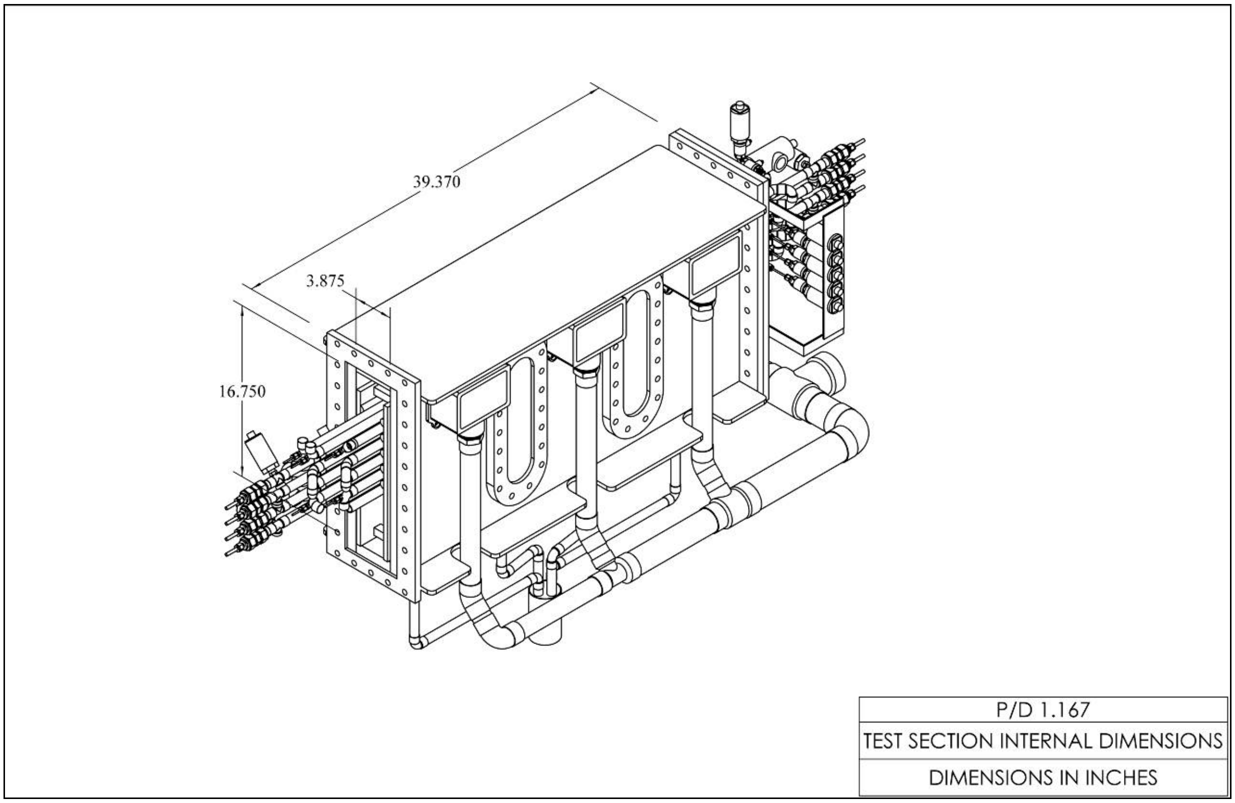

Figure 3-2 Test section inner dimensions

3.2.1 Tube pitches

The test section was designed to accommodate three tube bundles for three different tube pitches, P/D 1.167, P/D, 1.33, and P/D 1.5, which is equivalent to 3.5/3, 4/3, and 4.5/3. Each bundle has 20 tubes arranged in staggered equilateral triangles as shown in Figure 3-5 on Page 23. Each tube has an outside diameter (D) of 0.01905 m (0.75 inch), and tube pitch (P) is measured from one tube center line to the neighboring tube center line. Given the P/D ratio and the tube outside diameter, P can be calculated such that P for the above mentioned three cases are 0.0222 m (7/8 inch), 0.0254 m (1 inch), and 0.0285 m (1 1/8 inch), respectively; this represents a 0.0031 m (1/8 inch) step increase.

3.2.2 Tube bundle installation

The tube bundle installation begins by mounting two endplates, sometimes called tube-sheets, on each side of the test section, passing the copper tubes through the hole pattern of the endplates, and swaging (mechanically rolling) the copper tubes into the endplates. Tubes are sealed with steel endplates by expanding the copper tube, i.e. welding the tubes without fusing the two metals. Each tube bundle (each P/D bundle) has its two endplates and two inside plates. The endplate holds the hole pattern and hole contours and dimensions specified for swaging the tube. The inside plates with the endplates form a box for the tube bundle. The inside plates have two purposes: to add thickness to the test section walls for maintaining the symmetry of the bundle, and to mount half dummy tubes. The half dummy tubes create symmetry for the refrigerant flow around the tubes and simulate an actual evaporator, i.e. making one side a mirror image of the other.

3.2.3 Water and refrigerant flow distribution

The test section is a four-pass heat exchanger. Water passes four times in alternating directions through the tubes before exiting the test section and flows in five channels as a result of dividing the total of 20 tubes by four passes. Therefore, each channel (path) includes four tubes. Water enters the test section from at the top of the bundle and leaves at the bottom. Refrigerant enters the test section at the bottom of the bundle and leaves at the top, i.e. counter to the flow of water.

Refrigerant enters the test section via a distributer at the bottom, which splits the inlet tube into four tubes. Each tube enters the bottom of the test section and goes through a tee where the flow is further split into two ports. Therefore, the total number of inlet ports is 8, equally spaced along the length of the test section. The ports are aimed downward, opposite to the flow direction, to reduce the flow kinetic, thus making the vapor equally distributed. In addition, four dummy tubes having the same diameter and tube pitch as the active tubes are swaged in the endplates as a part of the bundle. The dummy tubes further provide an even distribution of the two phase flow before entering the heated section of the bundle. Meanwhile, refrigerant exits the tube bundle through rollover rectangular openings on the sides of the test section. The total number of openings is six, three on each side.

3.2.4 Test section instrumentation

This subsection covers the test section’s water and refrigerant instrumentation beginning with the water instruments. Since the water entering the test section is divided into five channels (paths) parallel to each other, it is sufficient to have the water measurements only on one of the five paths. This instrument path was chosen to be the middle tube of the three-tube-set at each row, and was given the name “A.” The water measurements include temperature and pressure measurements. Temperature drop is measured for each of the four tubes of path "A," while pressure drop is measured across the first and last tubes; that also can be used for determining the total pressure drop across the four tubes. The other four paths were given the names "B", "C", "D", and "E" for which inlet and outlet temperatures and flow rate were measured in each path. A gate valve is installed upstream of the flow meter of each path to control the water flow rate to and consequently match the heat flux of each path to that of path "A".

3.2.4.1 Water instruments

Total temperature drop in path "A" is determined by measuring the temperature drop in each of the four tubes. An "insert tube" made of Stainless steel wrapped with thick helical cable is placed in the center of each enhanced tube. The insert tube carries seven thermistors, two for measuring the inlet and outlet water temperatures and five internal thermistors for determining the local heat transfer coefficient. Details about the insert tube are mentioned in the next subsection. The themistors were manufactured in the lab by encapsulating each thermistor in a set screw as shown in Figure 3-3 below. Once manufactured, the thermistor probes were calibrated and checked before being affixed to the insert tube.

Figure 3-3 Thermistor probe (the element is inside the set screw)

3.2.4.1.1 Insert tube

The water entering the test section flows within the test tube and over the insert tube as illustrated in Figure 3-4. The insert tube has two purposes: to increase the water velocity and thus the water heat transfer coefficient, and to support the seven thermistors. The higher the water heat transfer coefficient, the better the accuracy of the calculated refrigerant heat transfer coefficient. Two of the seven thermistors, the outermost ones, measure the inlet and outlet temperatures and are located at the endplates of the test section. The advantage of this location is to decrease any inaccuracy of the temperature measurement due to ambient loss. The other five thermistors are evenly distributed along the insert tube. The insert tube is centered inside the 1.3

m (51.5 inch) long and 0.01905 m (0.75 inch) nominally wide test tube. Dimensions of the test tubes are provided in Table 3-1 below.

The insert tube is made of stainless steel, 1.828 m (72 inch) length and 0.00635 m (0.25 inch) outer diameter, helically wrapped with a 0.00381 m (0.15 inch) outer diameter insulated tinned copper wire. The wire wrapping is approximately at a 45 degree angle with a 0.0254 m (1 inch) pitch. This configuration provides a helical channel path for the water to flow inside. Meanwhile, the wire wrap is to decrease the effect of thermal and velocity boundary layer, and thereby to provide the conditions for measuring the mixed cup temperature.

Table 3-1 Enhanced tubes dimensions

	Outside Dia. mm (inch)	*Nominal Wall mm (inch)*	*Fin/inch*	*Finished fin OD mm (inch)*	*Min. wall under fins mm (inch)*	*Root Dia. mm (inch)*
Turbo BII-HP	19.05 (0.75)	0.635 (0.025)	48	18.69 (0.736)	0.559 (0.022)	17.32 (0.682)
Turbo BII-LP	19.05 (0.75)	0.635 (0.025)	48	18.75 (0.738)	0.559 (0.022)	17.27 (0.680)

Four pressure transducers were used to measure the bundle water pressure. Two higher range transducers were installed on the first tube (at the top of the bundle) of path "A", where the water pressure is the highest. The other two transducers were installed on the last tube (at the bottom of the bundle). The measuring range of the pressure transducers on the first and the last tubes are 0- 2068.4 kPa (0-300 PSIA) and 0-1034.2 kPa (0-150 PSIA), respectively. All pressure transducers were manufactured by Viatran.

For the other four paths, the inlet and outlet temperatures are measured using thermistor probes, 10,000 ohm 0.1524 m (6 inch) long probes. Also, the water flow rate to each path, including path "A," is measured using Coriolis type flow meters manufactured by Micro Motion model ELITE CMF025.

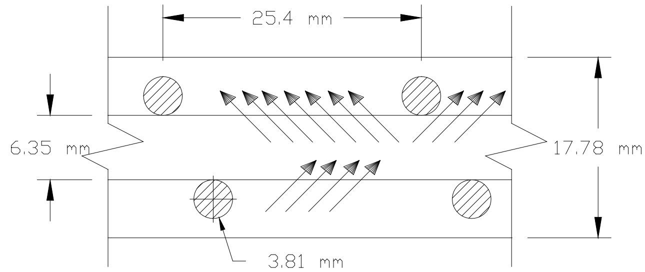

Figure 3-4 Cross sectional view of test tube and insert tube

3.2.4.2 Refrigerant instruments

For the refrigerant instruments, temperature and pressure are measured at five levels (heights) in the shell: one at the bundle inlet and four located above the plane of the four instrumented tubes of path “A” as illustrated in Figure 3-5 over. Only pressure measurements were used in the analysis; temperature measurements were used only to check the agreement between the temperature and the corresponding saturation temperature determined from the pressure transducers’ measurement. The concurrence of the temperature and the saturation pressure readings indicates that the test section is free from non-condensable gases. Temperature probes and pressure transducers are connected to the half dummy tubes installed on the bundle’s inside plates. The temperature probes were 100 ohm RTDs. Each refrigerant has its own set of pressure transducers, high pressure transducers for R-134a and low pressure transducers for R-123, 0- 517.1 kPa (0-75 PSIA) and 0-103.4 kPa (0-15 PSIA), respectively. In addition to the five measurement heights, the refrigerant exit pressure is measured. All pressure transducers were manufactured by Viatran.

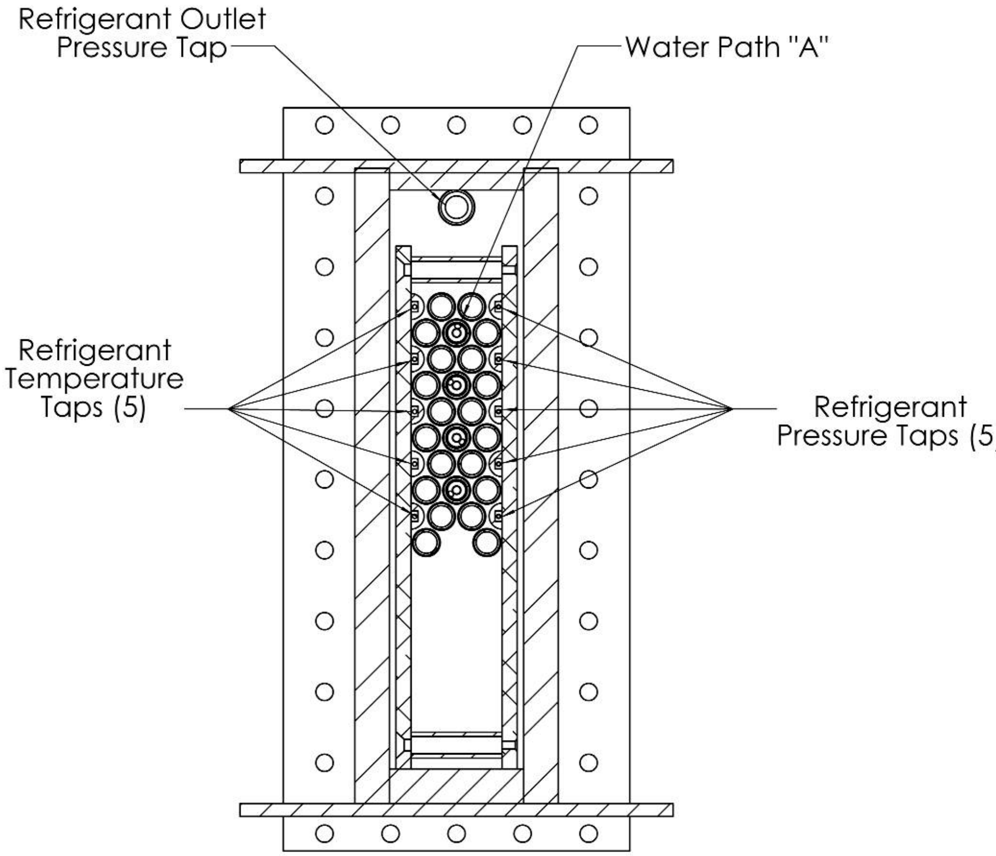

Figure 3-5 Test section cross sectional view

3.3 Refrigerant circuit

Next to the test section in the refrigerant flow direction is the condenser (see Figure 3-1). The two-phase flow refrigerant leaving the test section enters the condenser and goes through a 211 kW (60 Ton Refrigeration) plate heat exchanger made by FlatPlate, Inc. and supplied by a 50% water-glycol solution (or glycol for simplicity) to provide the cooling source. A 10 HP centrifugal pump draws the glycol from a reservoir, and heat is drawn from the reservoir using an 81 kW (23 Ton Refrigeration) reciprocating compressor chiller.

The refrigerant leaves the condenser as sub-cooled liquid and next goes through a strainer before entering the refrigerant pump. The refrigerant pump is a magnetically driven gear pump manufactured by Liquiflo with a capacity of 1.3 L/s (21 GPM) and delivers up to 1551.3 kPa (225 PSI) maximum pressure. A storage tank is installed parallel to the line connecting the condenser and the refrigerant pump to adjust the refrigerant charge to the desired test point. The test facility runs as a “critically charged system,” meaning for every data point, the refrigerant charge is adjusted. The storage tank contains cooling and heating coils such that the cooling coil is connected to the facility’s glycol supply, and the heating coil is connected to industrial water. The storage tank is linked to the test facility at three points: top, middle and bottom.

A filter dryer is located upstream of the refrigerant pump while the refrigerant flow meter, a Coriolis type flow meter manufactured by Micro Motion model ELITE CMF050, is located downstream of the filter dryer. The sub-cooled liquid refrigerant leaving the flow meter enters the pre-boiler, which adds heat to the refrigerant to raise its quality from sub-cooled to the desired test section inlet quality. The pre-boiler is a water heated shell and tube heat exchanger, with the refrigerant circulating in the tubes and the water circulating in the shell. The two-phase flow leaves the pre-boiler and enters the test section through the test section’s flow distributer explained in “Test Section” above. A control valve, a butterfly valve, is located between the test section and pre-boiler whose is to help adjust the refrigerant flow supply to the test section to bring the system to steady state. Steady state is reached when the change in the inlet saturation pressure is within 0.3 °C.

The last component of the refrigerant circuit is the purge unit. For R-123 testing, and before taking data points, the system must be free of non-condensable gases. This is accomplished through the purge unit, an EarthWise Purge made by Trane. It is installed above the test section level and connected to the top of the test section. When the unit is on, refrigerant vapor and non-condensable gases travel from the test section to the purge tank. The purge tank condenses the refrigerant and returns it to the system whereupon the non-condensable gases are purged to a carbon regeneration tank.

3.3.1 Refrigerant circuit instrumentation

Instruments in the refrigerant circuit include those used to monitor the operation of the test facility and to analyze data. The monitoring instruments include the following: the condenser inlet temperature and refrigerant pump inlet pressure and temperature. The temperature of the two-phase flow entering the condenser is measured, using a 1000 ohm RTD. Also, a sight glass is mounted on the line leading to the refrigerant pump, and a second sight glass is mounted on the line leaving the pre-boiler and entering the test section.

The data analysis instruments include refrigerant flow rate, pre-boiler inlet pressure and temperature, and pre-boiler outlet pressure and temperature. Refrigerant temperature entering and leaving the pre-boiler are measured using a 30,000 ohm thermistor probe and 1000 ohm, RTD, respectively. Refrigerant pressure entering and leaving the pre-boiler is measured using pressure transducers with the same measuring range and brand name as those used in the test section. Pressure transducers are switched according to each refrigerant.

3.4 Water circuits

3.4.1 Test section primary water circuit

The test facility has four water circuits, two primary circuits and two secondary circuits; one each for the test section and the other for the pre-boiler. For the test section primary water circuit, a 14.9 kW (20 HP) water pump (centrifugal pump) pumps water to the top of the test section. Water passes four times through the tube bundle and exits at the bottom. Initially, water is split into five channels (paths) before entering the test section, and when it exits the test section, it passes through five water flow meters. Downstream of the flow meters, the five paths merge and enter the filter tank, a high flow rate water filter with stainless steel housing. Water exits the filter and enters the test section secondary heat exchanger. The latter is a shell and tube heat exchanger; the primary water (heated water) circulates in the tubes and the secondary water (heating water) circulates in the shell. Heated water exits the heat exchanger to the pump inlet. A riser is connected to the pump suction pipe between the secondary heat exchanger and the pump. The riser provides the required NPSH for the pump and a filling port for the circuit. The height of the riser extends higher than the test section to ensure that the circuit is air free. In addition, an air release valve is installed on the pump delivery pipe before entering the test section.

3.4.2 Pre-boiler primary water circuit

The pre-boiler is a shell and tube heat exchanger; the refrigerant circulates in the tubes (two passes), and the heating water circulates in the shell. The components of the primary pre-boiler water circuit are similar to those of the test section: water pump, flow meter, filters, and secondary heat exchanger. The water pump is a 2.2 kW (3 HP) centrifugal pump and the flow meter is made by Micro Motion model ELITE CMF100. The secondary heat exchanger is the heat source of the circuit. Specifically, heating water flows in the tubes of the secondary heat exchanger while heated water flows in the shell. The system schematic and flow direction is illustrated in Figure 3-6.

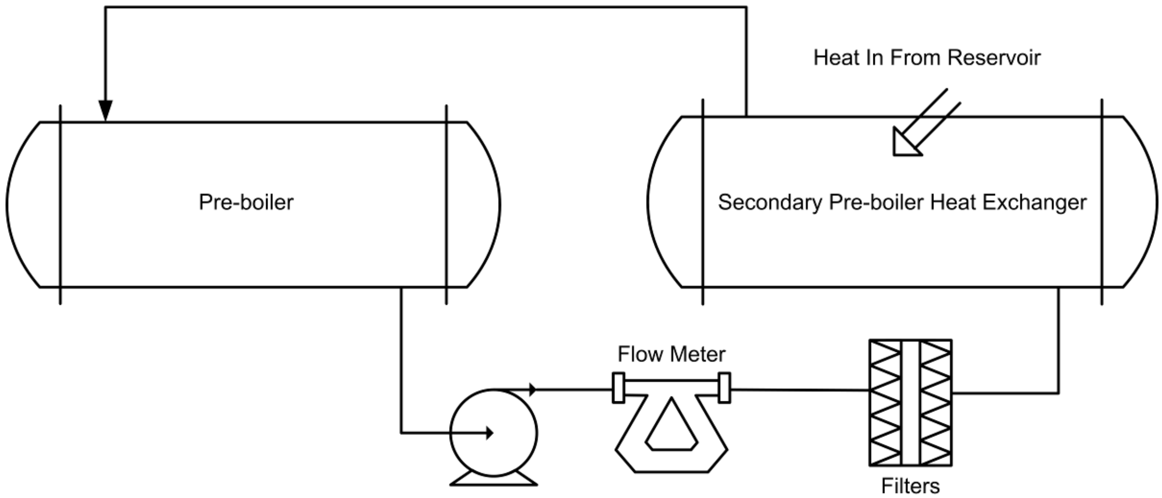

Figure 3-6 Pre-boiler circuit

3.4.3 Test section and pre-boiler secondary circuit

The two secondary circuits are linked to the hot water reservoir, where two pumps, one for each heat exchanger, circulate the hot water between the reservoir and the secondary heat exchangers. A gate valve is installed downstream of each pump, 2.23 kW (3 HP) centrifugal pump, to control the water flow rate, hence the heat load. Therefore, each secondary circuit is independently controlled to provide the specified heat load to each primary water circuit. Meanwhile, the hot water reservoir provides the heat load to both circuits; its capacity is 0.4504 m^3 (120 Gallons). Figure 3-7 over shows a schematic for the hot water system and the secondary circuits.

3.4.4 Hot water circuit

The hot water system, from a previous ASHRAE project (RP-984), uses the energy available from the building steam. First, steam pressure is regulated down to 170.2 kPaG (10 PSIG) and then steam leaves the pressure regulator and goes to a pneumatically controlled ball valve with a PID temperature controller. The controller uses a thermocouple for measuring the water temperature; the thermocouple is located at the pump delivery and upstream of the steam heat exchanger. When steam enters the tube side of a shell and tube heat exchanger, Water circulates in the shell side where it picks up the heat and delivers it to the hot water reservoir.

Next, the stream condensate leaving the heat exchanger is handled by a condensate tank. Since the steam condensate is under vacuum, it can't be connected directly to the building condensate. The condensate pump then pumps the steam condensate accumulated in the tank to the building condensate line.

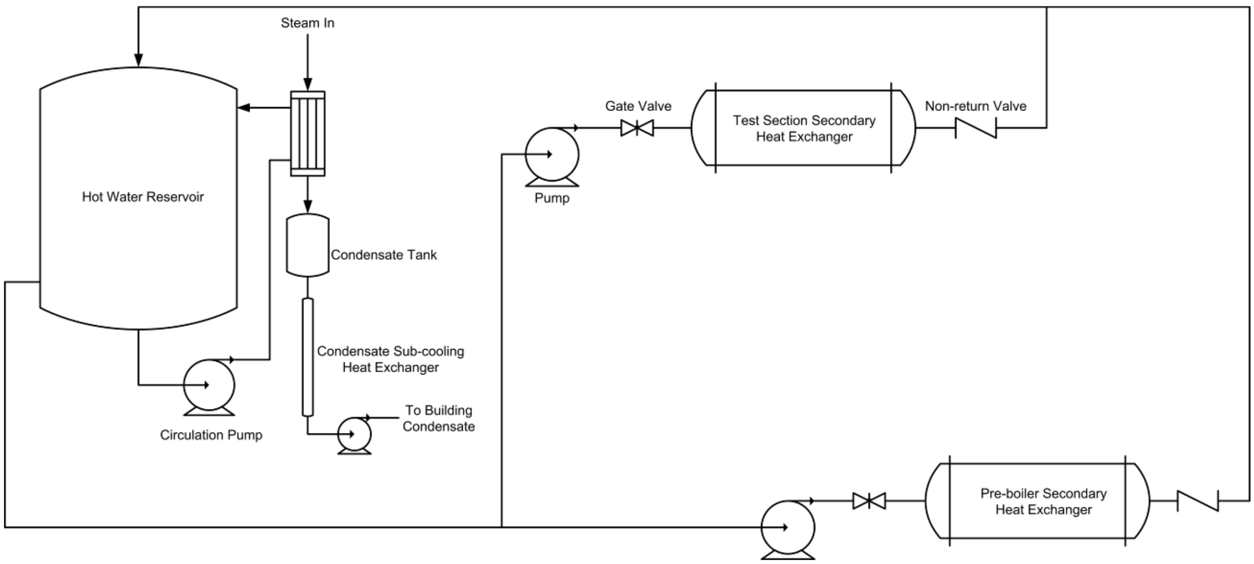

Figure 3-7 Hot water system and secondary circuits

3.4.5 Water circuits instrumentation

The instrumentation of the primary test section water circuit was explained in Section 3.2.4.1. However, the pre-boiler primary water circuit requires measuring the inlet and outlet temperature of the pre-boiler and the water flow rate. Therefore, temperature was measured using thermistors, 30,000 ohm 0.3048 m (12 inch) probes. Also, water flow rate was measured using a Micro Motion model ELITE CMF100 flow meter. The pre-boiler instrumentation is necessary for energy balance to determine the thermodynamic quality entering the test section. Meanwhile, the secondary circuits don't carry any instruments. Finally, for the hot water reservoir, the temperature of the water entering the steam heat exchanger was measured using a type K thermocouple, which is linked in the PID controller to control the water temperature.

3.5 Data acquisition

The data acquisition switch unit used is an Agilent 34980A whose accuracy has been adjusted to 6½ digits. The unit is connected to a PC via USB and controlled by Labview 8.5 made by National Instruments. The total number of instruments is 69 and they read resistance, voltage, and frequency. When the system reaches steady state, the software starts recording data every 25 seconds over a 25 minute period. Recorded data is saved in a Microsoft Excel (.csv) sheet.

3.6 Conclusion

This chapter presented the details of the test facility and test section. It also presented the facility's equipments and instrumentations. The test section was designed to accommodate three tube pitches: P/D 1.167, P/D 1.33, and P/D 1.5. Each bundle has 20 tubes arranged in staggered equilateral triangles, and all tubes were mechanically swaged into the endplates. The test section was designed as a four pass heat exchanger. Tubes were divided into five paths, each containing four tubes. The four middle tubes were chosen to be the "instrumented path." Water temperature drop was measured in each tube using an insert tube, which carried seven thermistors. The refrigerant pressure and temperature were measured at each height of the test section and above the plane of each instrumented tube.

Inlet quality to the test section was controlled via the pre-boiler, which, like the test section, used secondary water circuits to deliver heat from the hot water reservoir. Each secondary circuit was independently controlled to provide the specified heat load to each primary water circuit. The hot water reservoir used the energy available from the building steam.

Chapter 4 Data Reduction

4.1 Introduction

Tube bundle heat transfer performance is evaluated over a range of heat fluxes, mass fluxes, and other qualities. Notably, the heat transfer coefficients reported in this study are local to one location in the bundle. Moreover, the local heat transfer coefficient is determined by first measuring the water temperature distribution, hence the need for multiple measurement locations. Additionally, water temperature is measured at five locations in each of the four tubes of the instrumented water path, supported by a second degree polynomial aid to produce the curve fit $T = f(x)$. Once the temperature distribution is determined, the local heat flux can be calculated, and the local heat transfer coefficient can be determined using thermal resistance and local heat flux.

Although the main focus of the data analysis is the local analysis, the average analysis (per tube) is necessary as well for determining the average heat transfer coefficient and the overall heat transfer coefficient. Furthermore, the uncertainty analysis for the local heat transfer coefficient requires the overall heat transfer coefficient of each tube which is determined using a new method called the EBHT (Enthalpy Based Heat Transfer) analysis, explained in a later subsection.

The water heat transfer coefficient had to be measured using the modified Wilson plot technique before determining the refrigerant heat transfer coefficient. This method is applied in the single tube pool boiling study part of the research, which was performed in a separate test facility; details are available in Gorgy (2008).

4.2 Finite heat transfer governing equations

A finite heat transfer analysis determines the local heat transfer coefficient. In Figure 4-1 on Page 31, heat is transferred from the water to the cylinder's inner wall by convection, from the inner wall to its outer wall by conduction, and from the outer wall to the refrigerant by convection. Consequently, applying conservation of energy and the 1-D heat transfer equations on the finite control, assuming no fouling resistance, yields

$$h_w dA_i \left(T_{hot} - T_{wall,in}\right) = \frac{2\pi k_c dx}{\ln\left(\frac{D_o}{D_i}\right)}\left(T_{wall,in} - T_{wall,out}\right) \equiv dQ \tag{4-1}$$

and

$$h_r dA_o \left(T_{wall,out} - T_{cold}\right) = \frac{2\pi k_c dx}{\ln\left(\frac{D_o}{D_i}\right)}\left(T_{wall,in} - T_{wall,out}\right) \equiv dQ \tag{4-2}$$

where

$$dA_i = \pi D_i dx\,, \tag{4-3}$$

and

$$dA_o = \pi D_o dx\,. \tag{4-4}$$

Applying Newton's law of cooling yields

$$dQ = U \cdot dA_o \left(T_{hot} - T_{cold}\right). \tag{4-5}$$

Defining the thermal resistance of the tube wall as

$$R_{wall} = \frac{1}{2\pi dx k_c}\ln\left(\frac{D_o}{D_i}\right). \tag{4-6}$$

Using Equations (4-1), (4-2), (4-5), and (4-6), yields the following thermal resistances model

$$\frac{1}{UdA_o} = \frac{1}{h_w dA_i} + \frac{1}{2\pi dx k_c}\ln\left(\frac{D_o}{D_i}\right) + \frac{1}{h_r dA_o}\,. \tag{4-7}$$

Substituting Equations (4-3) and (4-4) yields

$$\frac{1}{U} = \frac{1}{h_w}\frac{D_o}{D_i} + R'_{wall} + \frac{1}{h_r}\,. \tag{4-8}$$

Solving for the heat transfer coefficient h_r in the above equation yields

$$h_r = \left(\frac{1}{U} - R'_{wall} - \frac{1}{h_w}\frac{D_o}{D_i}\right)^{-1}. \tag{4-9}$$

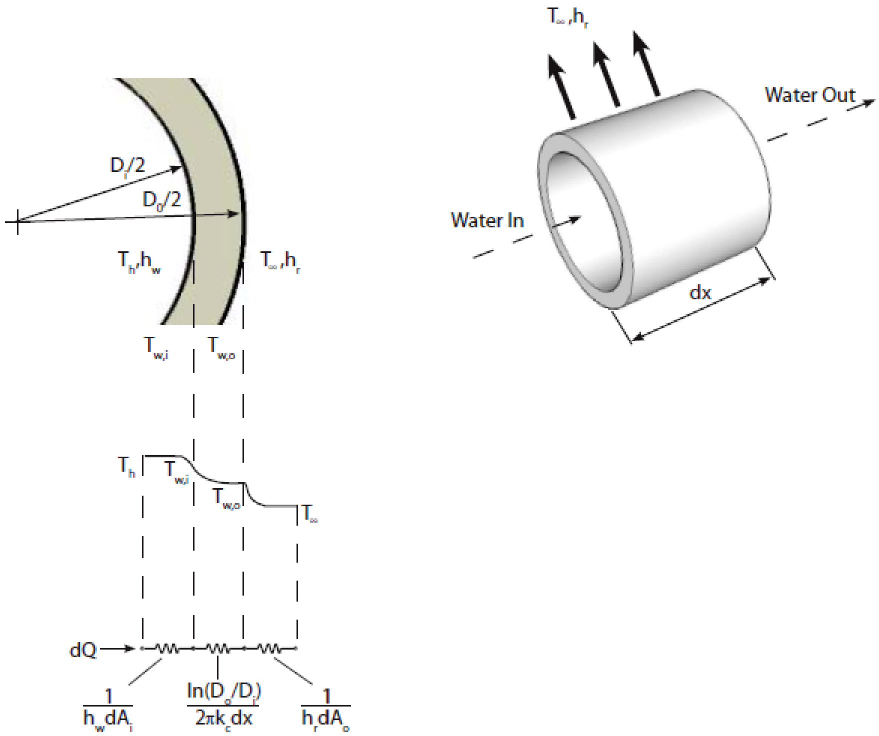

Figure 4-1 Thermal resistances illustration

4.3 Local heat transfer coefficient

Notably, Equation (4-9) is length independent. Therefore, all the variables of Equation (4-9) can be used in the local or average analysis. To determine the local heat transfer coefficient, Equation (4-9) is modified to

$$h_{local} = \left(\frac{1}{U_{local}} - R'_{wall} - \frac{1}{h_w} \frac{D_o}{D_i} \right)^{-1}, \tag{4-10}$$

where U_{local} is the local overall heat transfer coefficient. Following the definition of Newton's law of cooling yields

$$U_{lcoal} = \frac{q''_{lcoal}}{T_{local} - T_\infty}. \tag{4-11}$$

Substituting in Equation (4-10) above yields

$$h_{local} = \left(\frac{T_{local} - T_\infty}{q''_{local}} - R'_{wall} - \frac{1}{h_w} \frac{D_o}{D_i} \right)^{-1}. \tag{4-12}$$

As stated in Equation(4-12), the local heat transfer coefficient is determined at each local temperature measurement.

4.4 Local heat flux

In Equation (4-12) above, the local temperature T_{local} and refrigerant temperature T_{∞} are obtained by direct measurements while the local heat flux q''_{local} is determined by the enthalpy change on the finite element as

$$dQ = \dot{m} \cdot di \, . \tag{4-13}$$

For incompressible fluid, the finite enthalpy di can be expressed as

$$di = C_p \cdot dT + v \cdot dP \, . \tag{4-14}$$

Substituting in Equation (4-13) above and dividing by $\pi \cdot D_o \cdot dx$ yields

$$\underbrace{\frac{dQ}{\pi dx D_o}}_{q''_{local}} = \frac{\dot{m}}{\pi D_o}\left(C_p \frac{dT}{dx} + v\frac{dP}{dx} \right). \tag{4-15}$$

The LHS of the above equation represents the definition of the local heat flux. For the temperature slope, the five temperature measurement locations of each tube determine the temperature profile equation, which is determined using a second order polynomial curve fit as

$$T = C_1 x^2 + C_2 x + C_3 , \tag{4-16}$$

and the slope is found by taking the derivative

$$\frac{dT}{dx} = 2C_1 x + C_2 \, . \tag{4-17}$$

The pressure drop term of Equation (4-15) can be determined by assuming a linear water pressure drop across the tube since the pressure can be determined at the inlet and outlet of each tube. Therefore, dP/dx is reduced to $\Delta P/L$. The last necessary component in Equation (4-12) is the water heat transfer coefficient, which is determined using the modified Wilson plot method.

4.5 Water heat transfer coefficient

The water flows between the enhanced tube and the insert tube following the swirl shape of the insert tube as illustrated in Figure 3-4 on Page 22. For flow inside a tube, the heat transfer coefficient for no phase change can be determined using

$$h_i = \frac{Nu_D \cdot k_w}{D_h}, \tag{4-18}$$

where all the water properties are evaluated at the average inlet and outlet temperatures.

For a turbulent internal flow, the Nusselt number can be determined using Gnielinski's correlation (1976) presented as

$$Nu_D = \frac{(f/8)(\mathrm{Re}_D - 1000)\mathrm{Pr}}{1 + 12.7(f/8)^{1/2}\left(\mathrm{Pr}^{2/3} - 1\right)}. \tag{4-19}$$

The above correlation, also called the modified Petukhove's correlation (1970), is widely applied in flow inside tubes; Gnielinski's correlation works over a wide range of Reynolds numbers (3000 to 5×10^6) and Prandtl numbers (0.5 to 2000) with accurate results, the friction factor is defined as

$$f = \left(0.79\ln(\mathrm{Re}_D) - 1.64\right)^{-2}. \tag{4-20}$$

The friction factor proposed by Gnielinski in the above equation is that of a smooth tube. Since the tubes used are internally enhanced, the friction factor is calculated according to its basic definition as

$$f = \frac{\Delta P}{\rho} \cdot \frac{D_h}{L_c} \cdot \frac{2}{V^2}. \tag{4-21}$$

The internal enhancement of the tubes (micro-fins) and the insert tube's swirls affect accuracy in measuring both the characteristic length and the hydraulic diameter of the above equation (calculation of the hydraulic diameter is explained in 3.2.4.1.1). Therefore, the Gnielinski correlation needs a correction factor multiplier, which is determined using the modified Wilson plot technique. Accordingly, the correction factor becomes the leading coefficient of the water heat transfer coefficient as

$$h_w = C_i \cdot h_i. \tag{4-22}$$

4.5.1 *The modified Wilson plot technique*

The modified Wilson plot technique introduced by Briggs and Young (1969) is for obtaining heat transfer correlations for shell and tube heat exchangers. This technique was applied in the pool boiling part of the research, which requires choosing a model for the boiling heat transfer coefficient is chosen. Literature showes that for enhanced tubes, the refrigerant heat transfer coefficient is assumed to be a function only of the heat flux and can be expressed as

$$h_r = C_o \left(q''\right)^n . \tag{4-23}$$

Recalling the thermal resistance equation

$$\frac{1}{UA_o} = \frac{1}{h_w A_i} + R_{wall} + \frac{1}{h_r A_o} . \tag{4-24}$$

After substituting Equations (4-22) and (4-23), and multiplying both sides of the equation by $h_i \cdot A_i$, the thermal resistance equation is transformed into the straight line equation

$$\underbrace{\left(\frac{h_i A_i}{U_o A_o} - R_{wall} h_i A_i\right)}_{Y} = \underbrace{\frac{1}{C_i} + \frac{1}{C_o} \underbrace{\left(\frac{h_i A_i}{(q'')^n A_o}\right)}_{X}}_{Y_{predicted}} . \tag{4-25}$$

Data points are collected at different flow rates on either side of the heat exchanger to determine the above straight line equation, while the linear regression of the data points determines the slope and intercept. Meanwhile, the inverse of the intercept is the correction factor for the tube side heat transfer coefficient and the inverse of the slope is the correction factor for the shell side heat transfer coefficient. Six data points are taken at different water flow rates covering the full range of Reynolds numbers of the test facility; the selected number of points gives the narrowest confidence interval of the linear regression.

The exponent n must be assumed first to perform the linear regression between Y and X in the above straight line equation (Equation (4-25)). Through trial and error, n is iterated to produce the minimum sum of the absolute percentage difference between Y and $Y_{predicted}$. To decrease the effect of the chosen boiling model, the points are taken at one selected value of heat flux with a maximum change of 8% between any of the six points.

4.6 Total heat transfer governing equations

Defining a tube as the control volume and applying the 1st law of thermodynamics yields

$$\frac{dE_{st}}{dt} = \dot{E}_{in} + \dot{E}_{gen} - \dot{E}_{out} . \tag{4-26}$$

Since the problem is steady state with no energy generation, the above equation reduces to

$$\dot{E}_{in} = \dot{E}_{out} . \tag{4-27}$$

The energies entering the tube are the inlet water enthalpy and the refrigerant inlet enthalpy; meanwhile, the energies leaving the test section are the outlet water enthalpy and the refrigerant outlet enthalpy. Thus, the above SS equation can be rewritten as

$$\dot{m}\cdot i_{w,in}+\dot{m}_r\cdot i_{r,in}=\dot{m}_r\cdot i_{r,out}+\dot{m}\cdot i_{w,out}\,. \tag{4-28}$$

Rearranging yields,

$$\dot{m}\cdot i_{w,in}-\dot{m}\cdot i_{w,out}=\dot{m}_r\cdot i_{r,out}-\dot{m}_r\cdot i_{r,in}\equiv Q\,. \tag{4-29}$$

Assuming incompressible flow for the water side yields

$$Q=\dot{m}\left(C_p\left(T_{in}-T_{out}\right)+v\underbrace{\left(P_{in}-P_{out}\right)}_{\Delta P}\right). \tag{4-30}$$

Thus Equation (4-30) determines the average heat transfer coefficient, specially the average overall heat transfer coefficient.

4.7 The tube-average heat transfer coefficient

Determining the average heat transfer coefficient requires the thermal resistances equation obtained from “4.2”

$$\frac{1}{U}=\frac{1}{h_w}\frac{D_o}{D_i}+R'_{wall}+\frac{1}{h_r}\,. \tag{4-31}$$

Substituting U_o for U and rearranging yields

$$h_{avg}=\left(\frac{1}{U_o}-R'_{wall}-\frac{1}{h_w}\frac{D_o}{D_i}\right)^{-1}. \tag{4-32}$$

Meanwhile the overall heat transfer coefficient is determined according to a new method, the EBHT (Enthalpy Based Heat Transfer), where the pressure drop energy is taken into account.

4.7.1 The enthalpy-based heat transfer analysis (EBHT).

Classically, the overall heat transfer coefficient of the heat exchanger is determined using the Log Mean Temperature Difference “LMTD” method as

$$Q=U_oA_o\Delta T_{LMTD}\,. \tag{4-33}$$

Where ΔT_{LMTD} is defined as $\left(\Delta T_1 - \Delta T_2\right) / \ln\left(\Delta T_1 / \Delta T_2\right)$. Therefore, to determine the overall heat transfer coefficient, equations Equation (4-30), with the pressure term equal to zero, and Equation (4-33) are solved simultaneously.

The derivation of the LMTD method starts by defining the change of the water enthalpy as the product of the temperature difference and the fluid specific heat. Essentially, this is a simplified definition of the enthalpy, where the effect of the change in pressure is neglected. This simplification is usually useful since it leads to solving the overall heat transfer coefficient with simple algebraic equations. This is because the majority of the shell and tube heat exchangers do not experience large change of the water enthalpy due to pressure drop. In other words, the temperature difference term is much higher than the pressure drop term.

However, in the current study, the water flow inside the test tube experiences a large pressure drop which makes a significant change in the water enthalpy. Therefore, the study must consider the pressure drop energy in the calculation of the overall heat transfer coefficient and also in the energy equation (Equation (4-30)).

A new method called the Enthalpy Based Heat Transfer was derived from first principles for calculating the overall heat transfer coefficient in terms of the heat exchanger temperatures and pressures. This derivation follows that of the LMTD method. The EBHT works for parallel flow, counter flow heat exchangers, no phase change and phase change problems. For solving the phase change problem, the specific heat of the cold side is set equal to infinity in the case of boiling and the specific heat of the hot side is set equal to infinity in the case of condensation.

4.7.2 The governing equations of the enthalpy-based heat transfer analysis

Hot side energy balance assuming incompressible flow is expressed as

$$dQ = -\dot{m}_h \left(C_{p,h} \cdot dT_h + v_h \cdot dP_h \right). \tag{4-34}$$

Rearranging yields

$$dT_h = -\frac{1}{C_{p,h}} \left(\frac{dQ}{\dot{m}_h} + v_h \cdot dP_h \right). \tag{4-35}$$

For the cold side energy balance assuming incompressible flow

$$dQ = \dot{m}_c \left(C_{p,c} \cdot dT_c + v_c \cdot dP_c \right). \tag{4-36}$$

Rearranging yields

$$dT_c = \frac{1}{C_{p,c}}\left(\frac{dQ}{\dot{m}_c} - v_c \cdot dP_c\right). \tag{4-37}$$

An extended form of Newton's law of cooling can be expressed as

$$dQ = U \cdot dA \cdot \Delta T\ , \tag{4-38}$$

where,

$$\Delta T \equiv T_h - T_c\ . \tag{4-39}$$

Combining the above equations yields

$$\frac{d\left(\Delta T\left(x\right)\right)}{dx} + \left(\frac{1}{\dot{m}_h \cdot C_{p,h}} + \frac{1}{\dot{m}_c \cdot C_{p,c}}\right) \cdot U \cdot \frac{d}{dx} A(x) \cdot \left(\Delta T\right) = \frac{v_c}{C_{p,c}} \cdot \frac{d}{dx} P_c(x) - \frac{v_h}{C_{p,h}} \cdot \frac{d}{dx} P_h(x)\ . \tag{4-40}$$

The solution to the above 1st order ODE can be expressed as

$$\Delta T\left(x\right) = e^{-\left(\frac{1}{\dot{m}_h \cdot C_{p,h}} + \frac{1}{\dot{m}_c \cdot C_{p,c}}\right) \cdot U \cdot A(x)} \int \left(\frac{v_c}{C_{p,c}} \cdot \frac{d}{dx} P_c(x) - \frac{v_h}{C_{p,h}} \cdot \frac{d}{dx} P_h(x)\right) \cdot e^{\left(\frac{1}{\dot{m}_h \cdot C_{p,h}} + \frac{1}{\dot{m}_c \cdot C_{p,c}}\right) \cdot U \cdot A(x)} dx + C \cdot e^{-\left(\frac{1}{\dot{m}_h \cdot C_{p,h}} + \frac{1}{\dot{m}_c \cdot C_{p,c}}\right) \cdot U \cdot A(x)}\ . \tag{4-41}$$

The constant C in the above equation is determined using the inlet boundary condition $\Delta T\left(x\right) = \Delta T_1\big|_{x=0}$. For the case of pool boiling, the specific heat of the cold side is set equal to infinity. Also, the pressure drop of the water side is assumed to be linear along the test section. The area is defined as

$$A(x) = \pi D_o x \tag{4-42}$$

Substituting the inlet boundary condition, the area definition, and the linear pressure drop assumption, Equation (4-41) reduces to the following equation, which gives the temperature difference between the water side and the refrigerant side at any distance x

$$\Delta T\left(x\right) = \frac{-\left(\dot{m}_h \cdot v_h \cdot \Delta p_h\right)}{U \cdot A} + \left(\frac{\Delta T_1 \cdot U \cdot A + \left(\dot{m}_h \cdot v_h \cdot \Delta p_h\right)}{U \cdot A}\right) \cdot e^{-\left(\frac{U \cdot \pi \cdot D_o}{\dot{m}_h \cdot C_{p,h}}\right) \cdot x}\ . \tag{4-43}$$

Substituting the outlet boundary condition $\Delta T\left(x\right) = \Delta T_2\big|_{x=L}$ in Equation (4-43) and rearranging yields

$$\ln\left(\frac{\Delta T_2 + \dfrac{\left(\dot{m}_h \cdot v_h \cdot \Delta p_h\right)}{U_o \cdot A}}{\Delta T_1 + \dfrac{\left(\dot{m}_h \cdot v_h \cdot \Delta p_h\right)}{U_o \cdot A}}\right) + \frac{U_o \cdot A}{\dot{m}_h \cdot C_{p,h}} = 0 \,. \tag{4-44}$$

The only unknown in the above Equation is the overall heat transfer coefficient, which is determined by trial and error. Note that Equation (4-44) reduces to the LMTD as Δp_h goes to zero.

4.8 Local quality

Similar to the local heat transfer coefficient, the local quality is determined at each temperature measurement location (thermistor) and at the minimum flow area between the tubes. The thermodynamic quality is determined by performing an energy balance between the refrigerant side and the water side as

$$\dot{m}_{ref} \cdot \Delta x \cdot h_{fg} = q''_{local} \cdot \pi D L \,. \tag{4-45}$$

To calculate the quality entering the instrumented tube, the test section’s 1 m side is theoretically divided into four horizontal planes and five vertical sections, producing 20 control volumes as shown in Figure 4-2 over. The test section then becomes a (4×5) matrix. Above each plane (row) lies a group of five tubes; the vertical sections (columns) divide the test section so that the thermistors are centered in each vertical section. Therefore, applying the energy balance on each control volume yields

$$\frac{\dot{m}_{ref}}{5} \cdot \underbrace{\Delta x}_{\left(x_{i+1,j} - x_{i,j}\right)} \cdot h_{fg} = 5 q''_{local_{i,j}} \pi D \frac{L}{5} \,, \tag{4-46}$$

or

$$x_{i+1,j} = \frac{5 q''_{local_{i,j}} \cdot \pi D L}{\dot{m}_{ref} \cdot h_{fg}} + x_{i,j} \,. \tag{4-47}$$

Since the quality at the bundle bottom is constant at all five locations and equals the test section inlet quality, the quality at each row is determined from the bottom up. The subscript i, j in the above equation corresponds to (row,column); with the quality at row i and the local heat flux $q''_{local_{i,j}}$, the quality at the next row $i+1$ is determined.

The local quality (the quality at the minimum cross-sectional area) is calculated by adding the quality entering the instrumented tube to the quality rise due to the local heat flux at the tube centerline. The latter quality is determined by performing an energy balance around the instrumented tube (i.e. within each of the 20 control volumes) as shown in Figure 4-3 over. Therefore, the refrigerant mass flow rate used in the energy balance is the mass flow assigned for each control volume divided by three, and the local heat flux is half of the heat flux determined at that location. Thus, the energy balance can be expressed as

$$\frac{\dot{m}_{ref}/5}{3} \cdot \underbrace{\Delta x}_{\left(x_{local_{i,j}} - x_{i,j}\right)} \cdot h_{fg} = \frac{q''_{local}}{2} \cdot \pi D \frac{L}{5}, \tag{4-48}$$

or

$$x_{local_{i,j}} = \frac{q''_{local}/2 \cdot \pi DL}{\dot{m}_{ref}/3 \cdot h_{fg}} + x_{i,j}. \tag{4-49}$$

According to this method, there are 20 tube-entrance qualities and 20 local qualities.

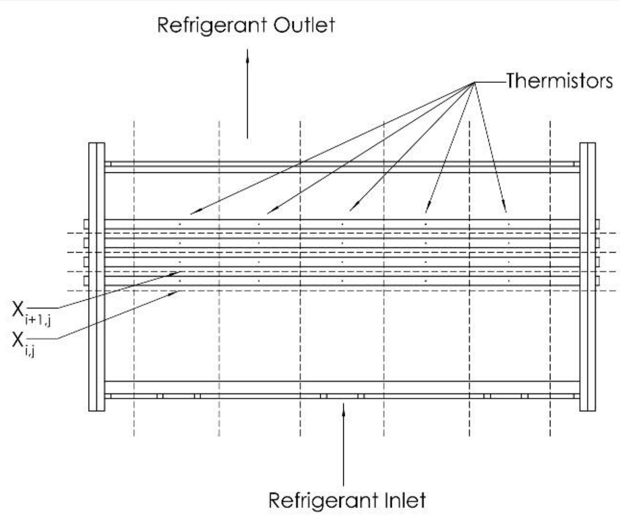

Figure 4-2 Test section side view for quality calculations

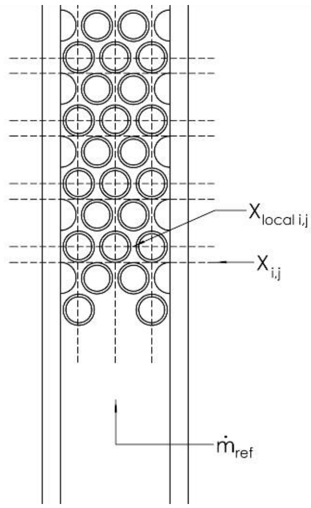

Figure 4-3 Test section cross section for quality calculation

4.9 Mass flux

The mass flux (also called mass velocity) is calculated based on the minimum area between tubes as

$$G = \dot{m}/A_{\min} \ , \tag{4-50}$$

where

$$A_{\min,P/D} = \left(\left(P/D\right)\times D - D\right)\left(L_T\right) \text{ m}^2 . \tag{4-51}$$

Then, the minimum area for each tube bundle, P/D 1.167, P/D 1.33, and P/D 1.5 is calculated as follows

$$\begin{aligned} A_{\min,P/D\ 1.167} &= \left(\left(1.167\right)\times 0.01905 - 0.01905\right)\left(1\right) \text{ m}^2 \\ &= 3.18135\times10^{-3} \text{ m}^2 \\ A_{\min,P/D\ 1.33} &= 6.2865\times10^{-3} \text{ m}^2 \\ A_{\min,P/D\ 1.5} &= 9.525\times10^{-3} \text{ m}^2 \end{aligned} \quad . \tag{4-52}$$

4.10 Uncertainty analysis

The uncertainty analysis is performed for the average and the local refrigerant heat transfer coefficients using the Kline-McClintock (1953) second order law using MathCAD for the uncertainty analysis and simulation (an example sheet is provided in Appendix C). To determine the final uncertainty in the heat transfer coefficient first required defining the input variables uncertainty.

4.10.1 Input variables

The input variables can be the measured variables (temperature, pressure, and flow rate) or the calculated variables such as saturation temperatures, water heat transfer coefficient, and so forth. The flow rate uncertainty is determined from the flow meter's uncertainty listed by the manufacturer, which is ±0.1% of reading. In the following subsections, the uncertainty of the measured and calculated variables is discussed in detail.

4.10.1.1 Temperature uncertainty

The device to measure the temperature is the thermistor (high resistance element) which is well-known for its accuracy, stability, and fast response. The sources of uncertainty are the constant temperature bath used for calibration, the data acquisition system, and the calibration curve fit $T = f(R)$. First, the accuracy of the constant temperature bath u_{CTB} is 0.01 °C while the average slope (for all 10,000 ohm thermistors) of the curve fit is $\frac{dT}{dR} \sim -2.284 \times 10^{-3} \frac{^\circ C}{\Omega}$. Next, the accuracy of the data acquisition system, including measurement error, switching error, and transducer conversion error u_{RM} is calculated as $\left(0.008\% \cdot \text{Reading} + 0.001\% \cdot \text{Range}\right)$ while the reading is 10 kΩ and the range is 100 kΩ. Then, the accuracy of the curve fit is calculated as (t-stat × the standard error) and the uncertainty of the curve fit u_{TCF} is 1.28348×10^{-6} °C. Finally, the overall uncertainty is calculated using propagation of error as

$$u_T = \sqrt{\left({u_{CTB}}^2 + \left(\frac{dT}{dR} \cdot u_{RM} \right)^2 + {u_{TCF}}^2 \right)} = \pm 0.015^\circ C \,. \tag{4-53}$$

4.10.1.2 Saturation temperature uncertainty for R-134a

The sources of uncertainty for the pressure transducers are the data acquisition system and the calibration curve fit equation $P = f\left(V\right)$. First, the accuracy of the data acquisition system, including measurement error, switching error, and transducer conversion error u_{VM} is calculated according to $\left(0.002\% \cdot \text{Reading} + 0.0005\% \cdot \text{Range}\right)$. The reading is 5 VDC, and the range is 10 VDC. Second, the slope of the calibration curve fit is $\frac{dP}{dV} \sim 103.455 \frac{VDC}{kPa}$. The uncertainty of the curve fit u_{PCF} is 0.0806 kPa (t-stat × the standard error). Then, the overall uncertainty is calculated using propagation of error as

$$u_p = \sqrt{\left(\frac{dP}{dV} \cdot u_{VM}\right)^2 + u_{PCF}^{\ 2}} = \pm 0.08 \text{ kPa} . \quad (4\text{-}54)$$

The uncertainty given by the manufacturer, $u_{P,R134a}$, is 0.05% of the range 0-75 PSIA (0-517.106 kPa), which is ±0.25 kPa. Since, this uncertainty is higher than that calculated above, for more careful uncertainty calculations, the manufacturer's uncertainty is used. Finally, the saturation temperature change between 3 and 6 °C corresponding to 0.25 kPa increments is 0.022°C. Therefore, R-134a saturation temperature uncertainty is

$$u_{Tsat,R134a} = \pm 0.022 \ ^{\circ}\text{C} . \quad (4\text{-}55)$$

4.10.1.3 Saturation temperature uncertainty for R-123

As for R-134a, the uncertainty listed by the manufacturer is used. The manufacturer's uncertainty, $u_{P,R123}$, is 0.05% of the range 0-15 PSIA (0-103.421 kPa), which is ±0.05 kPa. The maximum saturation temperature change over the range 3 to 6 °C, and 13 to 16 °C, corresponding to 0.05 kPa increments, is 0.03°C. Therefore, R-123 saturation temperature uncertainty is

$$u_{Tsat,R123} = \pm 0.03 \ ^{\circ}\text{C} . \quad (4\text{-}56)$$

4.10.1.4 Water properties

Water properties were called in Excel from RefProp 8.0 without using curve fit equations. Therefore, the water properties uncertainty is considered negligible.

4.10.1.5 Water pressure uncertainty

The water pressure uncertainty used in the analysis is the uncertainty listed by the manufacturer, which is 0.05% full range. The two different range pressure transducers, 0-300 PSIA (0-2068.427 kPa) and 0-150 PSIA (0-1034.213 kPa) have the uncertainty of ±1.0342 kPa and ±0.5171 kPa, respectively.

4.10.1.6 Water heat transfer coefficient uncertainty

The water heat transfer coefficient is a function of the water flow rate, water properties and the correction factor obtained from the Wilson plot technique. The correction factor is the dominant uncertainty of the water heat transfer coefficient and it is assumed to be the 95% confidence interval of the slope of the linear curve fit of the Wilson plot data. This confidence interval of the correction factor for R-134a on a Turbo BII-HP tube equals that of R-123 on Turbo BII-LP tube equal to 4 %

$$u_{h_w,HP} = u_{h_w,LP} = 0.04 \cdot h_w . \tag{4-57}$$

4.10.2 Average refrigerant heat transfer coefficient uncertainty

For the average heat transfer coefficient, based on the input variables discussed above, the final uncertainty can be determined by applying the propagation of uncertainties to the following equation

$$h_{avg} \approx \left(\frac{\dfrac{\Delta T_1 - \Delta T_2}{\ln\left(\Delta T_1 / \Delta T_2\right)} A_o}{\dot{m}\left(C_p\left(T_{in} - T_{out}\right) + v\left(P_{in} - P_{out}\right)\right)} - R'_{wall} - \frac{1}{h_w}\frac{D_o}{D_i} \right)^{-1} . \tag{4-58}$$

Due to the difficulty of solving for the overall heat transfer coefficient using the EBHT (trial and error method), the overall heat transfer coefficient term in the above equation is replaced by the total heat transfer (Equation(4-30)) divided by the LMTD. This does not significantly change the estimated uncertainty in the average heat transfer coefficient.

$$u_{h_{avg}} = \sqrt{\left(\frac{\partial h_{avg}}{\partial \Delta T_1} \cdot u_{\Delta T_1}\right)^2 + \left(\frac{\partial h_{avg}}{\partial \Delta T_2} \cdot u_{\Delta T_2}\right)^2 + \left(\frac{\partial h_{avg}}{\partial \dot{m}} \cdot u_{\dot{m}}\right)^2 + \left(\frac{\partial h_{avg}}{\partial C_p} \cdot u_{C_p}\right)^2 + \ldots\ldots} \tag{4-59}$$

Uncertainties are calculated for each data point and are error bars on the results plots. The percentage uncertainty ranges from 1.5% (high heat flux) to 45% (low heat flux).

4.10.3 Local refrigerant heat transfer coefficient uncertainty

Similar to the average heat transfer coefficient, the local heat transfer coefficient is determined by applying propagation of error on Equation (4-60) over. The uncertainty in all the variables in the previously mentioned equation is given above, except the local temperature T_{lcoal} and the temperature slope dT/dx . The uncertainty of the local temperature is the same as the temperature uncertainty (note: the uncertainty of the temperature slope is discussed in the next subsection)

$$h_l = \left(\frac{T_{lcoal} - T_{sat}}{\dot{m} / \pi D_o \left(C_p \left| dT/dx \right| + v\, \Delta P/L \right)} - R'_{wall} - \frac{1}{h_w} \frac{D_o}{D_i} \right)^{-1} . \tag{4-60}$$

4.10.3.1 Uncertainty of the local temperature slope

The uncertainty in the temperature derivative (temperature slope) is difficult to determine using the propagation of error method for the other inputs. Therefore, a Monte Carlo type simulation is conducted to determine the temperature slope uncertainty. The overall description of this method is as follows. Using the inlet and outlet temperature measurements enables the prediction of the average heat transfer coefficient and using the inlet temperature and the predicted heat transfer coefficient, the temperature drop curve $T_{theor}\left(x\right)$ is determined. The temperature measurement uncertainty is added to each $T_{theor}\left(x\right)$ location according to a normal distribution of the uncertainty. A second order polynomial is then added to the “error imposed” points. The final uncertainty is then the percentage difference between the actual slope and the slope of the curve fit generated from the “error imposed” points.

Recalling that the insert tube measures seven temperature locations, each test point returns a temperature matrix (one by seven), and a curve fit equation is generated (Equation(4-62)). Substituting the inlet temperature and the overall heat transfer coefficient in Equation (4-61) below gives five theoretical values of the five internal local positions (even though those local temperatures are already measured). Consequently, each test point returns a theoretical one by seven matrix. The theoretical temperatures are calculated as

$$T_{theor}\left(x\right) = \frac{-\dot{m}_h v_h \Delta P_h}{UA} + \left(\frac{\Delta T_1 UA + \dot{m}_h v_h \Delta P_h}{UA} \right) e^{-\left(U \pi D / \dot{m}_h C_{p,h} \right) x} + T_\infty . \tag{4-61}$$

12,000 random number, generated by normal distribution, matrices (again each matrix is one by seven) between -0.015 °C and +0.015 °C (representing the uncertainty in the temperature measurement) on the theoretical temperature matrix is added, one of the 12,000 matrixes at a time, to the theoretical temperature matrix. A 2nd order polynomial curve fit is used to fit all the 12,000 temperature matrices to produce 12,000 equations in the form

$$T_{model} = C_1 x^2 + C_2 x + C_3 . \tag{4-62}$$

The slope of the 2nd order polynomial above (the first derivative) is compared to the theoretical slope as shown in the following equations

$$\left.\frac{dT}{dx}\right|_{theor} = -\left(\frac{U\pi D_o}{\dot{m}C_p}\right)\left(T\left(x\right) - T_\infty + \frac{\dot{m}v\Delta P}{UA}\right), \tag{4-63}$$

$$\left.\frac{dT}{dx}\right|_{model} = 2C_1 x + C_2\,, \tag{4-64}$$

$$u_{dTdx} = \frac{\left.\frac{dT}{dx}\right|_{model} - \left.\frac{dT}{dx}\right|_{theor}}{\left.\frac{dT}{dx}\right|_{theor}}\,. \tag{4-65}$$

Each set of temperatures generates five local temperature slopes at positions 1 through 5 along the tube. The 12,000 estimates of the temperature slope at position 1 are then sorted from minimum to maximum; the 11400th point (95% confidence interval of the 12,000 points) is the uncertainty in the temperature slope. Finally, Equation (4-66) below can be applied on all variables used in calculating the local heat transfer coefficient. Moreover, the local heat transfer uncertainty was calculated for each data point ranges from 1.0% (high heat flux) to 115% (low heat flux).

$$u_{h_l} = \sqrt{\left(\frac{\partial h_l}{\partial T_{lcoal}}\cdot u_{T_{lcoal}}\right)^2 + \left(\frac{\partial h_l}{\partial T_{sat}}\cdot u_{T_{sat}}\right)^2 + \left(\frac{\partial h_l}{\partial \dot{m}}\cdot u_{\dot{m}}\right)^2 + \left(\frac{\partial h_l}{\partial C_p}\cdot u_{C_p}\right)^2 + ...} \tag{4-66}$$

4.11 Conclusion

This chapter presented the methods and equations used in determining the local heat transfer coefficient, local heat flux, local quality, mass flux, and average heat transfer coefficient. It also presented the modified Wilson plot method for determining the water heat transfer coefficient. Also, the chapter introduces a new method (Enthalpy Based Heat Transfer) to determine the heat exchanger’s overall heat transfer coefficient using enthalpy change. This method is very useful for designing heat exchangers that experience significant pressure drop. Next, the local quality and mass flux are determined at the minimum cross sectional area, and finally, for calculating the uncertainty in the temperature derivative, a Monte Carlo type simulation was conducted.

Chapter 5 Introduction to Results

5.1 Introduction

The presentation of results is divided into two sections; the first is the effect of tube pitch on high pressure refrigerant (R-134a in Chapter 6), and the second is the effect on low pressure refrigerant (R-123 in Chapter 7). Each chapter addresses the experimental results for the two refrigerants based on three tube pitches: P/D 1.167, 1.33 and 1.5; the tube outer diameter is 0.01905 m (0.75 inch). Each chapter also covers heat transfer performance with respect to the change of heat flux, mass flux and quality. Two analyses (average and local) were used in this study; however, the results plots are for the local analysis, since it is the study focus. The method and equations used in determining the local heat transfer coefficient, local heat flux, and local quality are in Chapter 4.

5.2 Energy balance

An energy balance is performed on each of the six bundles before data collection begins, on both the refrigerant side and the water side, to verify the accuracy of the instruments, since the total heat load can be calculated using the refrigerant side or the water side independent of the other. This is the case when of the refrigerant leaving the test section is superheated; in this case, the total heat transfer is calculated as

$$Q = \dot{m}_{ref}\left(i_{superheated} - i_{subcooled}\right). \tag{5-1}$$

The sub-cooled and the superheated states in the equation above are defined at the pre-boiler inlet and at the test section exit, respectively. Sub-cooled liquid is the state of the refrigerant at the pre-boiler inlet at all test conditions, but the superheated state is not normally reached at the test section exit. However, it can be reached when the liquid refrigerant level in the test section is lowered, and the outlet temperature reads higher than the saturation temperature at the outlet pressure. The water total heat transfer is the sum of the pre-boiler heat load and the test section heat load as

$$Q = Q_{pre-boiler} + Q_{test\ section}, \tag{5-2}$$

where both the pre-boiler load and the test section load can be determined as,

$$Q_{water} = \dot{m}_{water}\left(i_{in} - i_{out}\right). \tag{5-3}$$

The energy balance results for all bundles showed an agreement of 0.1 to 1.8% between the refrigerant and water sides.

5.3 Test matrix

The primary global variables for designing flooded refrigerant evaporators are heat duty, mass flux, tube arrangement, and tube pitch. Within the tube bundle, variables like heat flux and quality vary considerably. Therefore, data collection is mapped through changing the heat flux, mass flux, and inlet quality; these are the control variables for operating the test facility. A range of heat flux, mass flux (based on the minimum cross sectional area), and bundle inlet quality (test matrix inputs) are proposed according to actual flooded evaporator design parameters. Therefore, the test matrix is a three dimensional matrix (5×6×4), where the number of points corresponds to the input variables as shown in Table 5-1 below.

Table 5-1 Test matrix inputs

Mass flux (kg/s.m²)	15	20	25	35	45	55
Heat flux (kW/m²)	5	15	30	45	60	
Inlet Quality	0.10	0.35	0.55	0.70		

The chiller providing the cooling source to the test facility has a capacity of 83 kW, which in turn becomes the capacity of the test facility. Meanwhile, the total heat load (bundle load plus pre-boiler load) and outlet quality are calculated for each element of the matrix. The points exceeding 100% outlet quality and a total load of 83 kW are considered out of range and thus eliminated from the test matrix.

Comparing the performance of the three bundles required holding the proposed input variables constant between the tube pitches. However, for the same mass flux, the mass flow rate increases with the increase of tube pitch; thus, a higher heat load is required. Therefore, the bigger tube pitch had more points that exceeded 83 kW. As a result, the P/D 1.167 has more runs than P/D 1.33, and P/D 1.33 has more runs than P/D 1.5. For the P/D 1.5 bundle, an extra mass flux (10 kg/s.m²) added to the test matrix increased the number data points of this bundle, hence offering a better chance of a fair comparison among all three bundles. The results section contains the number of points in each test matrix.

5.4 Data presentation

Data points are sorted according to heat flux, mass flux and local quality. Those three variables are interrelated, which makes it difficult to determine the change in the heat transfer coefficient with respect to one variable independent of the other two (i.e. the other two held constant). Rather, the range of the other two variables is kept as narrow as possible. Next, the bundles' heat transfer coefficient vs. heat flux plots often includes the single pool boiling curve for comparing the convective and pool boiling for each tube pitch. Ultimately, heat flux proves to be the most influential variable for enhanced tubes rather than mass flux or quality; therefore, the first and most indicative plot of the bundle performance is the heat transfer coefficient vs. heat flux.

5.5 Water temperature drop

The water temperature drop is observed in the bundle through four instrumented tubes as explained in Chapter 3. Each tube carries inlet and outlet thermistors and five local thermistors. A second order polynomial is used to curve fit the temperature drop over each individual 1 m long tube. The local heat transfer coefficient, local heat flux, local quality are determined using the polynomial curve fit as explained in Chapter 4. The following set of figures (Figure 5-1through Figure 5-4) show one selected run. Since each tube carries five local thermistors, each run of the test matrix produces 20 local points of heat transfer coefficient, heat flux, and local quality. Curve fitting each tube individually gives a more accurate curve fit equation than would curve fitting all four tubes at once, and the better the curve fit, the more accurate the temperature slope. In addition, the uncertainty of the temperature slope is narrower than that for a curve fitting all four tubes. Note: the figures below are arranged from highest (maximum temperature difference) to the lowest (minimum temperature difference) heat flux. Ultimately, the second order polynomial provided the best curve fit for the experimental data via a Monte-Carlo simulation on the different curve fits to find out which produces the minimum error.

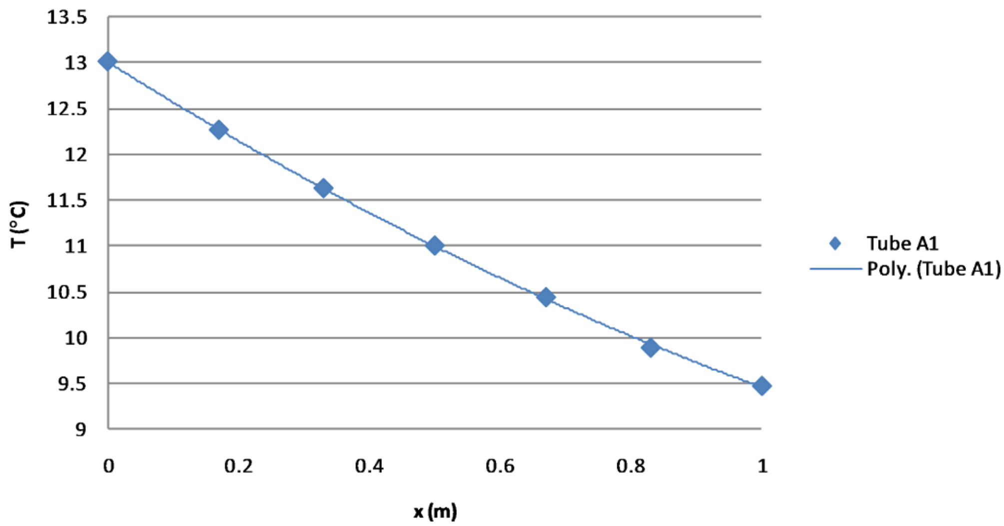

Figure 5-1 Tube A1 temperature drop

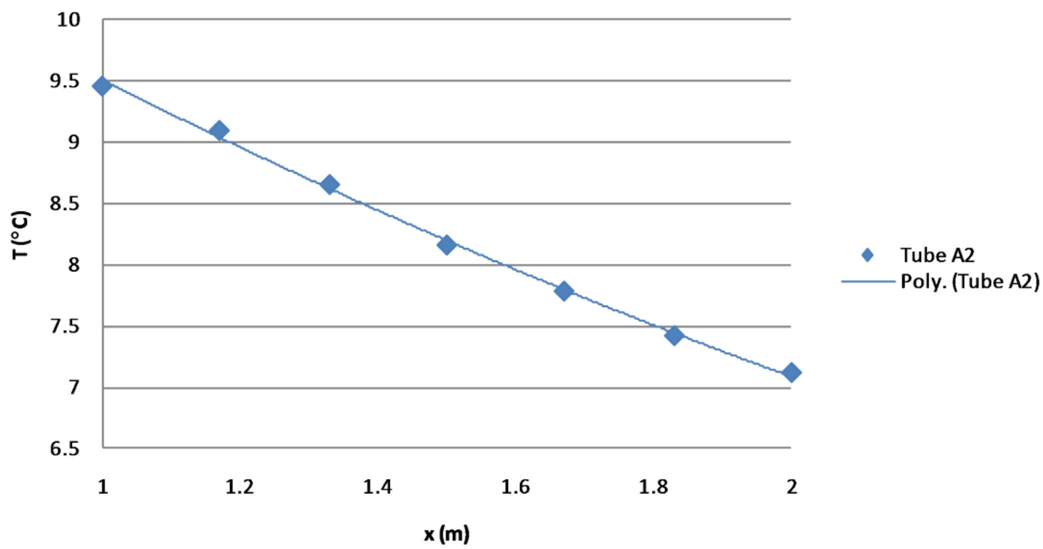

Figure 5-2 Tube A2 temperature drop

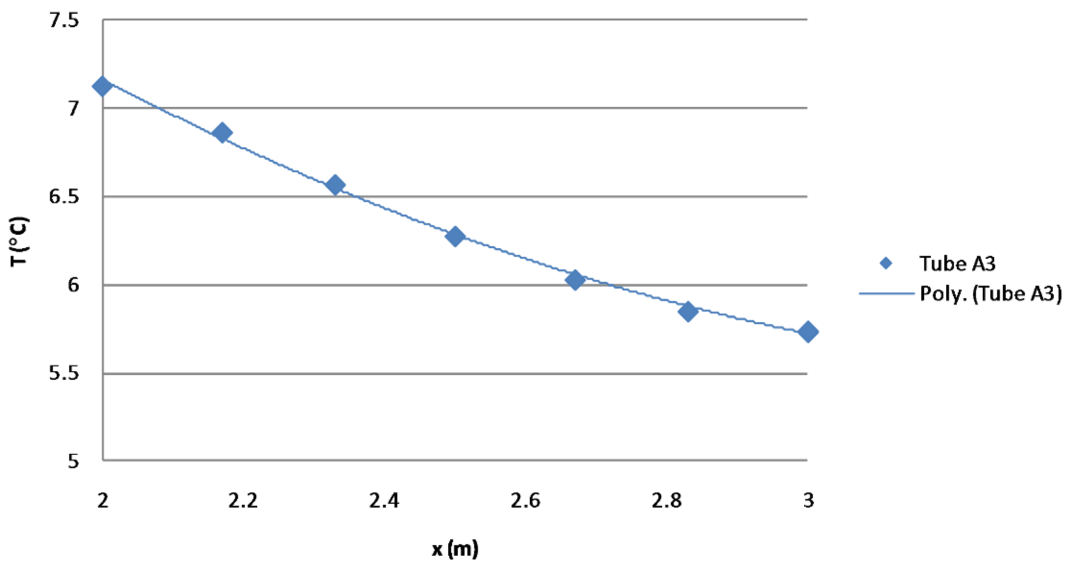

Figure 5-3 Tube A3 temprature drop

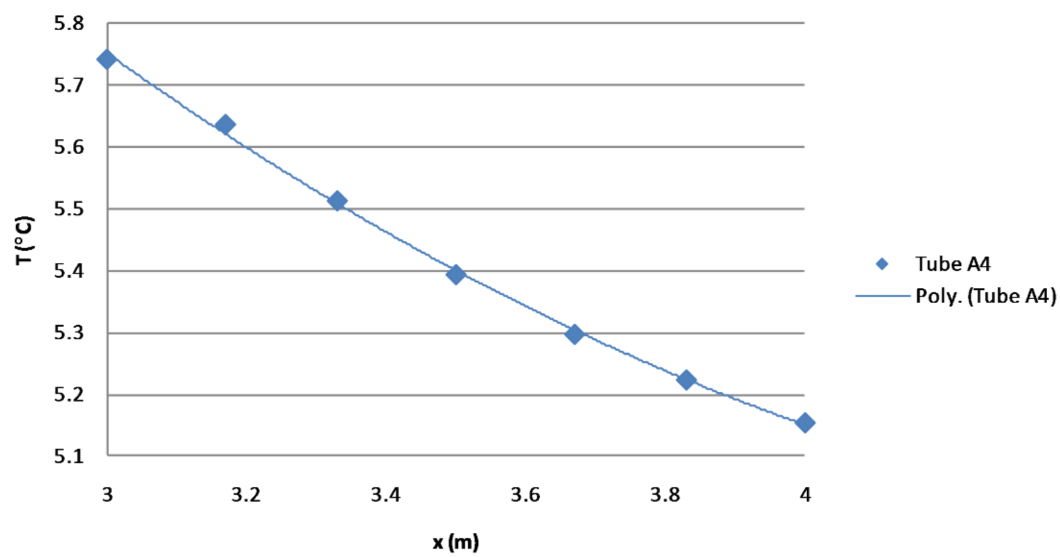

Figure 5-4 Tube A4 temperature drop

5.6 Pool boiling results

Pool boiling is considered much simpler than bundle boiling; since mass flux and inlet quality are not involved. Instead, the refrigerant entering the test section is sub-cooled or saturated liquid. Pool boiling testing requires activating one tube of the tube bundle or using a single tube test section. A comprehensive study of pool boiling, done as a part of this research on a single tube test facility, is accessible through Gorgy (2008). Also, some pool boiling data was taken in the current test facility to expand the heat flux range of the nucleate boiling curve of R-123.

Pool boiling (nucleate boiling) study is considered necessary for the following reasons. Firstly, pool boiling tests are needed in performing the Wilson plot method to determine the water-side heat transfer coefficient. Secondly, it provides the nucleate boiling data needed to design flooded evaporators. Thirdly, it provides an approach for understanding the boiling mechanism of enhanced tubes. Comparisons between nucleate boiling and bundle boiling can help studying convective effects in tube bundles. This sub-section presents, in the following visuals, the pool boiling results of R-134a and R-123 as well as the Wilson plot results.

Figure 5-5 and Figure 5-6 present the nucleate boiling of R-134a on Turbo BII-HP and R-123 on Turbo BII-LP, respectively. Both figures show a quick increase in performance at low heat flux changing to a slightly decreasing trend. The physical interpretation of this phenomenon is explained in detail in Chapter 8 of this document.

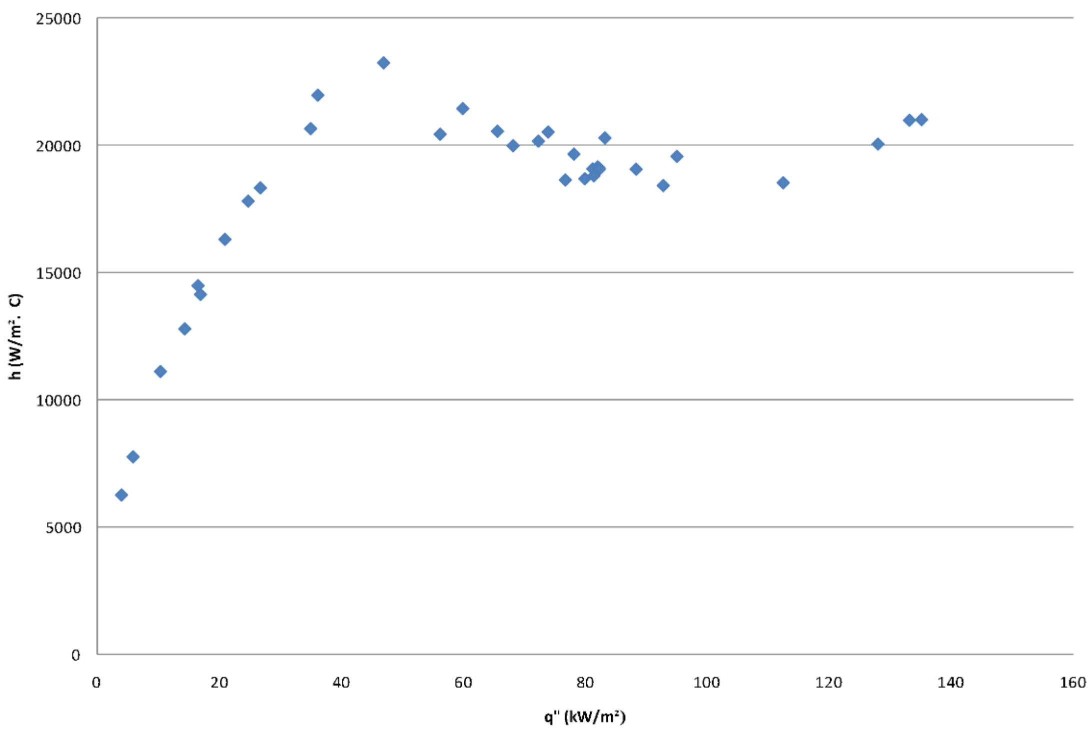

Figure 5-5 Pool boiling of R-134a on Turbo BII-HP

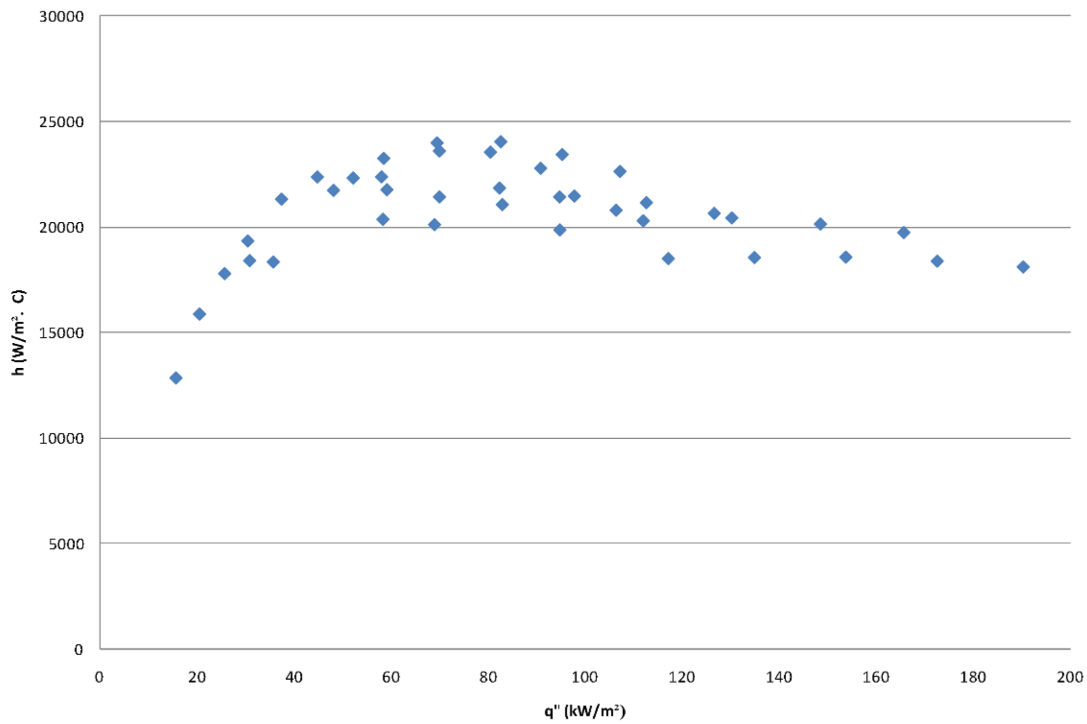

Figure 5-6 Pool boiling of R-123 on Turbo BII-LP

5.7 Wilson plot results

The figures over (Figure 5-7 and Figure 5-8) present the Wilson plot regression for Turbo BII-HP and Turbo BII-LP, respectively. On each plot, "X" represents the quotient $\left(h_i A_i / (q'')^n A_o\right)$, and "Y" represents the quotient $\left(h_i A_i / U_o A_o - R_{wall} h_i A_i\right)$. The calculation of each parameter, data collection method, and linear regression are explained at length in Chapter 4 of this document. The inverse of the intercept is the correction factor for the water-side heat transfer coefficient $\left(C_i\right)$. This value is 1.931 and 1.866 for Turbo BII-HP and Turbo BII-LP, respectively. The figures show that the experimental data collapsed properly to a linear trend indicating that a good Wilson plot was obtained.

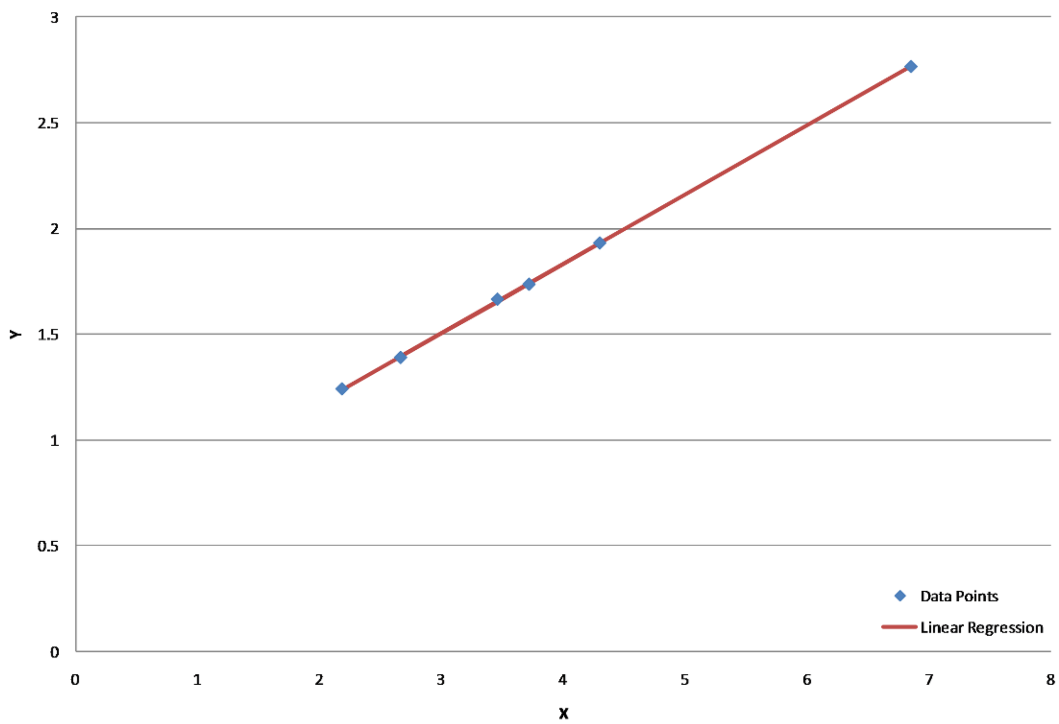

Figure 5-7 Wilson plot of R-134a on Turbo BII-HP

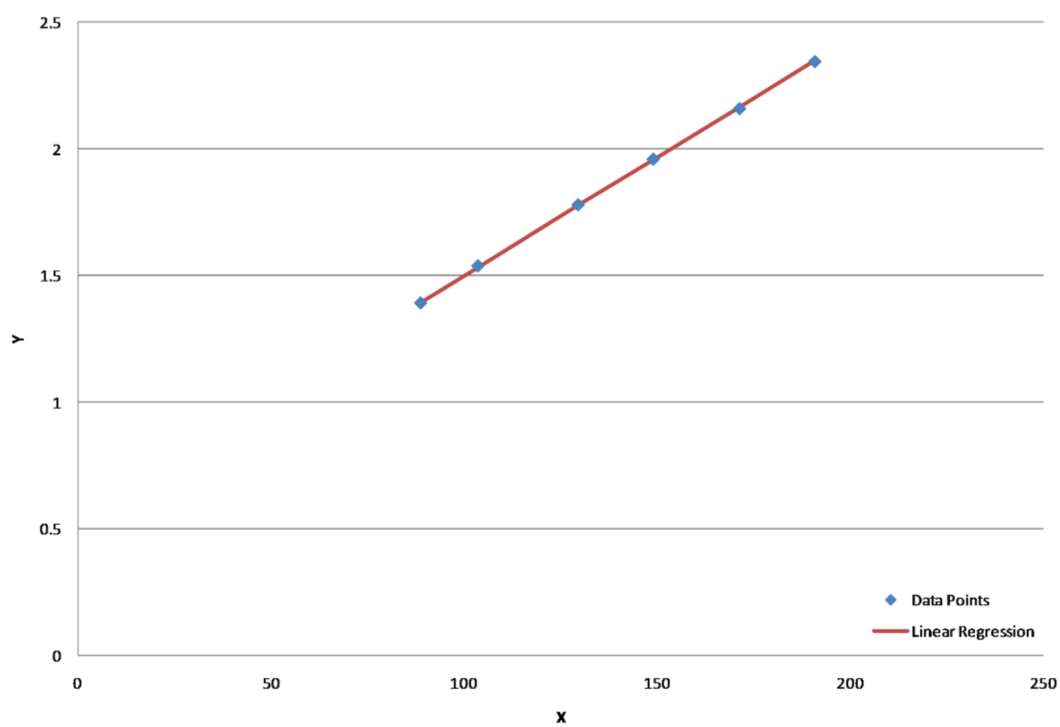

Figure 5-8 Wilson plot of R-123 on Turbo BII-LP

Chapter 6 Effect of Tube Pitch for R-134a

6.1 Introduction

Testing was performed at a saturation temperature of 4.44 °C using an enhanced Turbo BII-HP tube used with R-134a. The following subsections explain the results of each tube bundle along with the related conclusions. The results are presented as plots of the effect of heat flux, mass flux, and quality. Following the results of the third bundle, comparisons between the three bundles are presented along with the final conclusion of the effect of tube pitch on bundle performance.

6.2 P/D 1.167 results

Data were collected according to the proposed test matrix of the P/D 1.167 tube bundle based on a total of 55 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes, and local qualities, thus, 1100 total data points. Figure 6-1 over presents all 1100 points. The data is compared to that of the single tube pool boiling of the Turbo BII-HP tube. At low heat flux range (minimum heat flux to 20 kW/m^2), all points show enhanced performance due to convective boiling and as heat flux increases, the bundle performance becomes significantly lower than does the single tube performance.

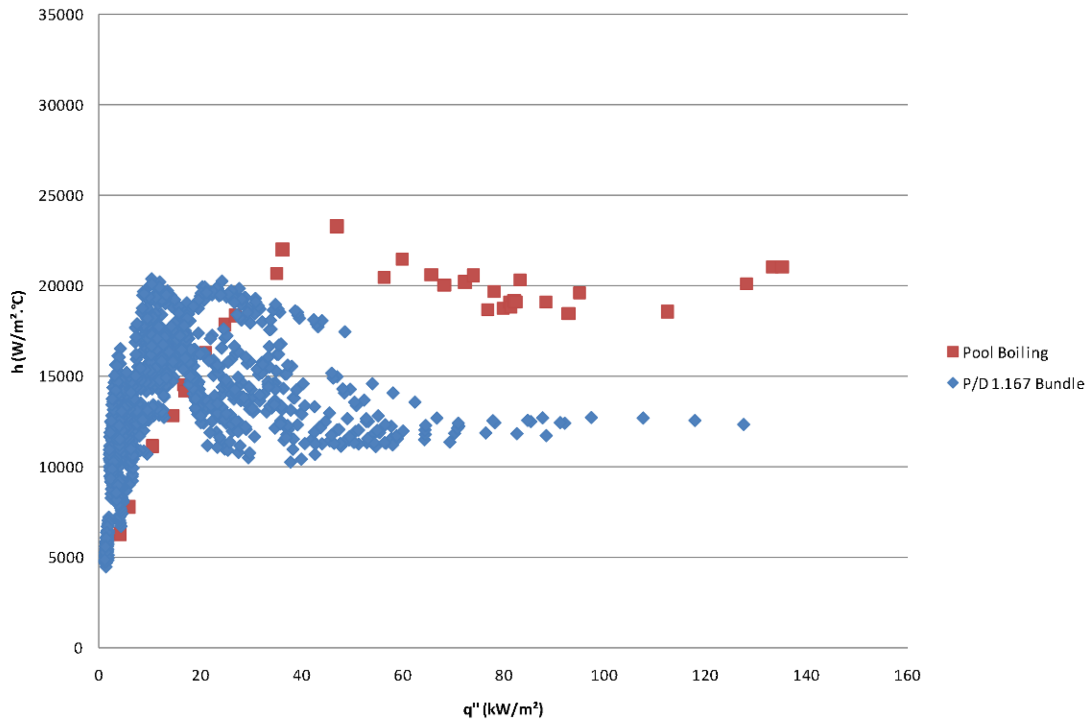

Figure 6-1 R-134a P/D 1.167 all data

The data presented above were sorted by quality as shown in Figure 6-2. Data points of a quality at 10% and 20% show enhanced performance at low heat flux, which increases with the increase in quality. Some points of the 55-60% Quality range show twice the performance of the single tube, while all the points above the 20 kW/m² mark show a much lower performance than does the single tube. This performance deterioration reaches 50% at the 55-60% Quality points range. Also, at higher heat fluxes, the higher the quality, the lower the performance. Next, all the points above 10 kW/m² show a decreasing trend with the increase of heat flux. Finally, at 60 kW/m² and above, the heat transfer coefficient does not show a significant change with the increase in heat flux.

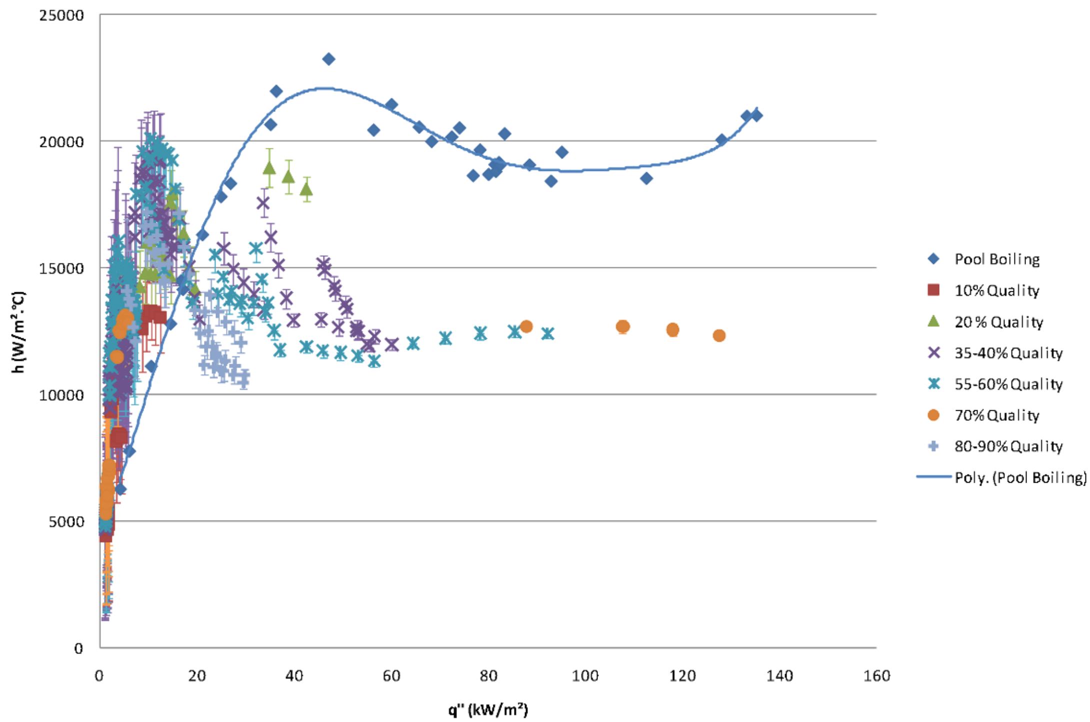

Figure 6-2 R-134a P/D 1.167 all data sorted by quality

6.2.1 Heat flux effect

Figures 6-3 through 6-6 present a different view of the change of the heat transfer coefficient with heat flux for different mass fluxes and different ranges of qualities. In the first plot (10-15% Quality), the heat transfer coefficient increases with the increase in heat flux with a near flat trend after. In the 35-40% Quality plot, the heat transfer coefficient increases with the increase in heat flux up to 10 kW/m² and then changes to a decreasing trend, to near flat trend at higher heat fluxes; the same trend persists for the higher quality plots. Those plots show that the heat transfer coefficient is strongly dependent on heat flux.

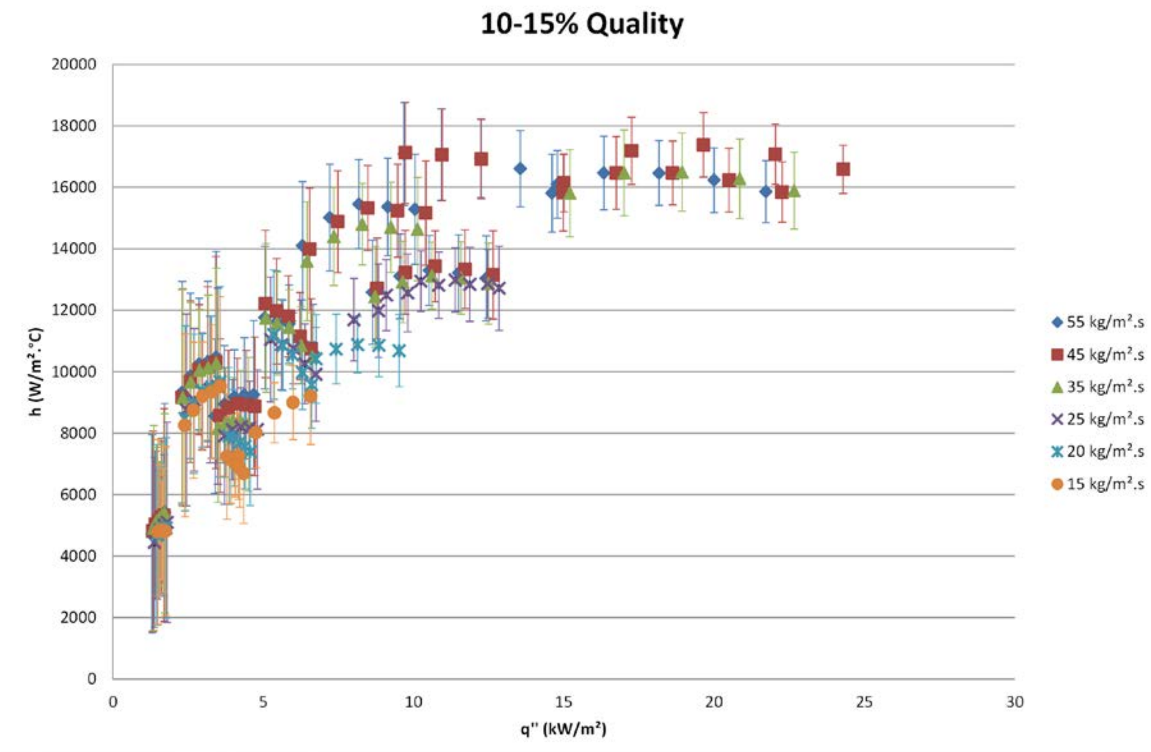

Figure 6-3 R-134a P/D 1.167 effect of heat flux at 10-20% Quality

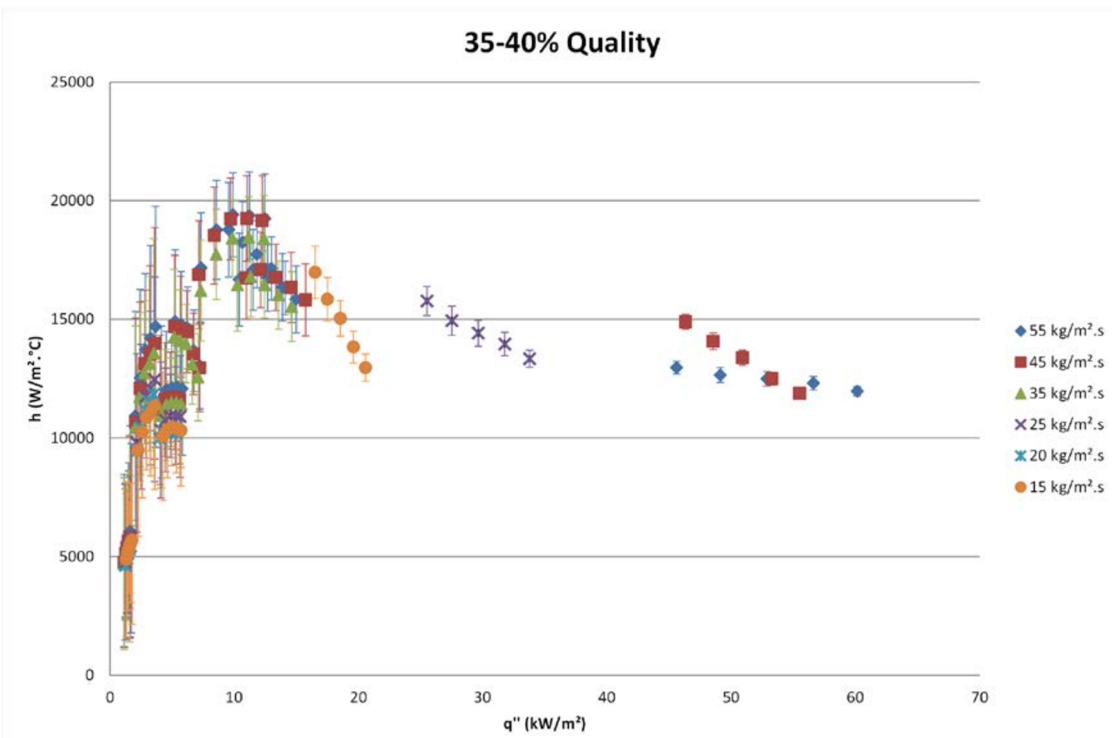

Figure 6-4 R-134a P/D 1.167 effect of heat flux 35-40% Quality

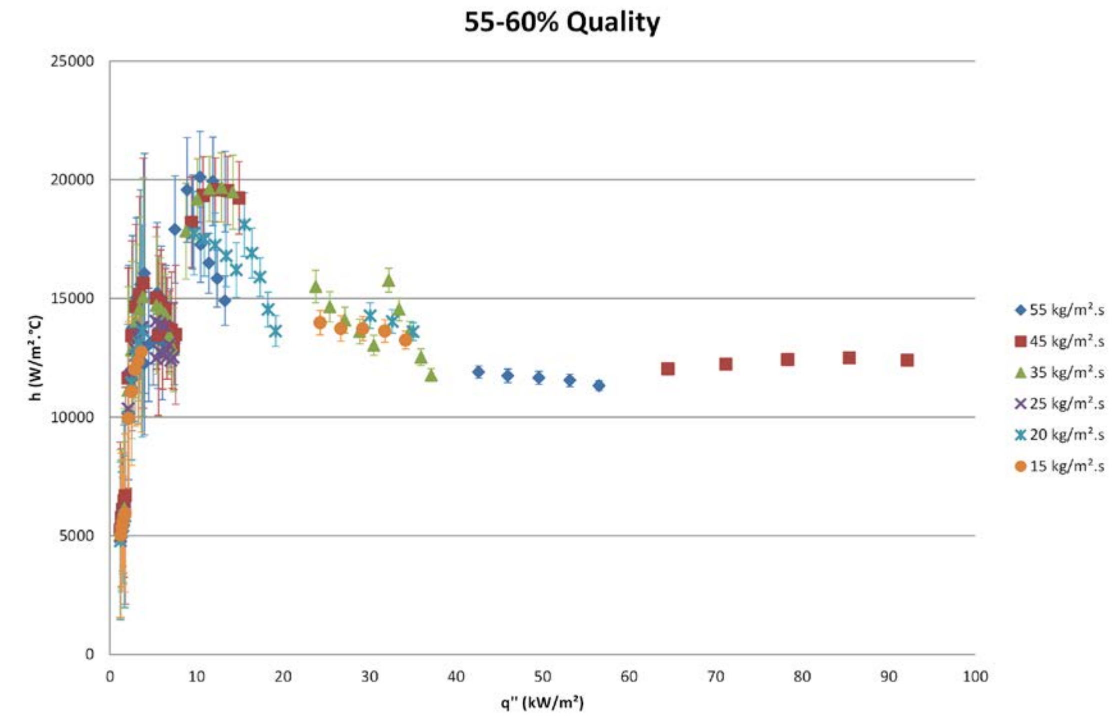

Figure 6-5 R-134a P/D 1.167 effect of heat flux 55-60% Quality

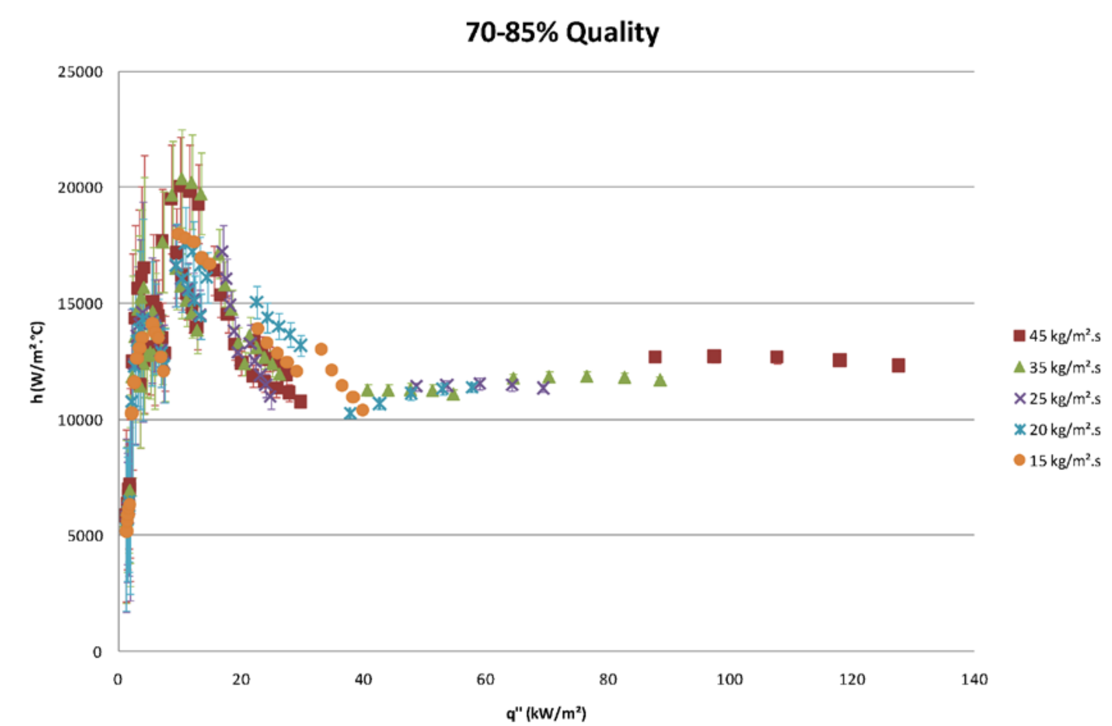

Figure 6-6 R-134a P/D 1.167 effect of heat flux 70-85% Quality

6.2.2 *Mass flux effect*

The mass flux effect can also be interpreted from the plots in Figure 6-3 to Figure 6-6. In Figure 6-3 (10-15% Quality), at the same heat flux, the heat transfer coefficient slightly increases with the increase in mass flux. For the higher quality plots and taking into account the heat transfer coefficient uncertainty, hardly any change occurs in the heat transfer coefficient with mass flux at the same heat flux. Therefore, the mass flux does not significantly affect performance.

6.2.3 *Quality effect*

For the effect of quality on the bundle performance, the heat transfer coefficient was plotted against quality for each mass flux point of the test matrix over a narrow range of heat flux points as presented in Figures 6-7 through 6-12. For 4-5 and 10 kW/m² for all mass fluxes, the heat transfer coefficient shows in all figures an increasing trend with the increase in quality. For higher heat fluxes, the heat transfer coefficient slightly decreases with the increase in quality. The fact that the heat transfer coefficient vs. quality trends are similar at all mass flux points reinforces the conclusion that the effect of mass flux is insignificant.

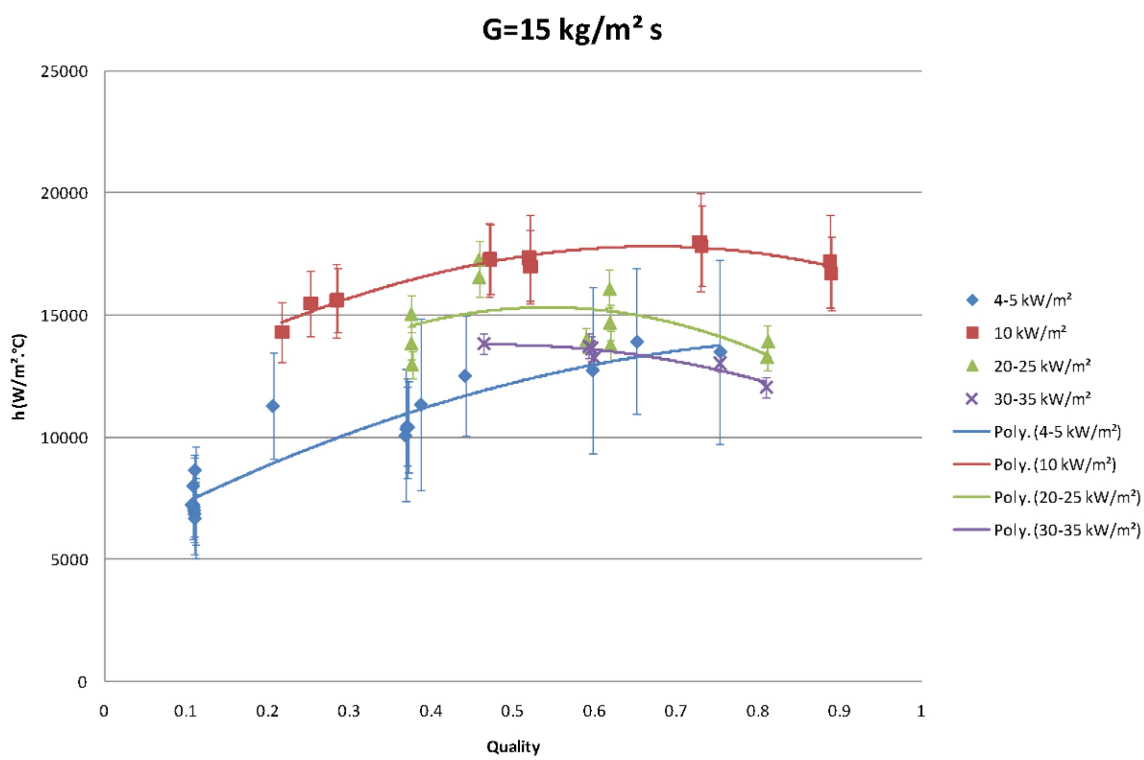

Figure 6-7 R-134a P/D 1.167 effect of quality at 15 kg/m².s

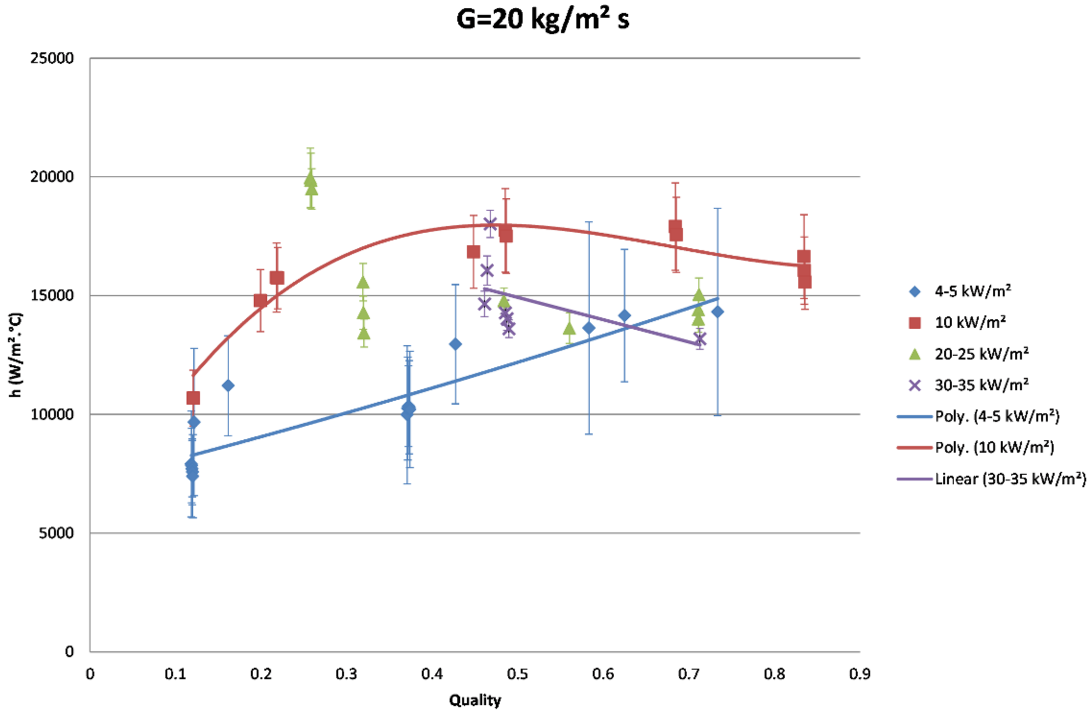

Figure 6-8 R-134a P/D 1.167 effect of quality at 20 kg/m².s

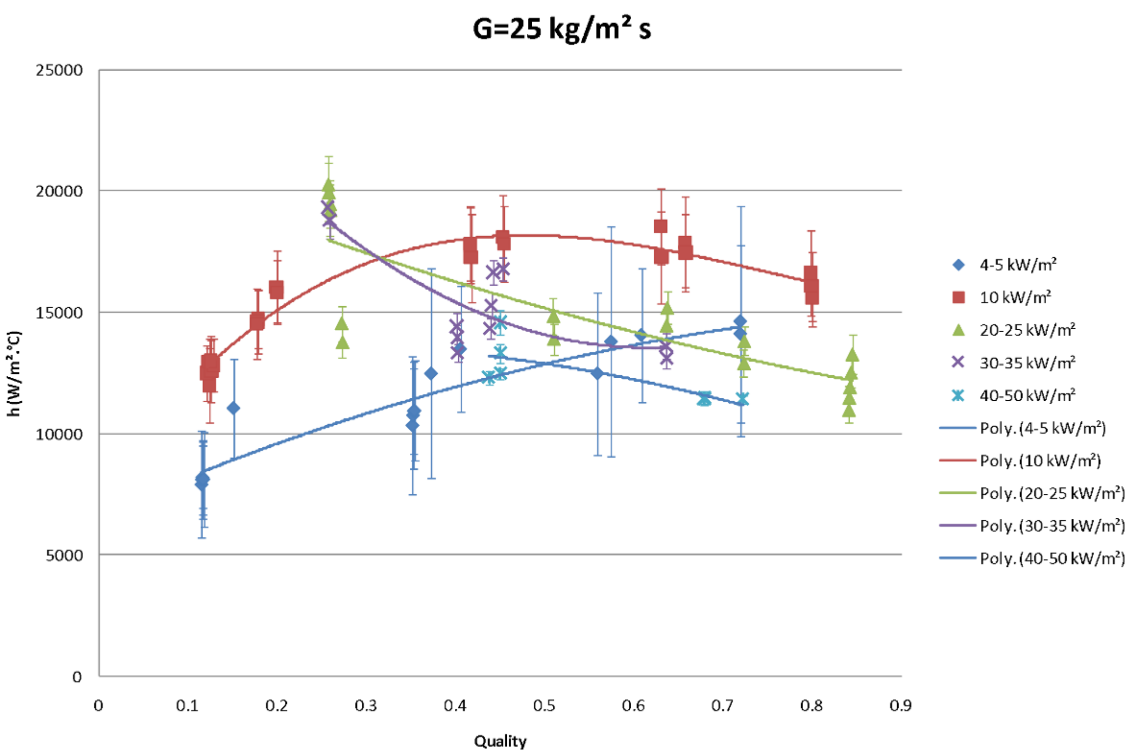

Figure 6-9 R-134a P/D 1.167 effect of quality at 25 kg/m².s

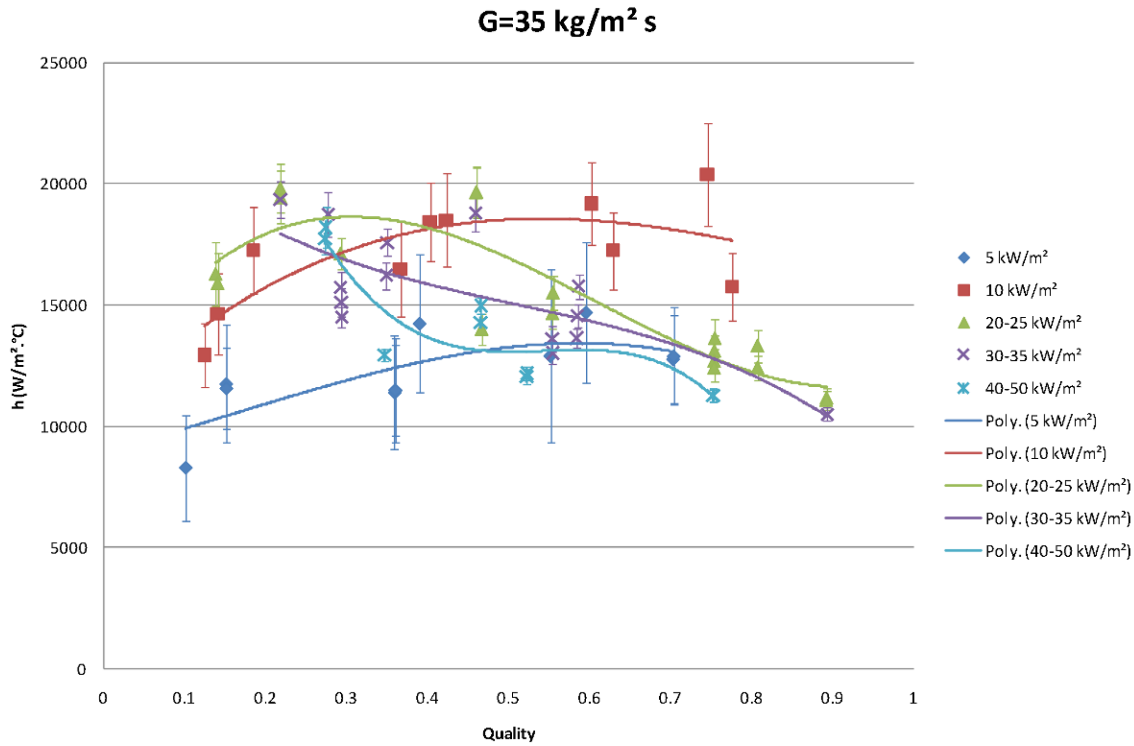

Figure 6-10 R-134a P/D 1.167 effect of quality at 35 kg/m².s

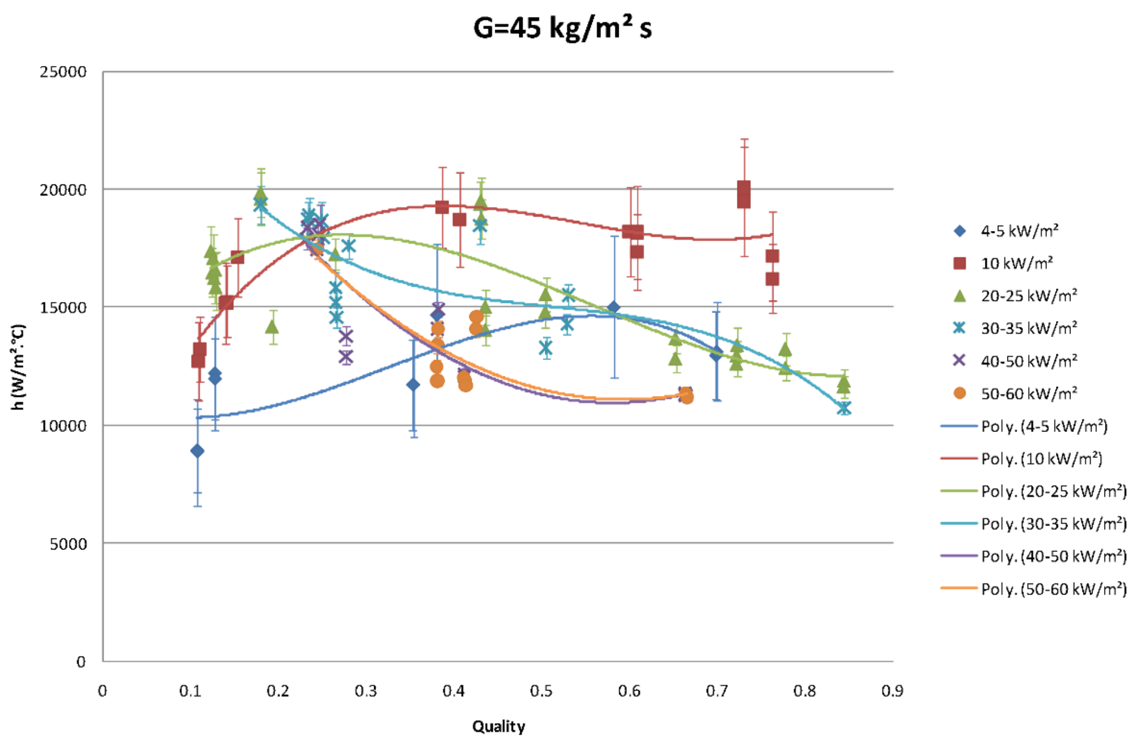

Figure 6-11 R-134a P/D 1.167 effect of quality at 45 kg/m².s

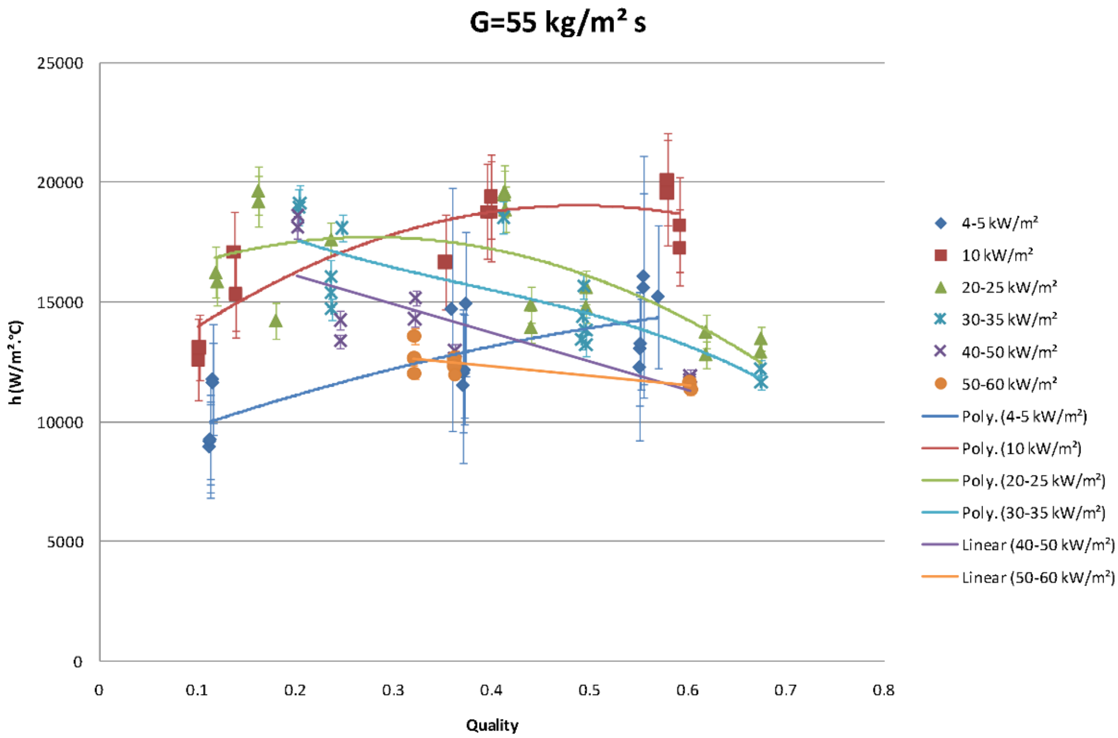

Figure 6-12 R-134a P/D 1.167 effect of quality at 55 kg/m².s

6.3 P/D 1.33 results

Data were collected according to the proposed test matrix of the P/D 1.33 tube bundle based on a total of 44 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes, and local qualities, thus, 880 total data points. Figure 6-13 over presents all 880 points. The data is compared to that from the single tube pool boiling of the Turbo BII-HP tube. At low heat flux range (minimum heat flux to 25 kW/m²), all points show enhanced performance due to convective boiling. At medium heat flux range, the bundle performance falls slightly below the single tube pool boiling performance while at high heat flux, both performances overlap.

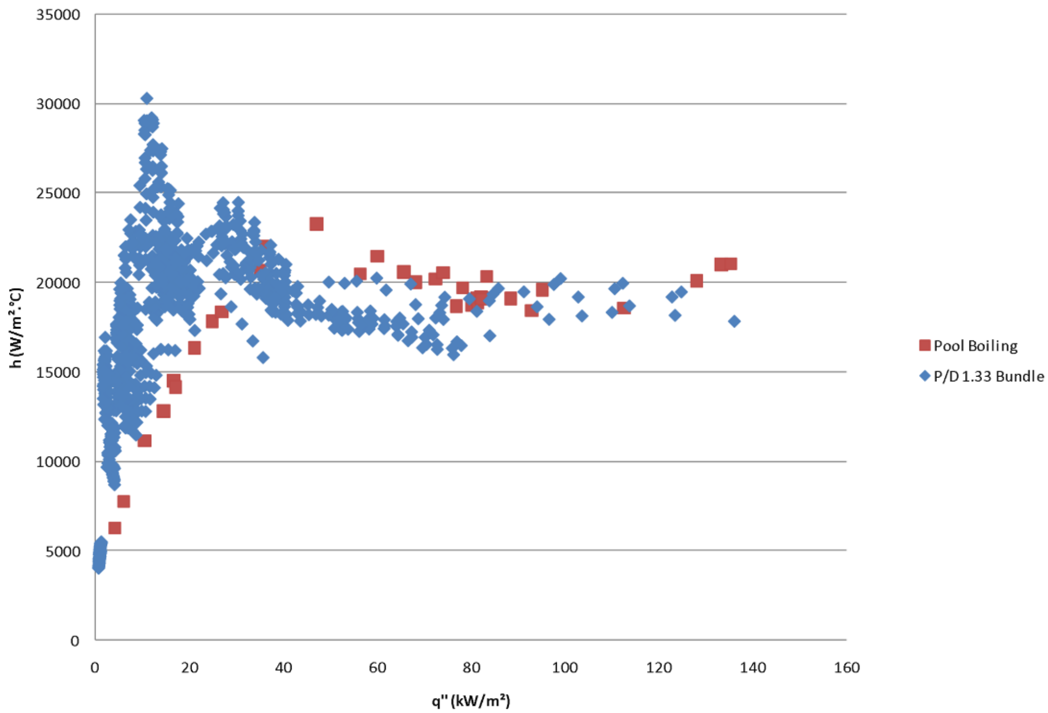

Figure 6-13 R-134a P/D 1.33 all data

The data presented above were sorted by quality as shown in Figure 6-14. Data points for a quality at 10% and 20% show enhanced performance at low heat flux, which increases with the increase in quality. Some points with a quality in the 70-80% range show 2.7 times the performance of the single tube pool boiling, while all the points above the 35 kW/m² mark show a slightly lower performance than does the single tube. This lower trend persists up to 75 kW/m². Also, at higher heat fluxes, high quality points (70-80%) have lower performance than do lower quality points (35-40%), next all the points above 10 kW/m² show a decreasing trend with the increase of heat flux. Finally, at 70 kW/m² and above, the heat transfer coefficient does not significantly change with the increase in heat flux.

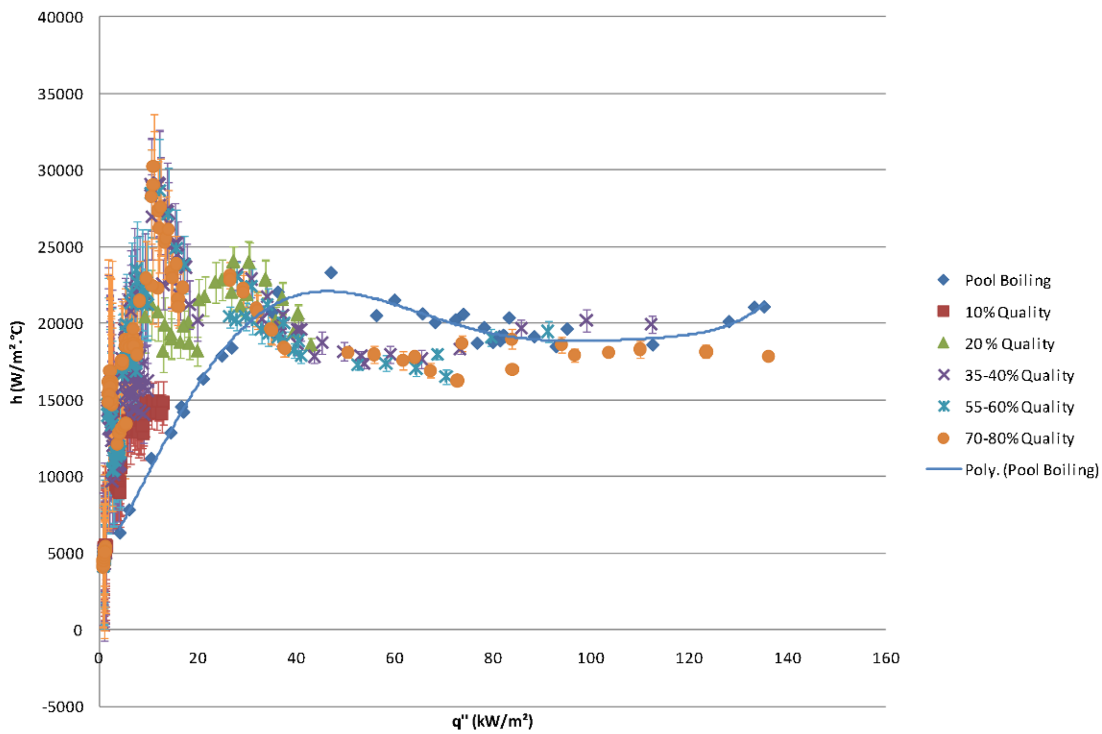

Figure 6-14 R-134a P/D 1.33 all data sorted by quality

6.3.1 Heat flux effect

Figures 6-15 through 6-17 present the change in heat transfer coefficient with heat flux for different mass fluxes and different ranges of quality. In the first plot (10-15% Quality), the heat transfer coefficient increases with the increase in heat flux with a near flat trend after. For the 35-40% Quality (Figure 6-16), the heat transfer coefficient increases with the increase in heat flux up to 10 kW/m² and then changes to a decreasing trend, to a near flat trend at higher heat fluxes, and the same trend persists for higher quality plots. Those plots show that the heat transfer coefficient is strongly dependent on heat flux.

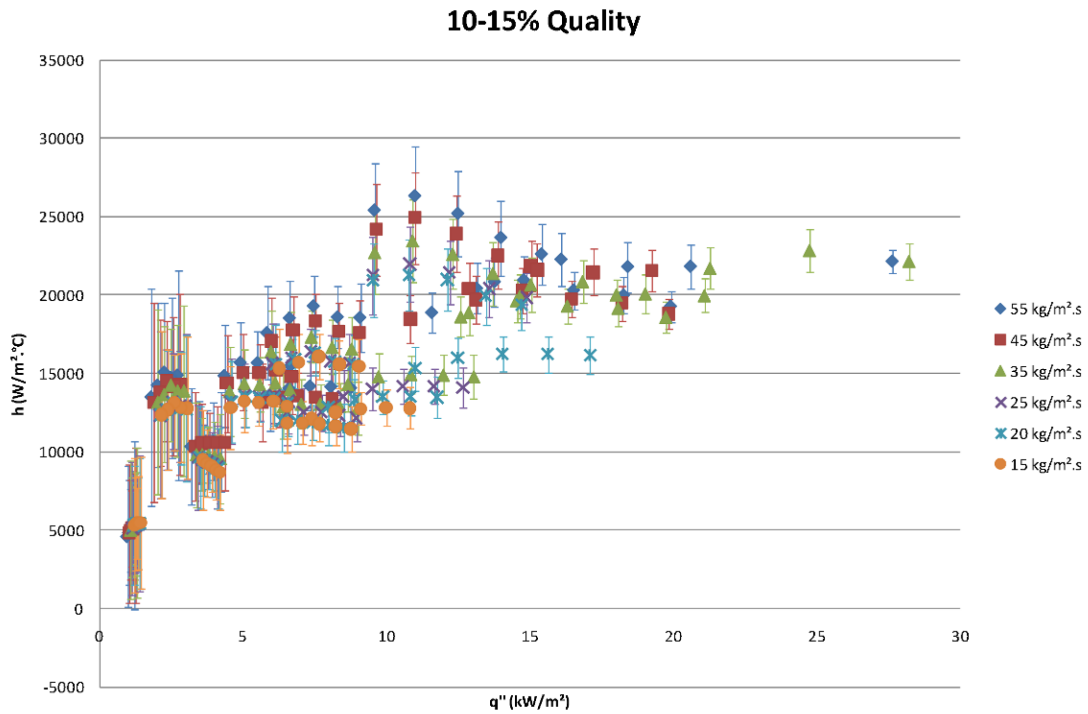

Figure 6-15 R-134a P/D 1.33 effect of heat flux at 10-15% Quality

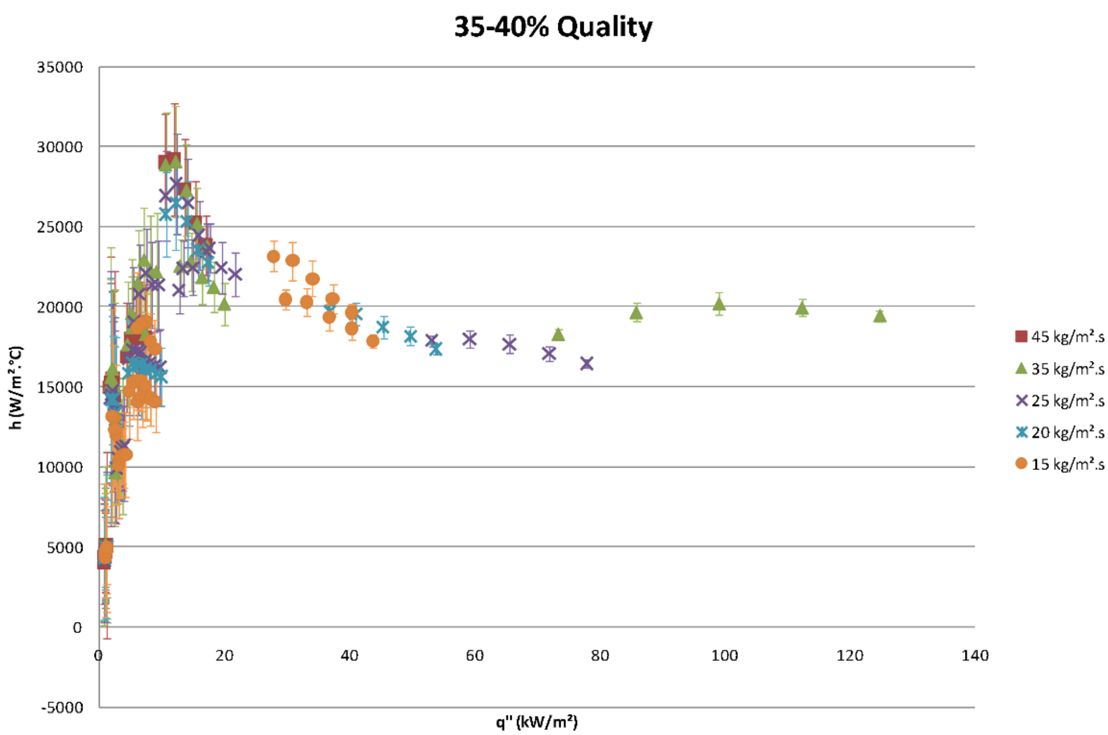

Figure 6-16 R-134a P/D 1.33 effect of heat flux at 35-40% Quality

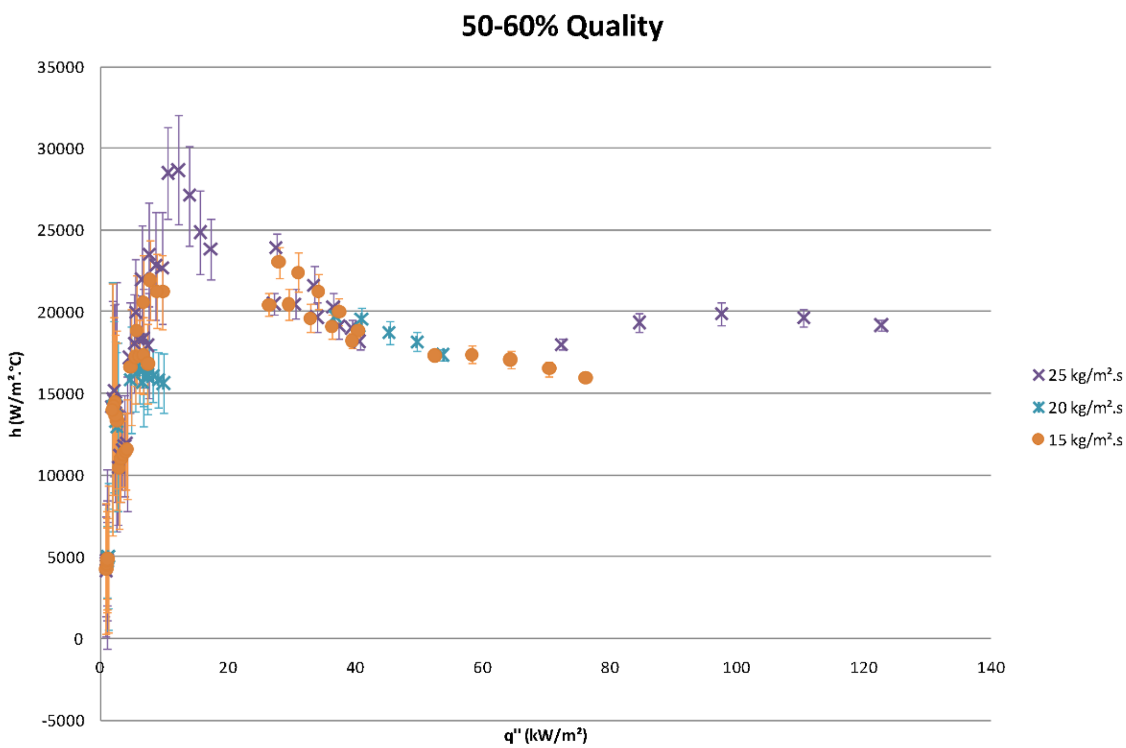

Figure 6-17 R-134a P/D 1.33 effect of heat flux at 50-60% Quality

6.3.2 Mass flux effect

The mass flux effect can also be interpreted from the plots in Figures 6-15 to 6-17. In Figure 6-15 (10-15% Quality), at the same heat flux, the heat transfer coefficient slightly increases with the increase in mass flux. For the higher quality plots and taking into account the heat transfer coefficient uncertainty, hardly any change registers in the heat transfer coefficient with mass flux at the same heat flux. Therefore, the mass flux does not show a significantly affect performance.

6.3.3 Quality effect

The heat transfer coefficient was plotted against quality for each mass flux point of the test matrix over a narrow range of heat flux points as presented in Figures 6-18 through 6-23. For the 4-5 and 9-15 kW/m² marks for all mass fluxes, the heat transfer coefficient shows an increasing trend with the increase in quality. For higher heat fluxes at 15, 20, 25, and 35 kg/m².s marks, the heat transfer coefficient does not significantly change with quality. However, the heat transfer coefficient shows an increasing trend for 20-40 kW/m² for 45 and 55 kg/m².s plots (Figure 6-22 and Figure 6-23).

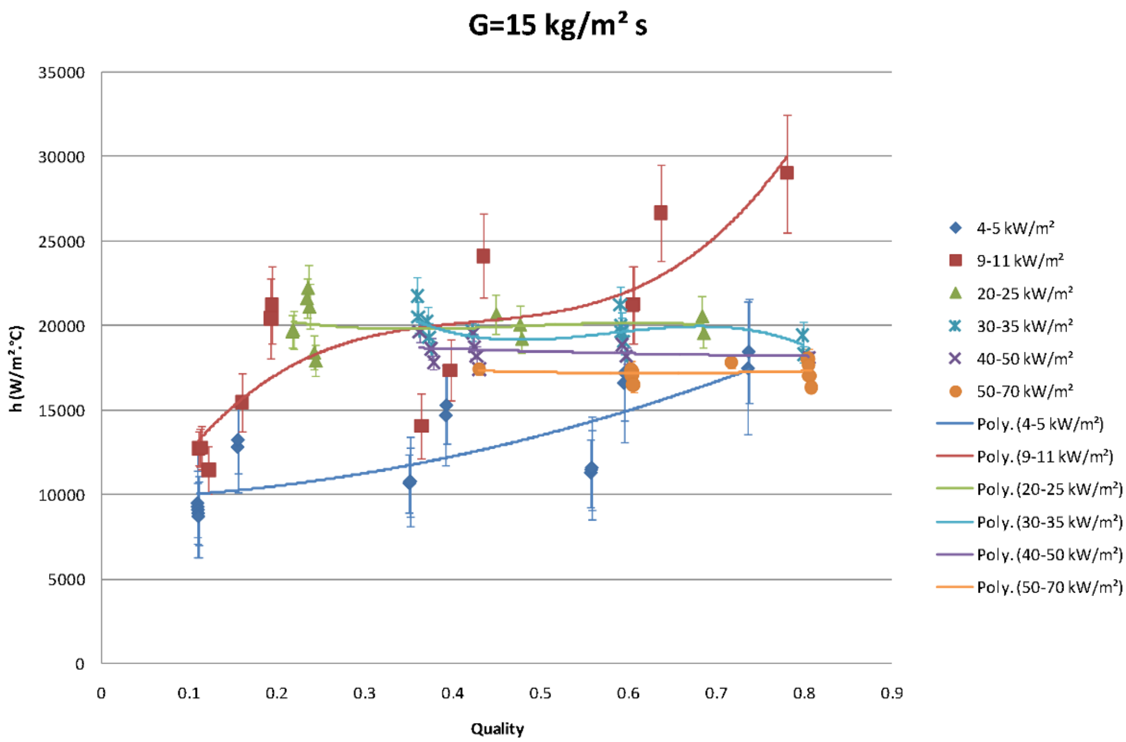

Figure 6-18 R-134a P/D 1.33 effect of quality at 15 kg/m².s

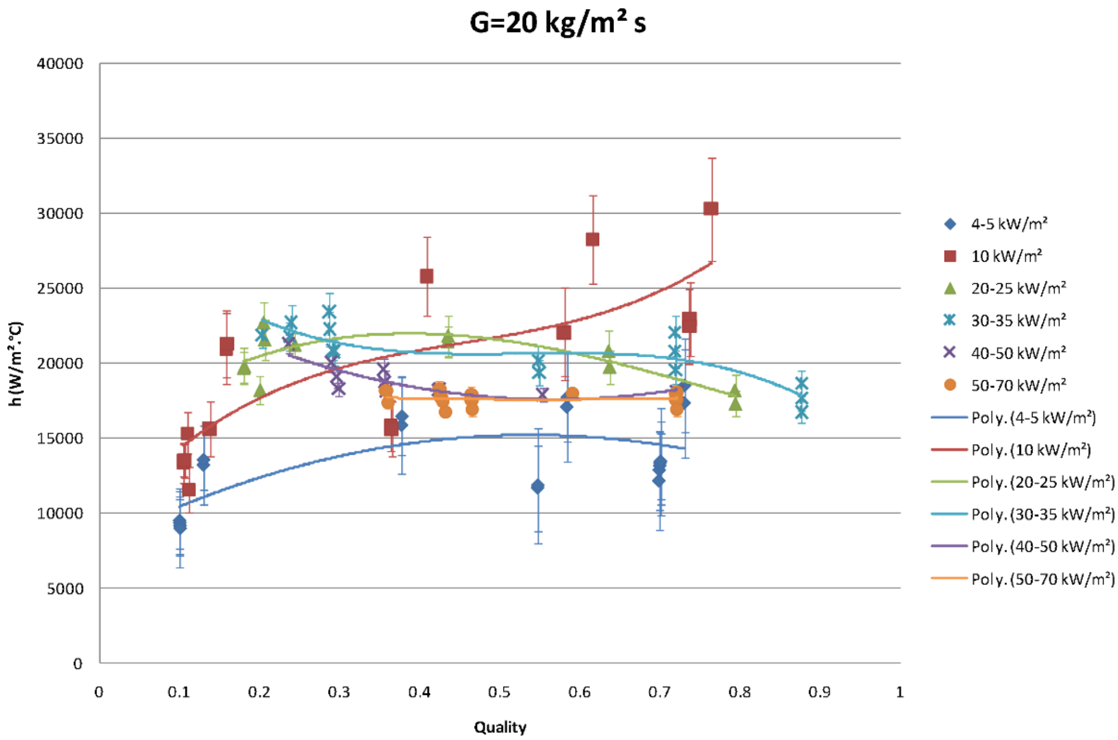

Figure 6-19 R-134a P/D 1.33 effect of quality at 20 kg/m².s

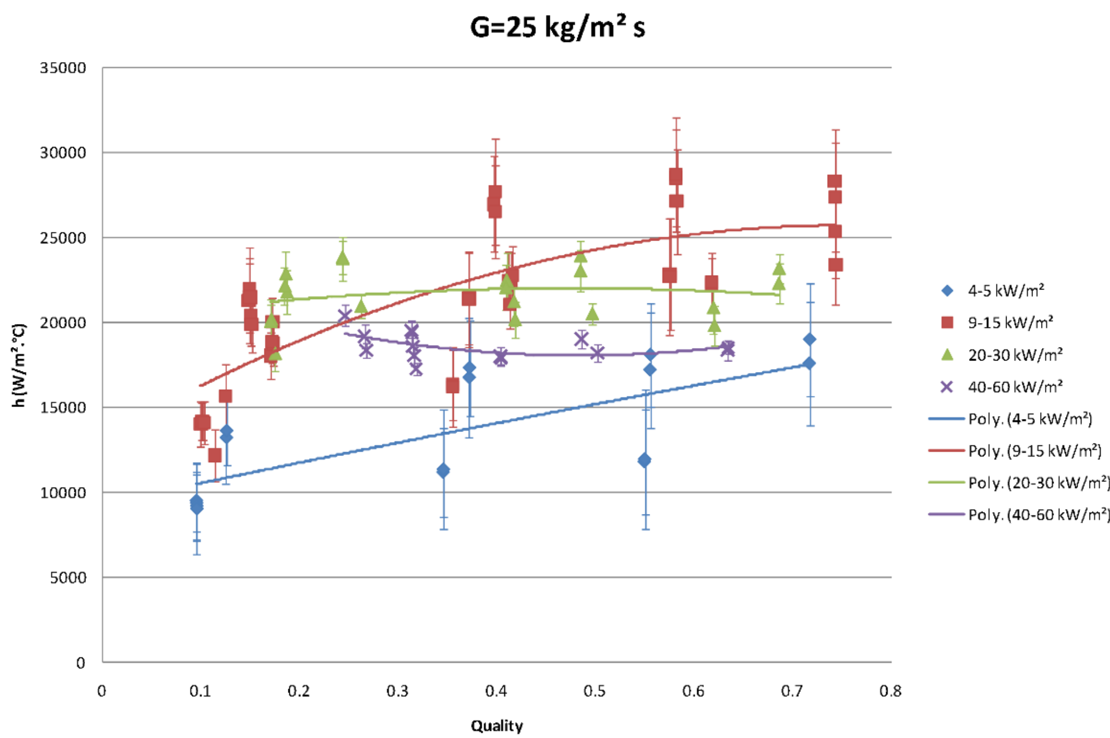

Figure 6-20 R-134a P/D 1.33 effect of quality at 25 kg/m².s

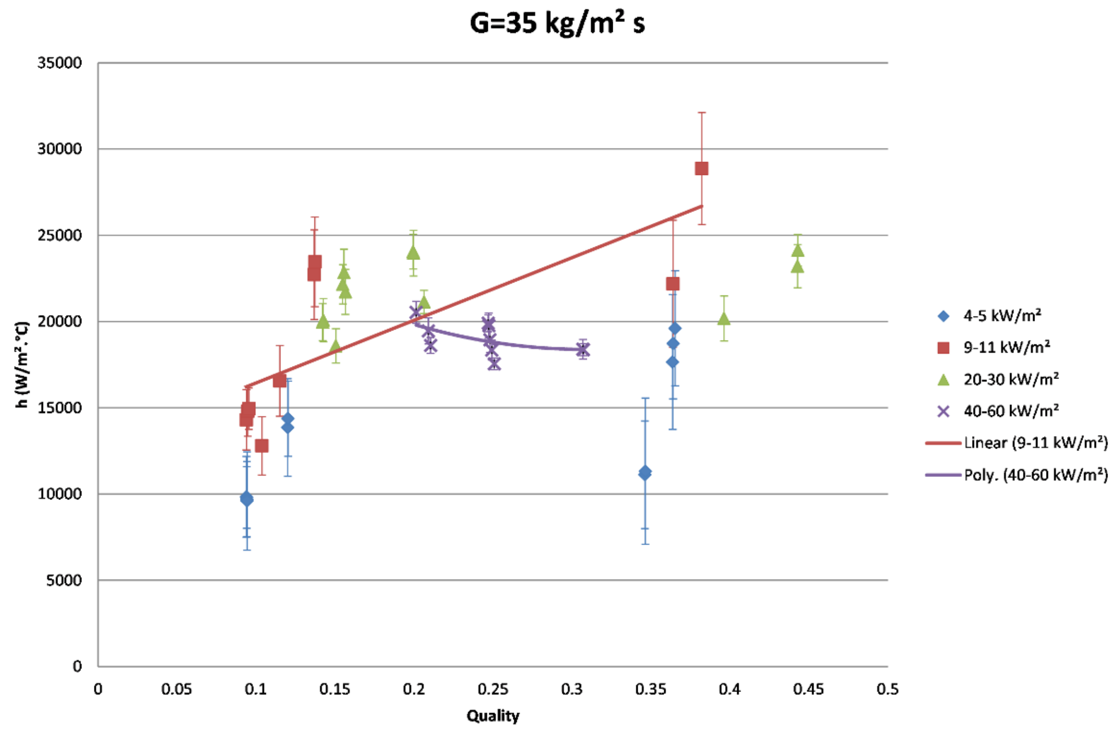

Figure 6-21 R-134a P/D 1.33 effect of quality at 35 kg/m².s

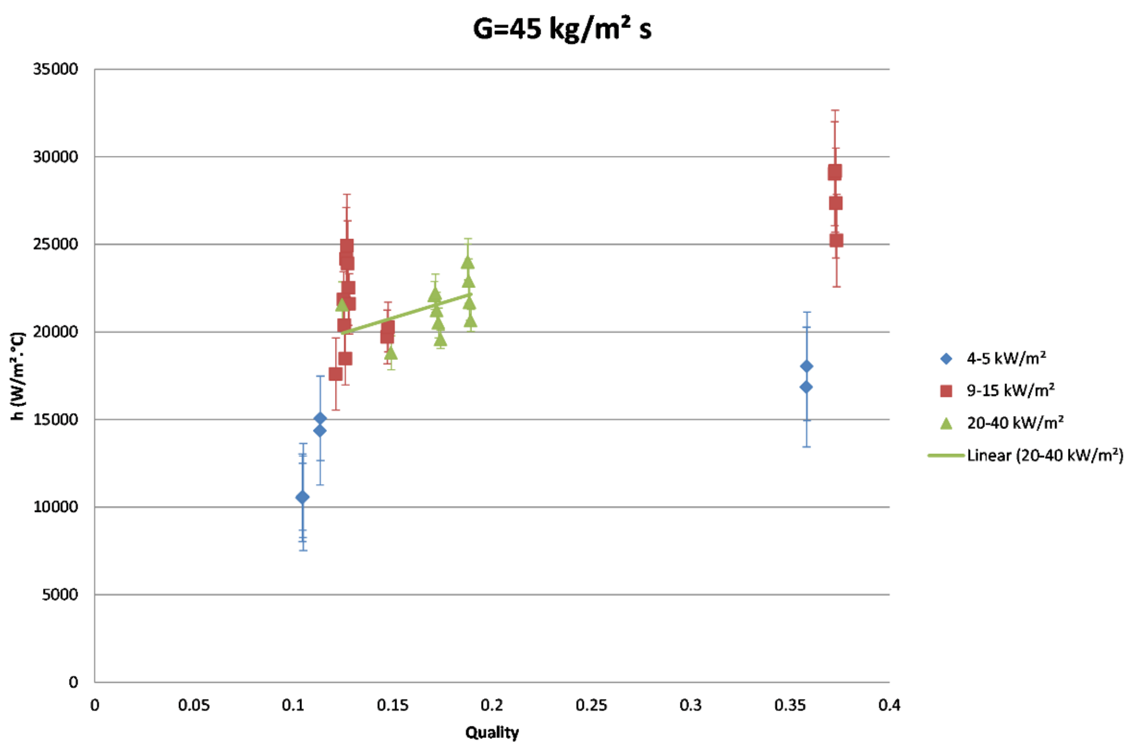

Figure 6-22 R-134a P/D 1.33 effect of quality at 45 kg/m².s

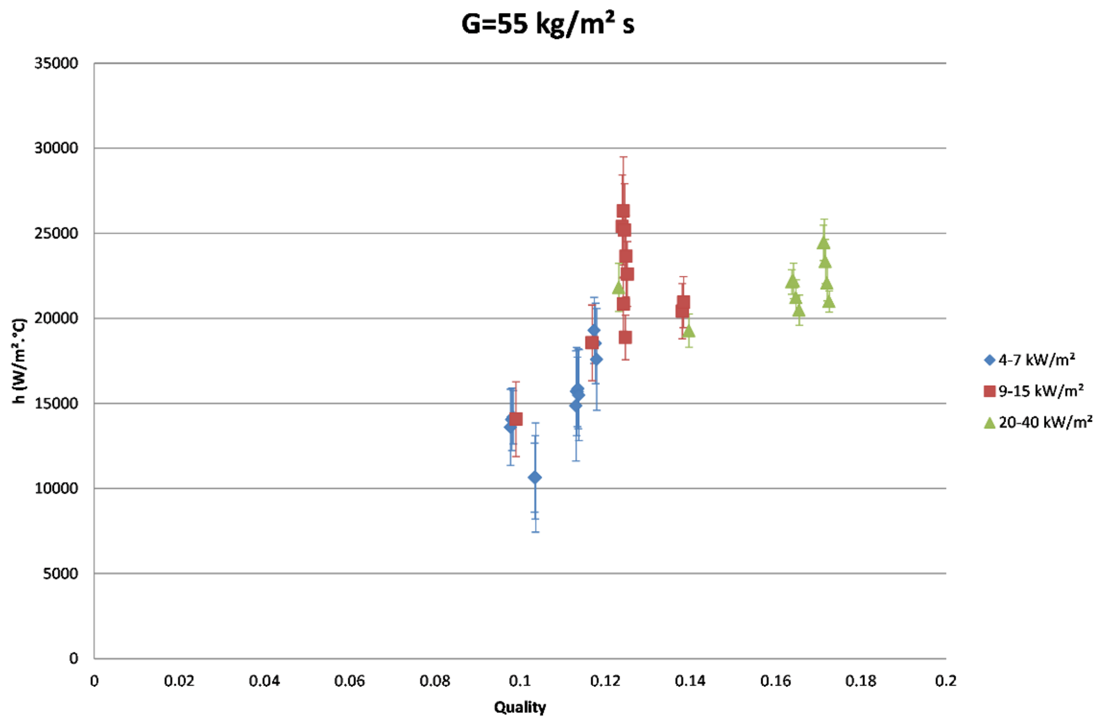

Figure 6-23 R-134a P/D 1.33 effect of quality at 55 kg/m².s

6.4 P/D 1.5 results

Data were collected according to the proposed test matrix of the P/D 1.33 tube bundle for a total of 38 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes, and local qualities, thus, 760 total data points as in Figure 6-24 below. The data is compared to that for the single tube pool boiling of the Turbo BII-HP tube and reveals at low heat flux range (minimum heat flux to 40 kW/m²), all points show enhanced performance due to convective boiling. For the 40-50 kW/m² mark, the performance is slightly lower than for the single tube performance. However, above 50 kW/m², both performances overlap.

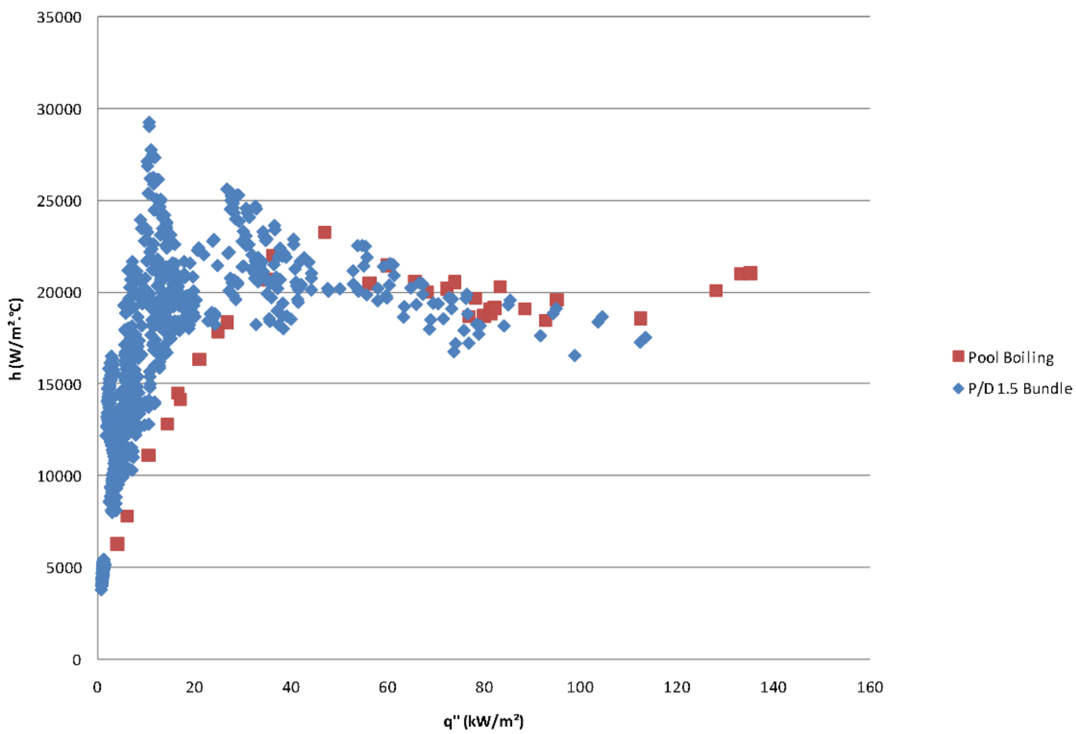

Figure 6-24 R-134a P/D 1.5 all data

The data presented above were sorted by quality as shown in Figure 6-25. First, data points of a quality at 10% and 20% show performance enhancement at low heat flux, which increases with the increase in quality. For example, some points of 70-80% Quality show 2.7 times the performance of the single tube, and all the points above the 40 kW/m² mark show slightly lower performance than does the single tube. Also, at higher heat fluxes, high quality points (70-80%) have slightly lower performance than do lower quality points (35-40%); however, all the points above 20 kW/m² show a decreasing trend with the increase in heat flux. At 70 kW/m² and above, the heat transfer coefficient does not significantly change with the increase in heat flux.

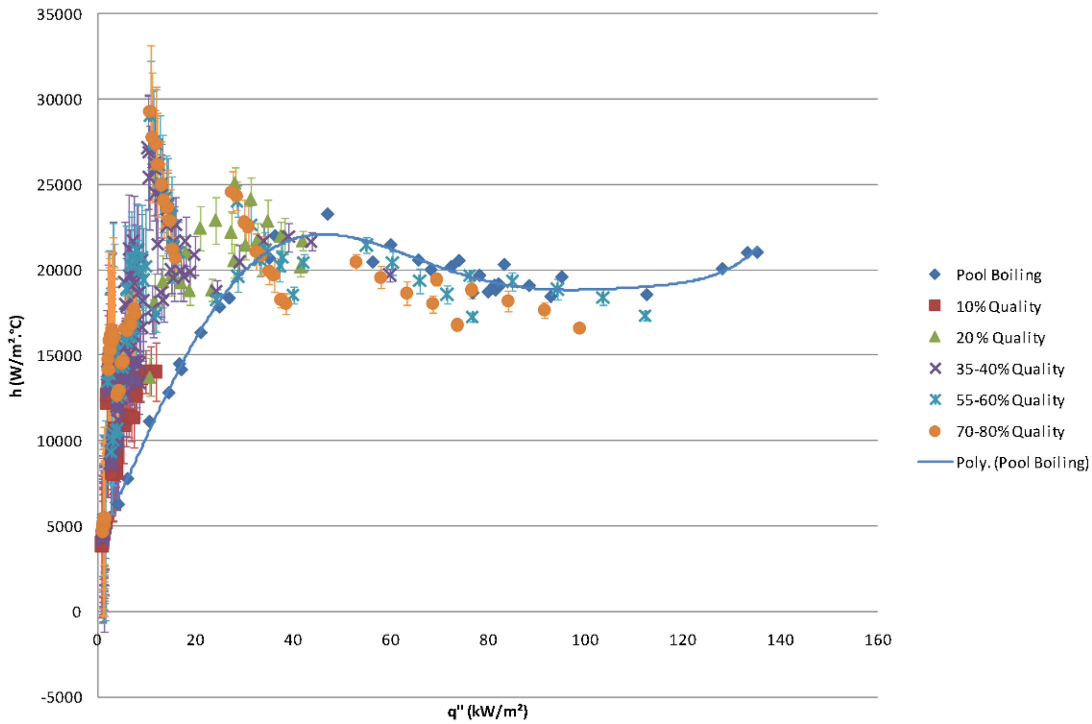

Figure 6-25 R-134a P/D 1.5 all data sorted by quality

6.4.1 Heat flux effect

Figures 6-26 through 6-28 show the change in heat transfer coefficient with heat flux for different mass fluxes and a different range of qualities. In the first plot (10-15% Quality), the heat transfer coefficient increases with the increase in heat flux with a near flat trend after. In the 35-40% Quality range, the heat transfer coefficient increases with the increase in heat flux up to 10 kW/m² and then changes to a decreasing trend, to a near flat trend at higher heat fluxes, and the same trend persists at higher quality plots. The plots overleaf show that the heat transfer coefficient is strongly dependent on heat flux.

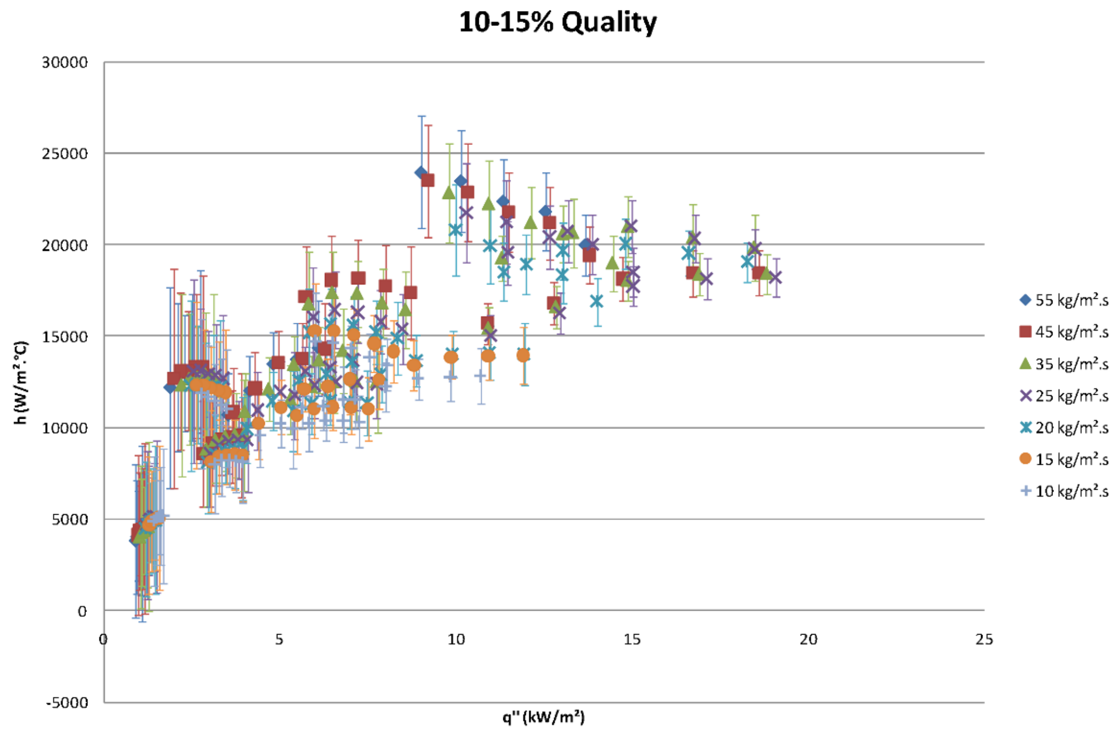

Figure 6-26 R-134a P/D 1.5 effect of heat flux at 10-15% Quality

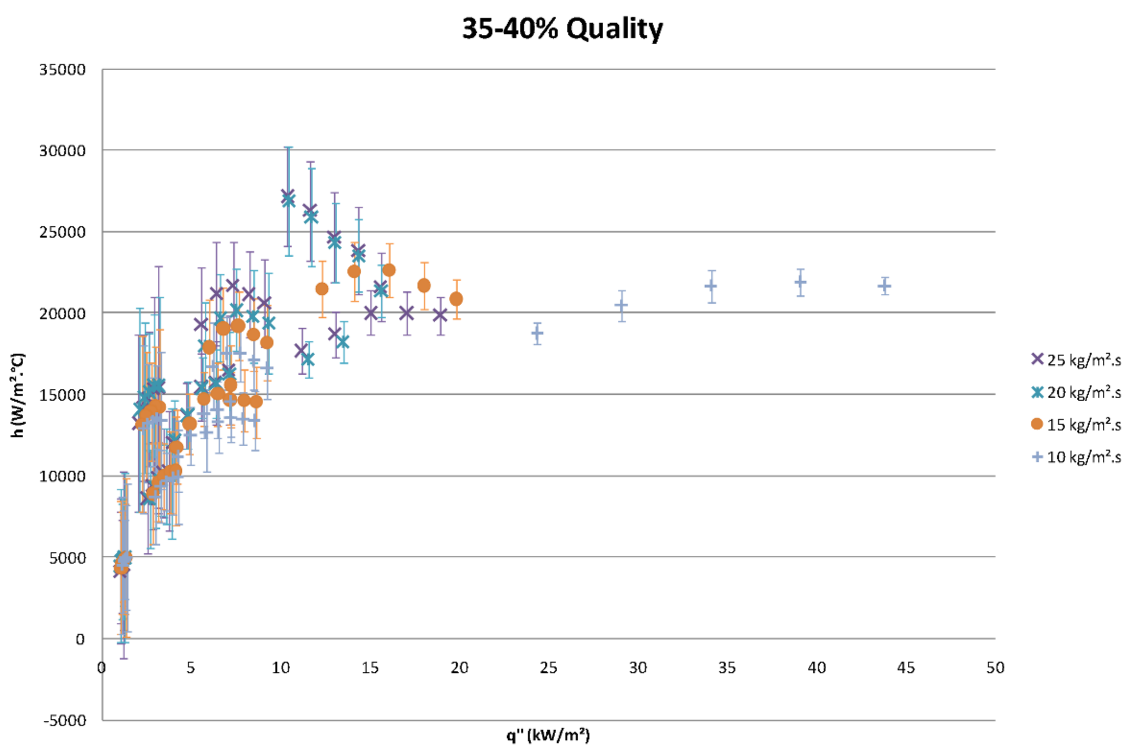

Figure 6-27 R-134a P/D 1.5 effect of heat flux at 35-40% Quality

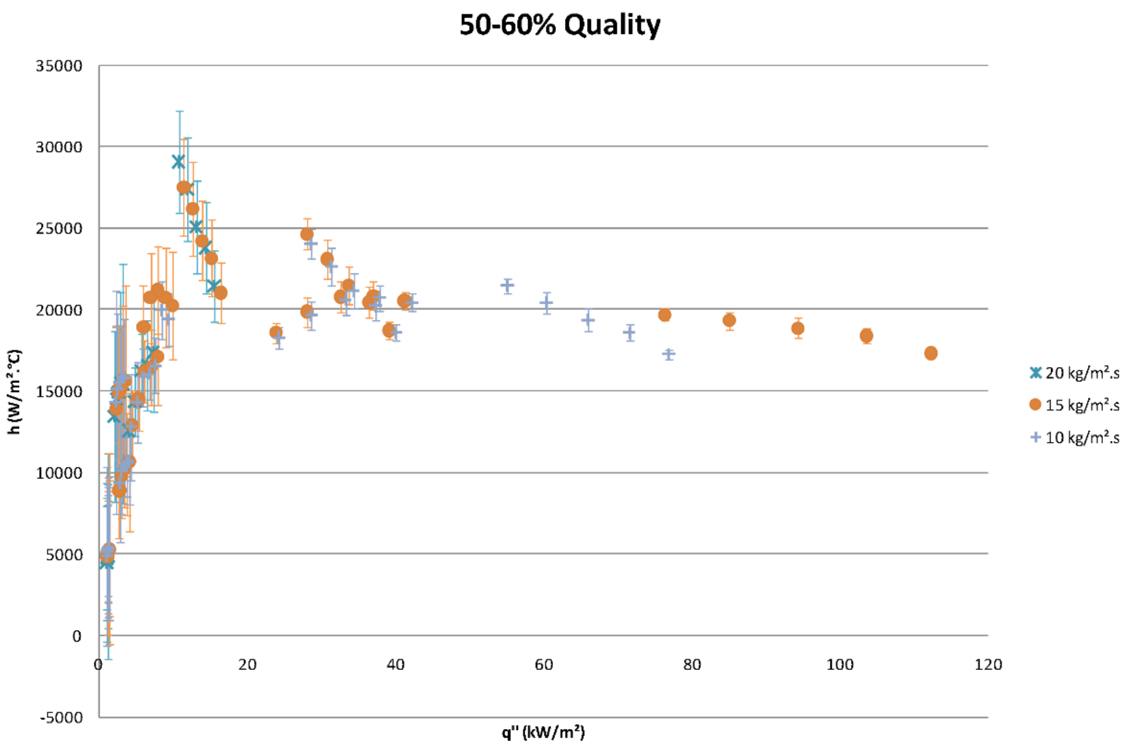

Figure 6-28 R-134a P/D 1.5 effect of heat flux at 50-60% Quality

6.4.2 Mass flux effect

Figures 6-26 through 6-28 can also help determine the effect of mass flux. In Figure 6-26 (10-15% Quality), at the same heat flux, the heat transfer coefficient slightly increases with the increase in mass flux. For the higher quality plots and taking into account the heat transfer coefficient uncertainty, hardly any change register in the heat transfer coefficient with mass flux at the same heat flux. Therefore, the mass flux does not significantly affect performance.

6.4.3 Quality effect

For the effect of quality on bundle performance, the heat transfer coefficient was plotted against quality for each mass flux point of the test matrix over a narrow range of heat flux points in Figures 6-29 through 6-35. For 4-5 and 9-15 kW/m² for 10, 15, 20, 25 and 35 kg/m².s plots (Figure 6-29 through Figure 6-32), the heat transfer coefficient shows an increasing trend with the increase in quality. For 45 and 55 kg/m².s plots (Figure 6-34 and Figure 6-35), the 9-15 kW/m² show a decreasing trend. For higher heat fluxes at 10, 15, 20, 25, and 35 kg/m².s plots (Figures 6-29 through 6-33), the heat transfer coefficient does not significantly change with quality. Finally, the heat transfer coefficient shows an increasing trend for 15-40 kW/m² for 45 kg/m².s plots.

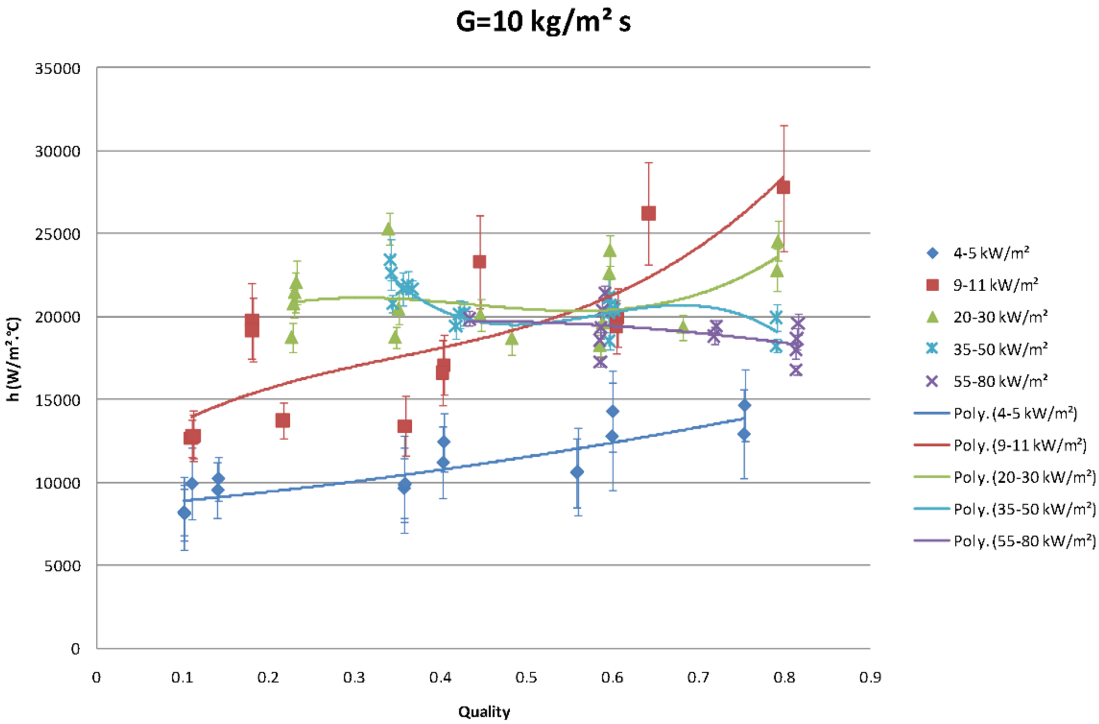

Figure 6-29 R-134a P/D 1.5 effect of quality at 10 kg/m².s

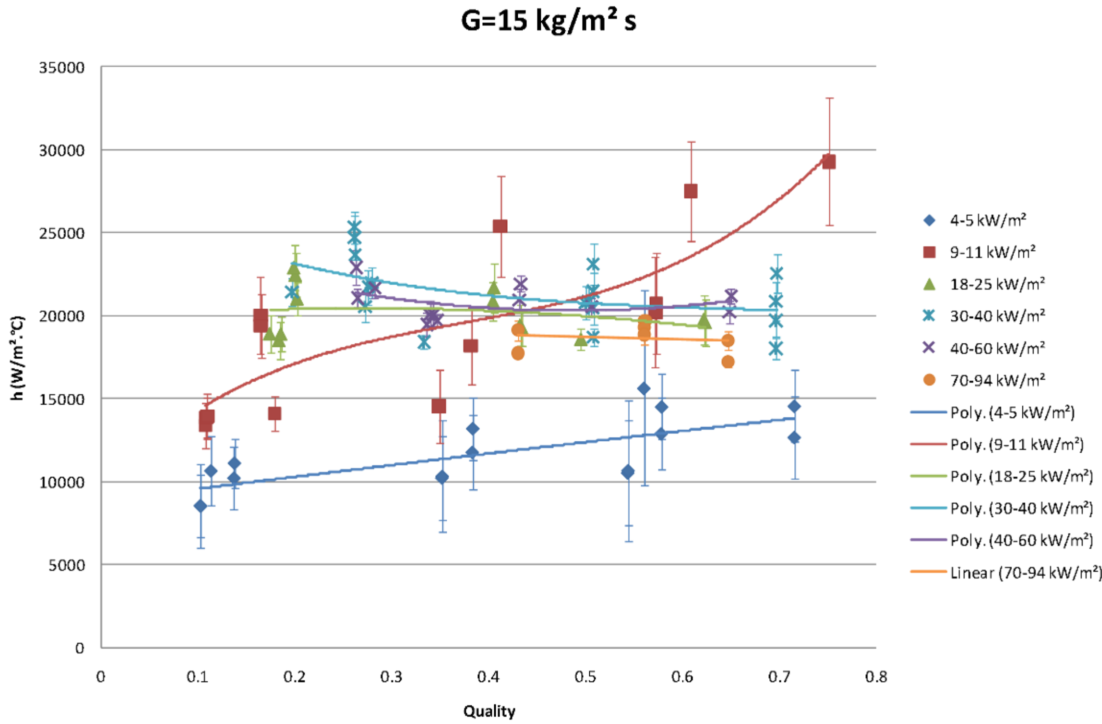

Figure 6-30 R-134a P/D 1.5 effect of quality at 15 kg/m².s

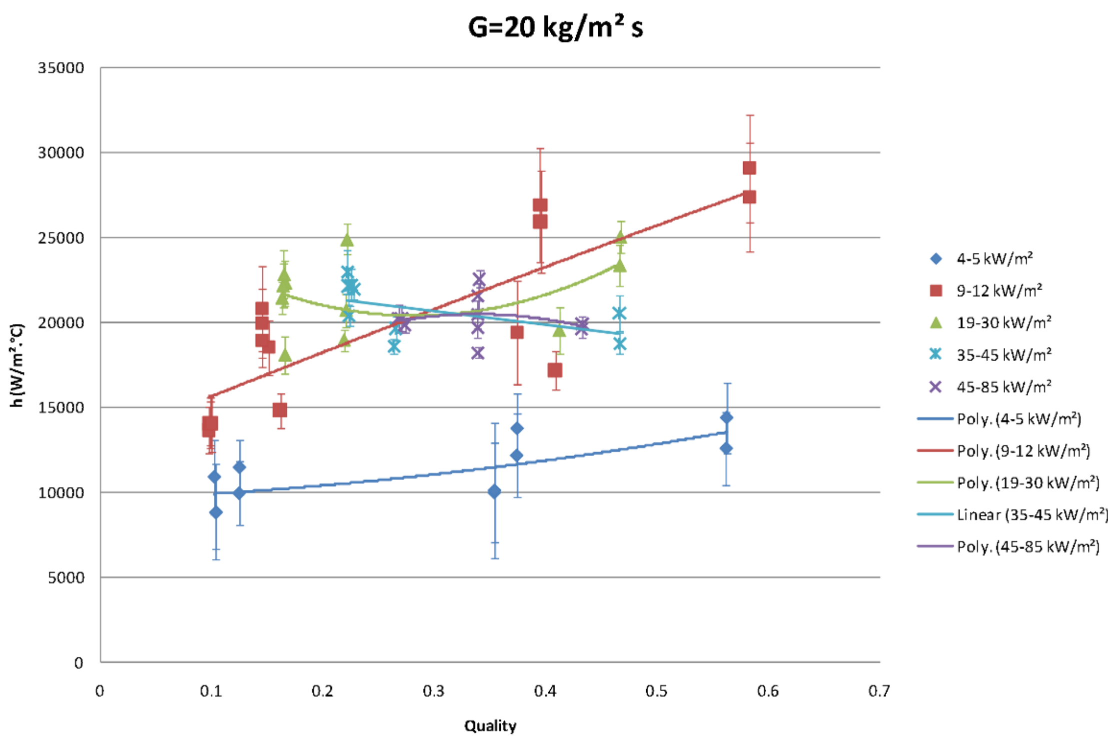

Figure 6-31 R-134a P/D 1.5 effect of quality at 20 kg/m².s

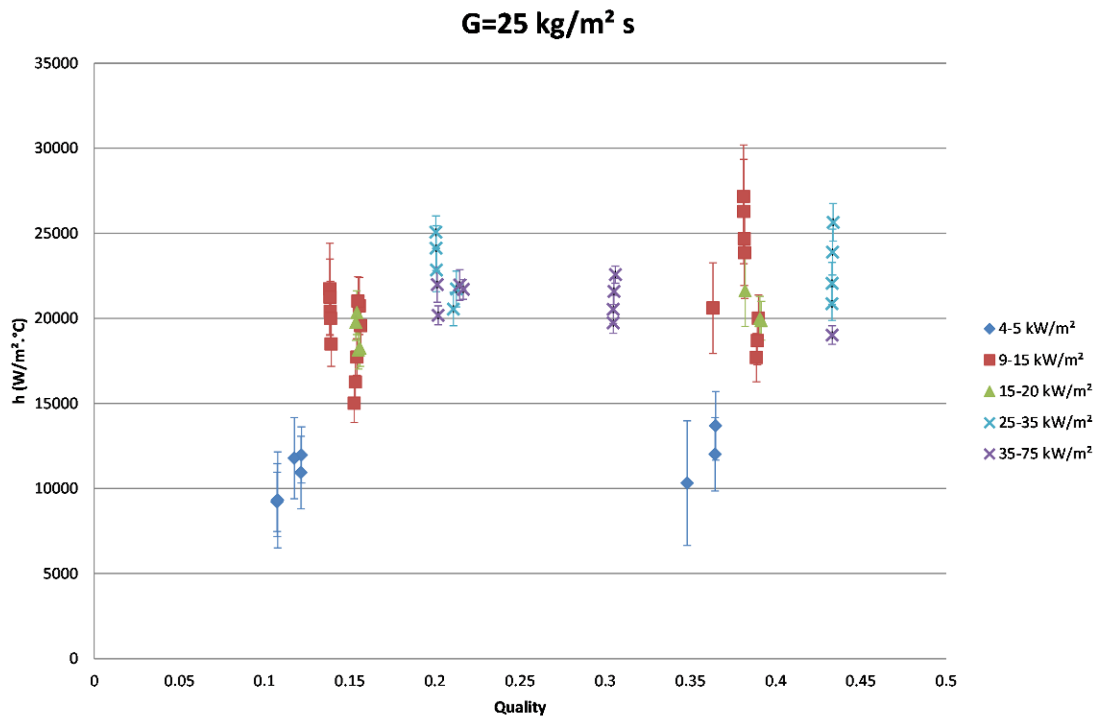

Figure 6-32 R-134a P/D 1.5 effect of quality at 25 kg/m².s

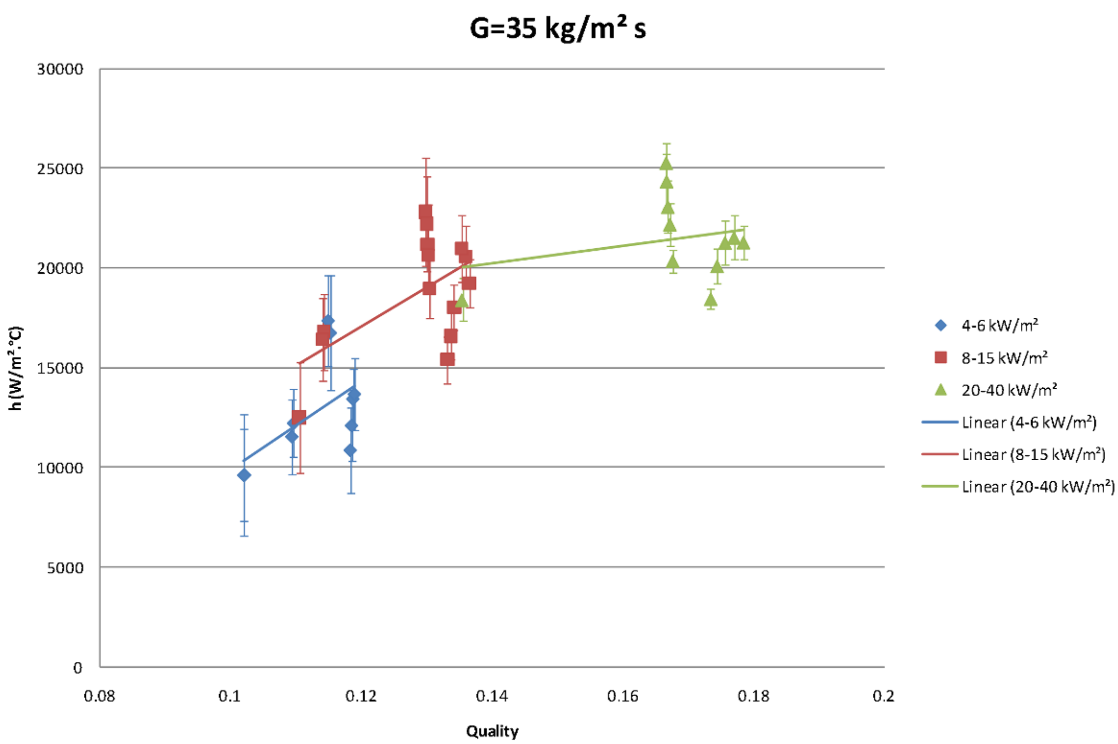

Figure 6-33 R-134a P/D 1.5 effect of quality at 35 kg/m².s

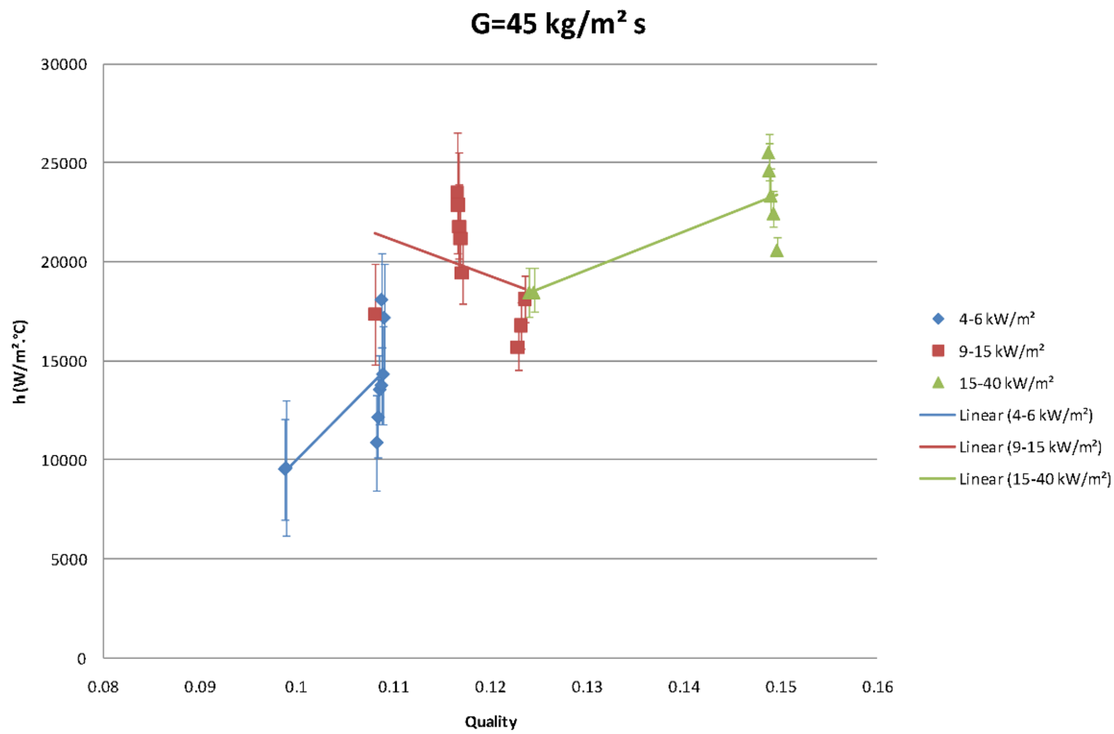

Figure 6-34 R-134a P/D 1.5 effect of quality at 45 kg/m².s

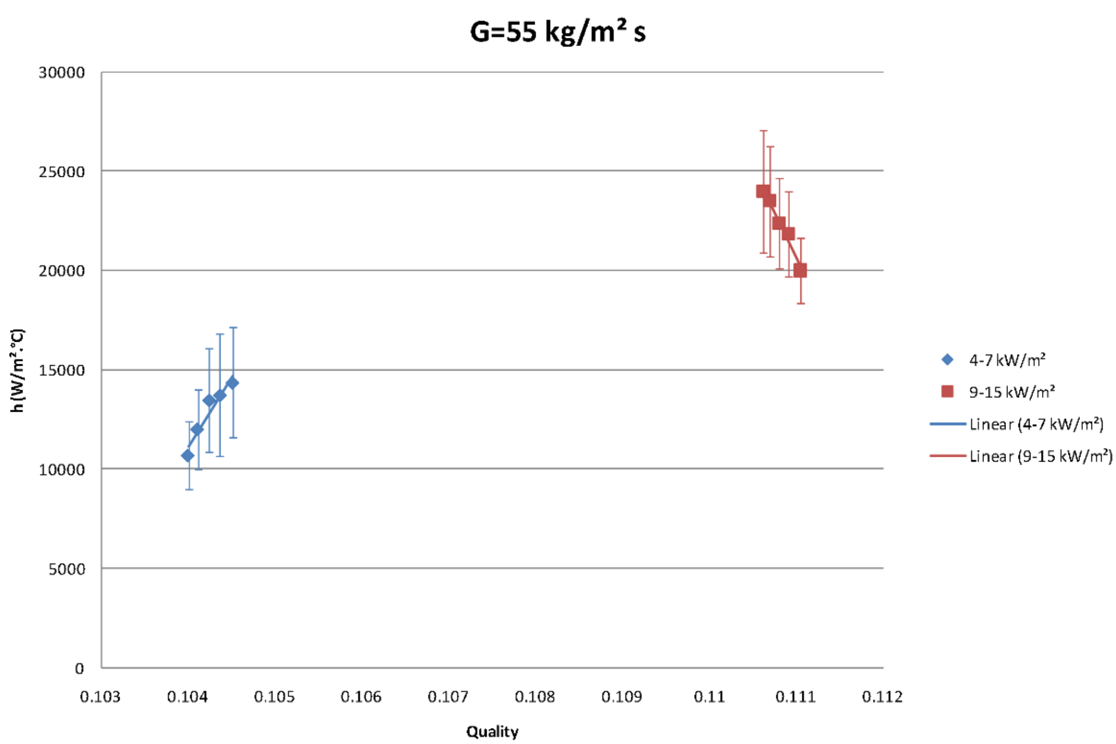

Figure 6-35 R-134a P/D 1.5 effect of quality at 55 kg/m².s

6.5 Saturation pressure change in the tube bundles

The following plots (Figures 6-36 through 6-38) show the saturation pressure change in the three tube pitches. Each plot shows the pressure change at each height in the bundle starting from the inlet. The saturation pressure (tube-average pressure) is measured at locations A4, A3, A2, and A1 (refer to Figure 3-5 in Page 23). Each plot includes the various mass flux ranges; each mass flux represents a test point with the maximum change in quality. The change in the saturation pressure is due to three components, hydrostatic pressure, dynamic pressure, and the frictional loss. The trends show that the saturation pressure change in the bundle is insignificant even for the smallest tube pitch (P/D 1.167), since the pressure change does not show a uniform trend within any of the bundles.

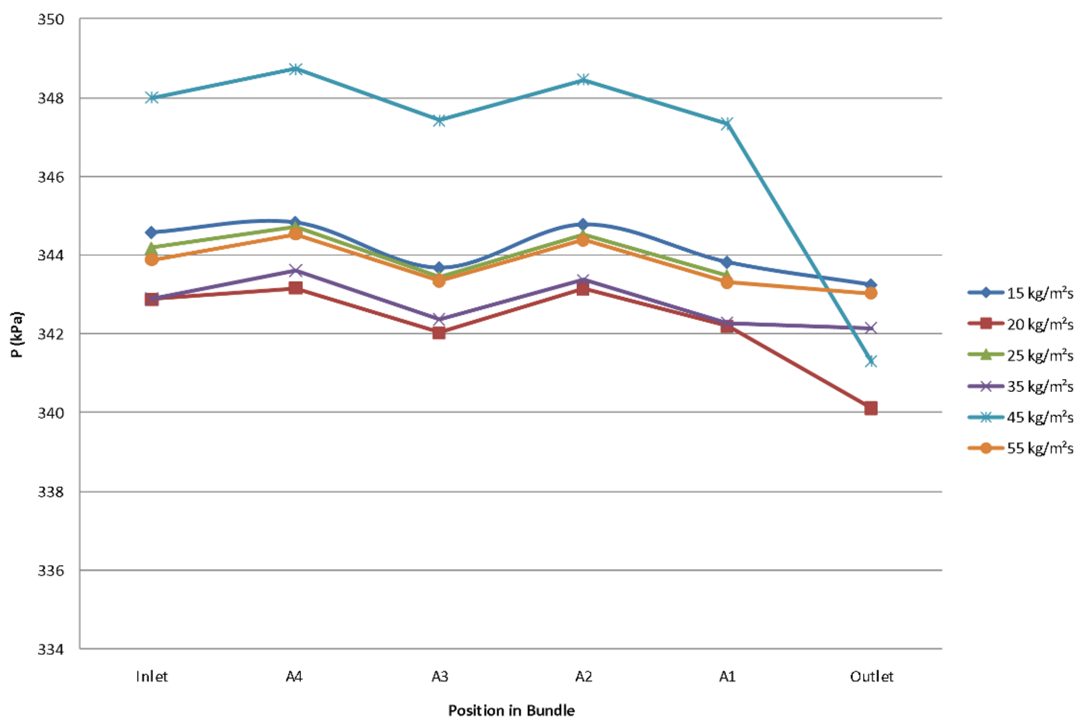

Figure 6-36 R-134a P/D 1.167 bundle saturation pressure

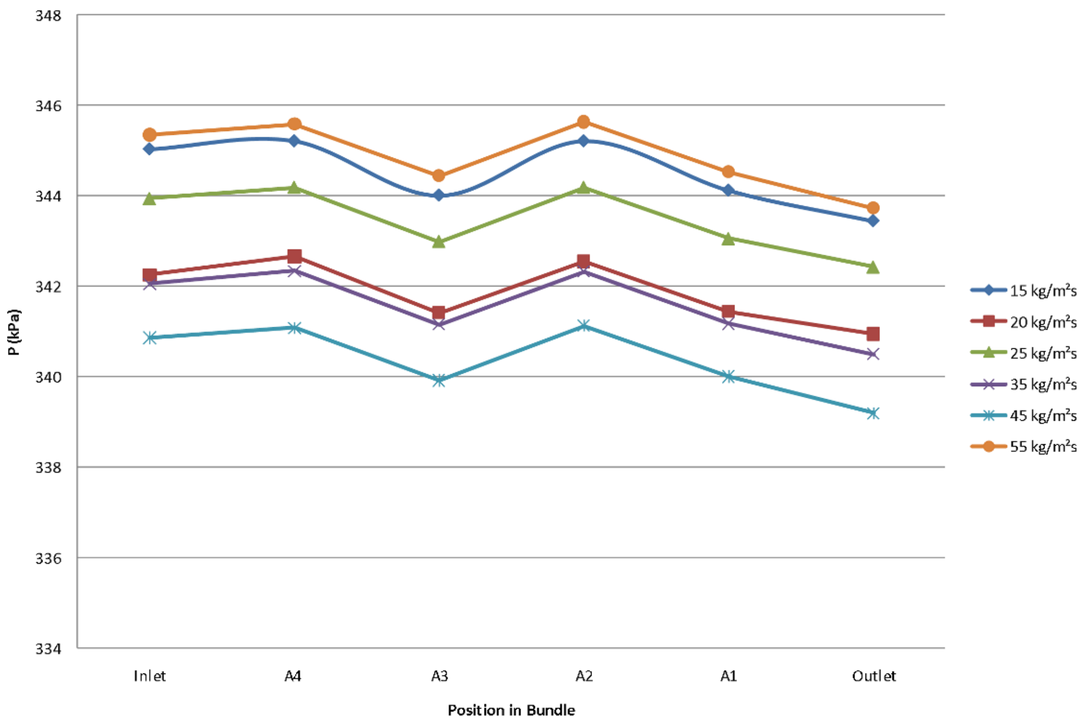

Figure 6-37 R-134a P/D 1.33 bundle saturation pressure

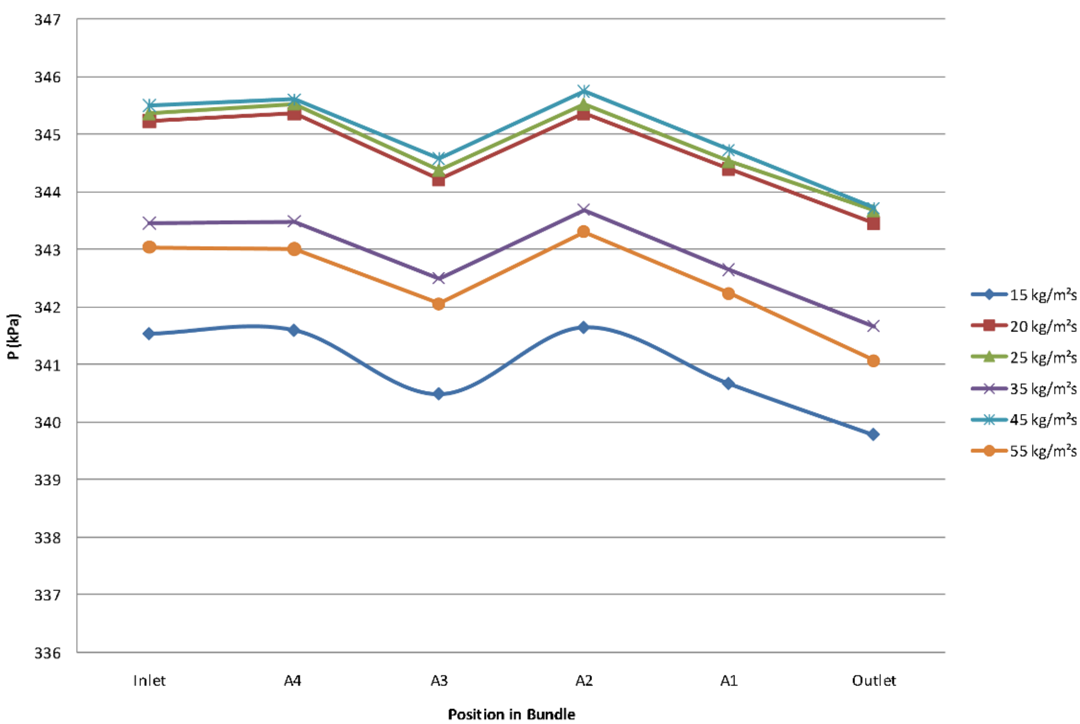

Figure 6-38 R-134a P/D 1.5 bundle saturation pressure

6.6 Heat transfer impact of varying the tube pitch

Studying the effect of heat flux, mass flux, and quality for the three tube pitches proved that the dominant variable is heat flux. That is not an unexpected conclusion since it has also been reported in open literature for enhanced tubes. Accordingly, tube pitch effect on bundle performance is conducted by comparing the heat transfer coefficient vs. heat flux plots of each bundle. Figure 6-39 below illustrates that comparison. The P/D 1.167 tube bundle shows that it has the lowest performance of the three tube pitches; its performance is significantly lower than that of the other two tube pitches and pool boiling. In fact, the heat transfer coefficient of some points is 1.5 times lower than that of the other two tube pitches. P/D 1.33 and P/D 1.5 show similar performance; nevertheless, the performance of P/D 1.5 is slightly higher than that of P/D 1.33 since it approaches pool boiling at medium and high heat fluxes.

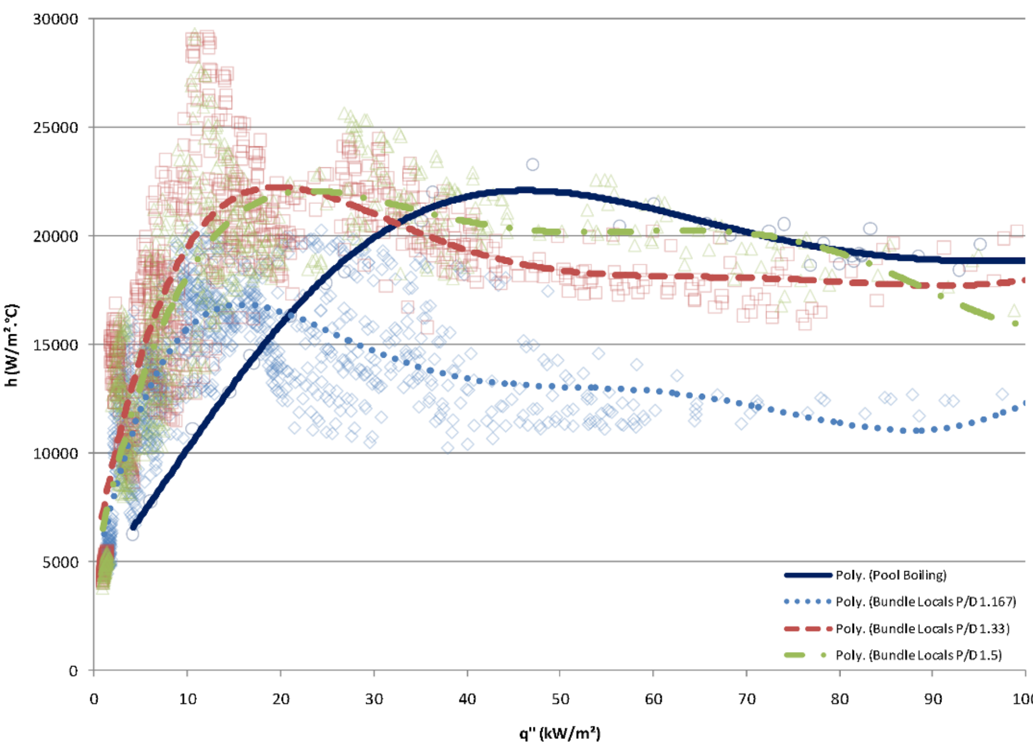

Figure 6-39 R-134a tube pitch comparison

The study compares all three tube bundles' performance based on same heat flux, same mass flux, and same flow rate. Although the same flow rate comparison is not the focus of this study, it is somewhat important to understand the effect of switching a tube bundle to a bigger tube pitch in a flooded evaporator under the same operating condition. The following comparisons were conducted: the heat transfer coefficient vs. heat flux at the same mass flux, heat transfer coefficient vs. heat flux at the same mass flow rate, heat transfer coefficient vs. quality at the same mass flux and heat flux, and heat transfer coefficient vs. quality at the same mass flow rate and heat flux. Figures 6-40 through 6-47 present those comparisons. For the heat transfer coefficient vs. heat flux comparison at 15 and 25 kg/m².s (Figure 6-40 and Figure 6-41), P/D 1.33 and P/D 1.5 show similar performance and increasing trend, but P/D 1.167 shows a fairly flat trend. For 0.35 and 0.45 kg/s (Figure 6-42 and Figure 6-43), P/D 1.33 and P/D 1.5 do not show significant change in performance, but in P/D 1.167, the heat transfer coefficient decreases with the increase in heat flux. For the heat transfer coefficient vs. quality at the same mass flux, mass flow rate, and low heat flux (Figure 6-44 through Figure 6-47), P/D 1.33 and P/D 1.5 show an increasing trend, and P/D 1.167 shows a flat trend. For the heat transfer coefficient vs. quality at the same mass flux and medium and high heat fluxes, P/D 1.33 and P/D 1.5 show a near flat trend while P/D 1.167 shows a decreasing trend. The comparison plots clearly show that the bigger tube pitch bundles revealed significantly low heat flux enhancement compared to P/D 1.167. Moreover, both P/D 1.33 and P/D 1.5 demonstrated similar results.

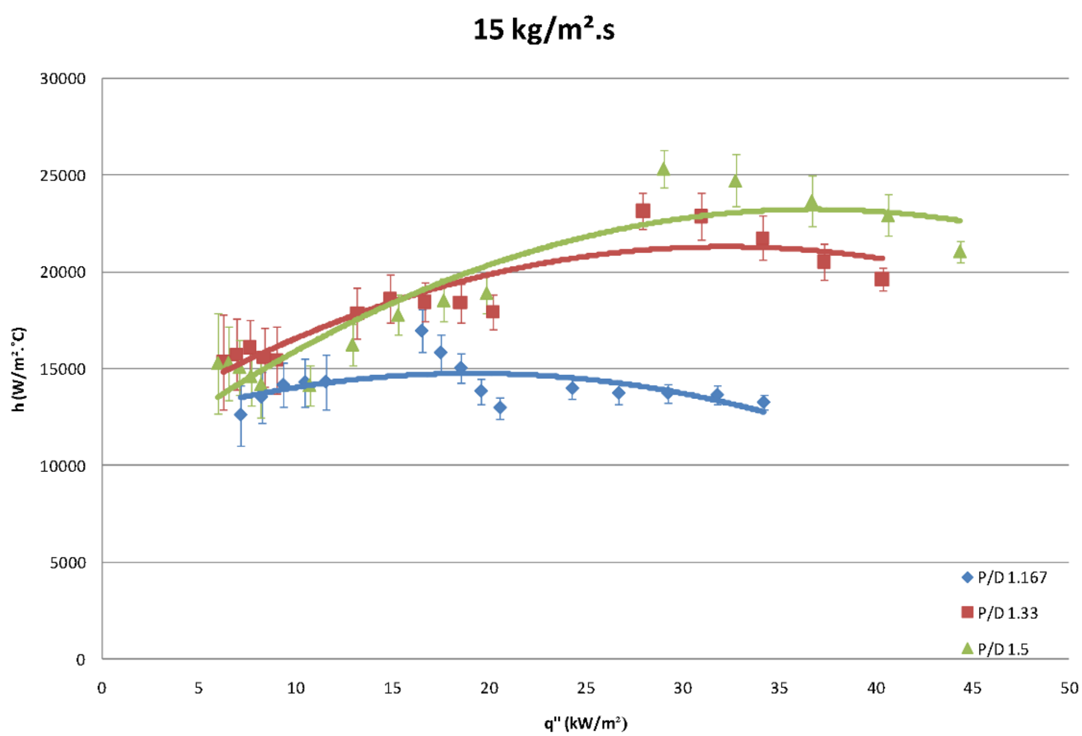

Figure 6-40 R-134a bundles comparison at 15 kg/m².s

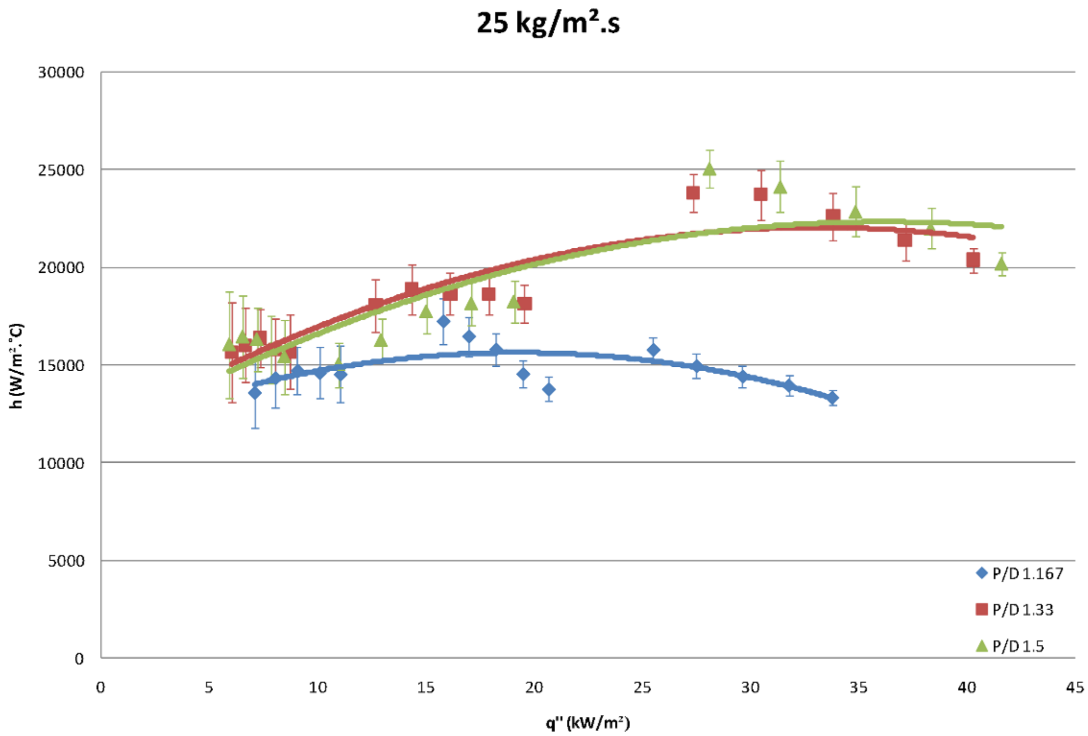

Figure 6-41 R-134a bundles comparison at 25 kg/m².s

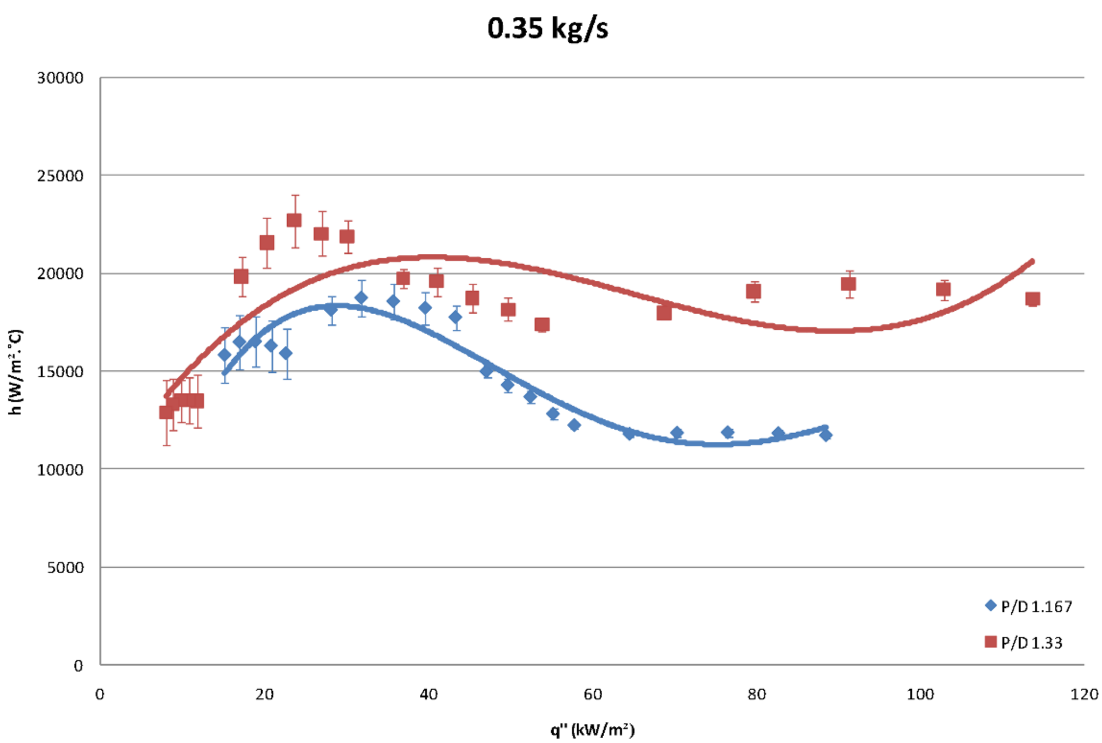

Figure 6-42 R-134a bundles comparison at 0.35 kg/s

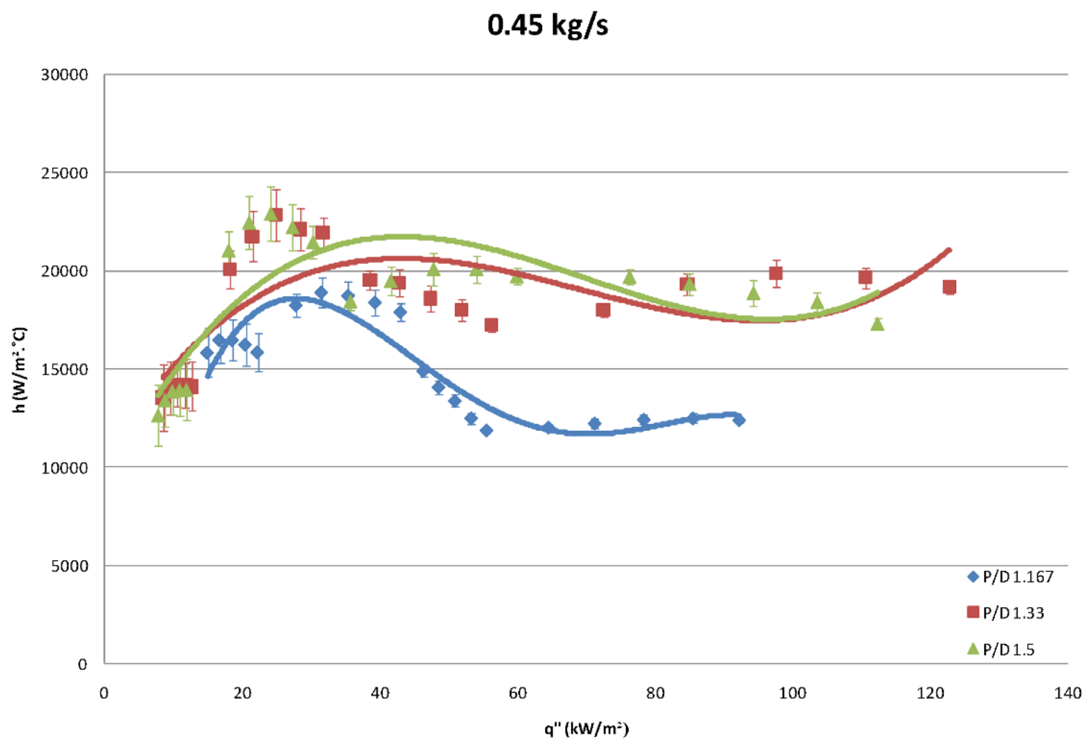

Figure 6-43 R-134a bundles comparison at 0.45 kg/s

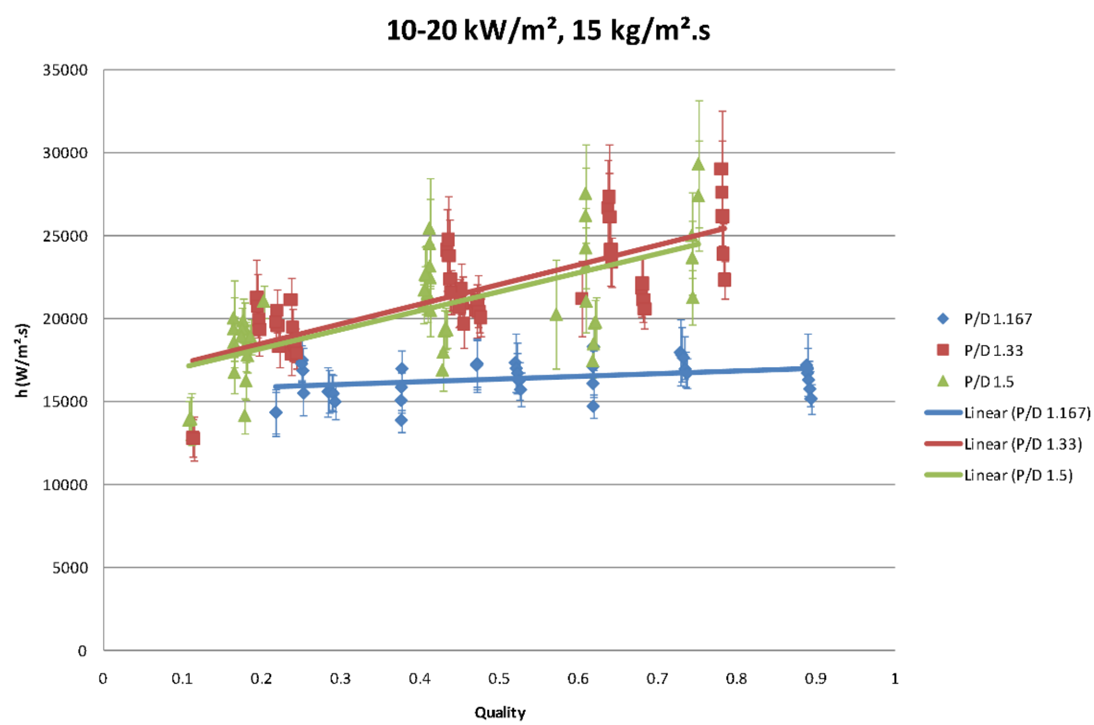

Figure 6-44 R-134a bundles comparison at 10-20 kW/m² and 15 kg/m².s

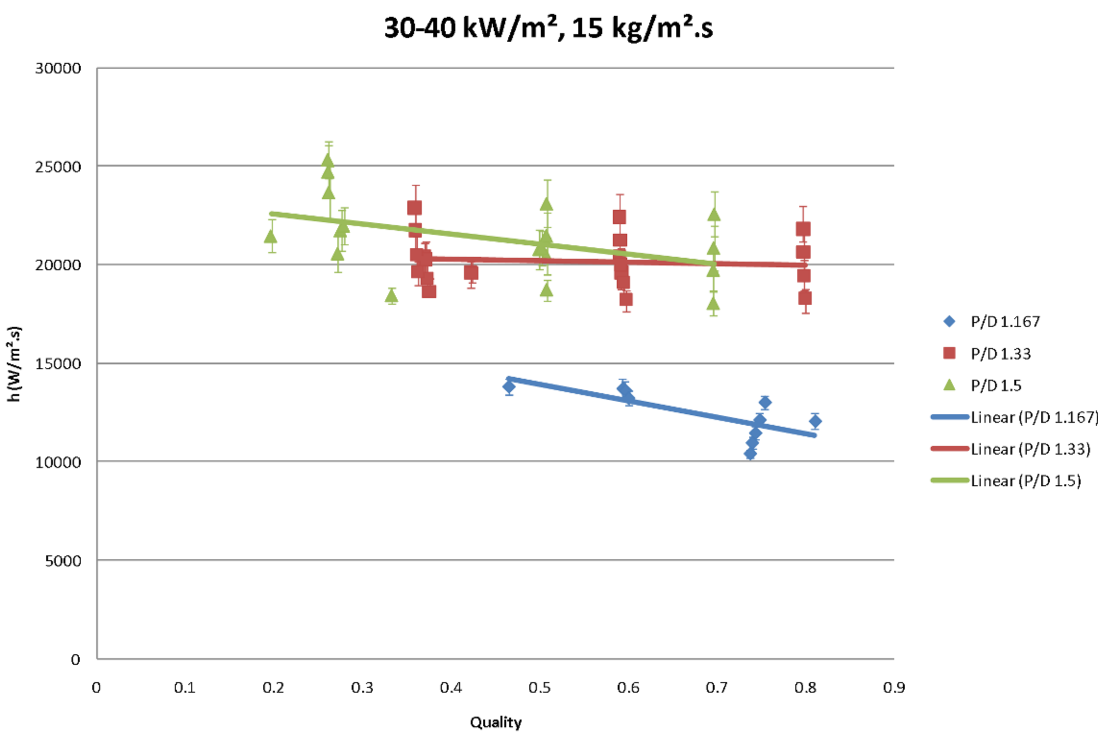

Figure 6-45 R-134a bundles comparison at 30-40 kW/m² and 15 kg/m².s

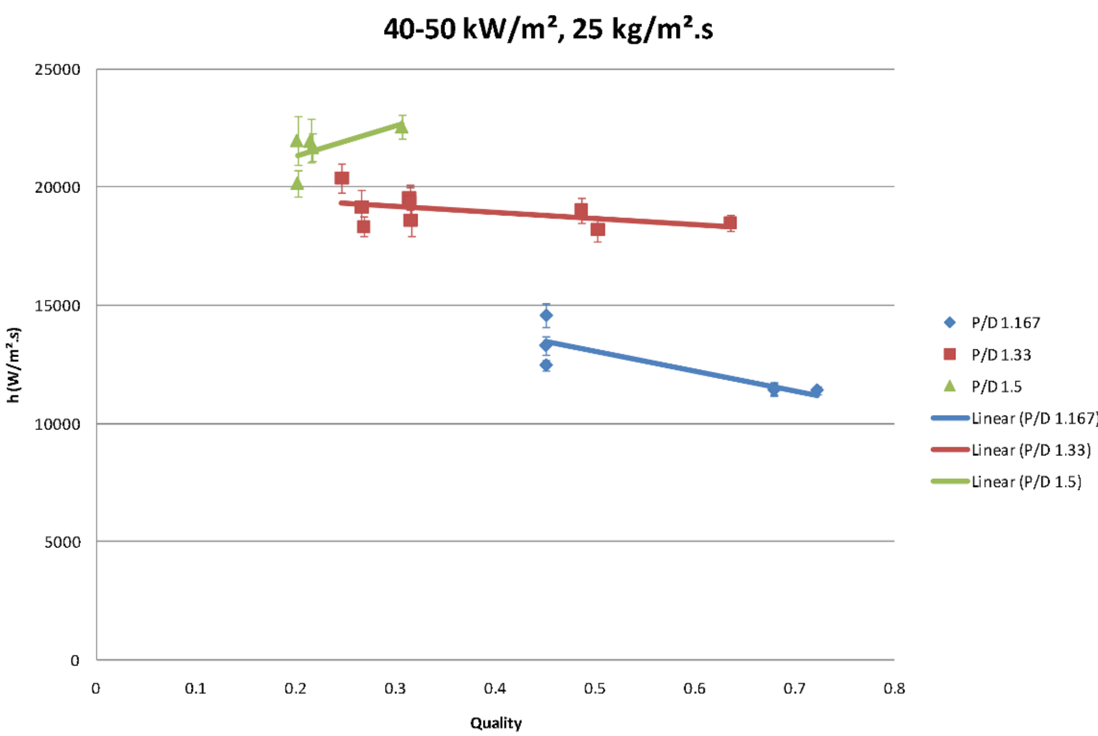

Figure 6-46 R-134a bundles comparison at 40-50 kW/m² and 25 kg/m².s

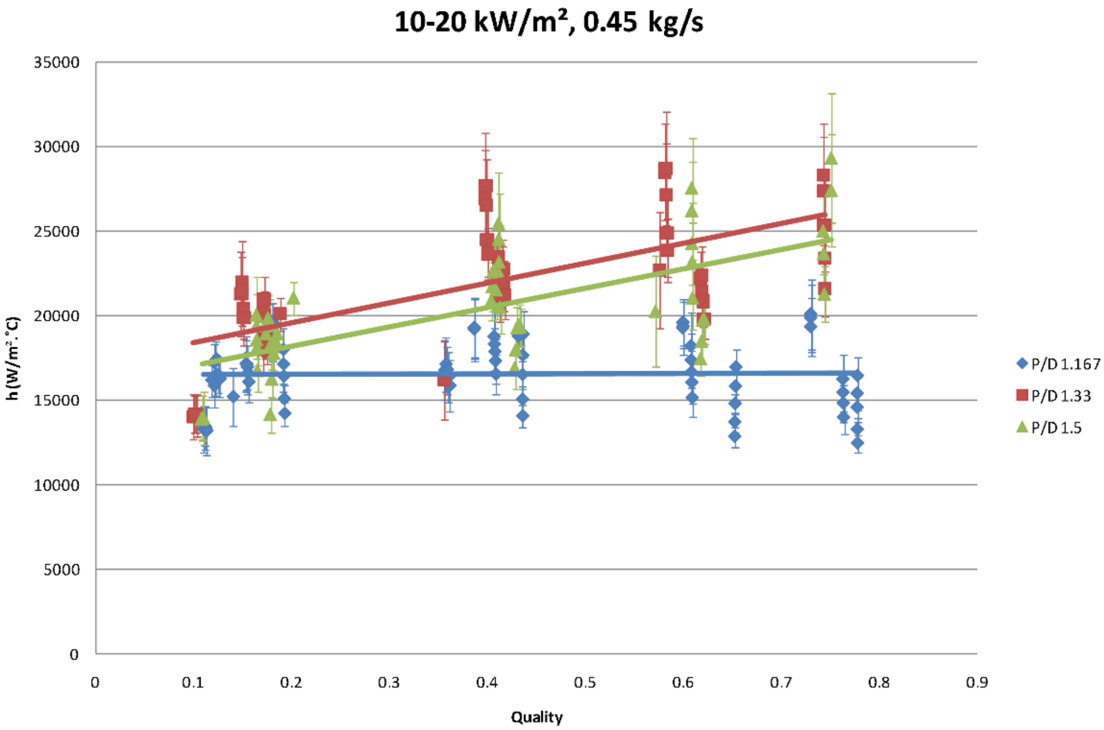

Figure 6-47 R-134a bundles comparison at 10-20 kW/m² and 0.45 kg/s

6.7 Conclusion

This chapter presented the experimental results from testing three tube pitches, P/D 1.167, P/D 1.33, and P/D 1.5 for R-134a over Turbo BII-HP enhanced tube bundles. The results of each tube bundle showed that the dominant parameter in the bundle performance is heat flux. Specifically, the heat transfer coefficient increases with the increase in quality at low heat flux. Moreover, the P/D 1.167 tube bundle showed significantly lower performance than P/D 1.33 and P/D 1.5 while the P/D 1.33 and P/D 1.5 tube bundles showed similar performance with P/D 1.5 slightly higher at medium and high heat flux. Evidently, the peak of the pool boiling curve exists in bundle boiling as well, but is shifted to the left; i.e. the curve peaks at a lower heat flux for convective boiling. All tube bundles experience "the low heat flux enhancement" at the same heat flux. Since P/D 1.33 and P/D 1.5 have the same low heat flux enhancement, predictably, increasing the tube pitch beyond P/D 1.33 will not increase low heat flux enhancement. Also, as tube pitch increases, the medium and high heat flux region approaches that for the single tube performance.

Chapter 7 Effect of Tube Pitch for R-123

7.1 Introduction

Most of the testing was performed at a saturation temperature of 14.44 °C. Originally, the desired saturation temperature was 4.44 °C as is the case for R-134a tests, but the current test facility's configuration has a limited range of high heat fluxes and mass fluxes at 4.44 °C for the low pressure refrigerant. The low pressure nature of R-123 increases the vapor volume considerably at low temperatures; thus, it is harder for the system's condenser to accommodate high mass velocity and vapor volume. Since the specific volume of R-123 at 4.44 °C is 1.5 times the specific volume at 14.44 °C, and to construct the proposed test matrix, data were primarily collected at 14.44 °C; moreover, data taken at 4.44 °C were limited to low heat flux and mass flux. No significant difference between the two saturation temperatures was noticed for any of the three tube bundles, which is also clear in the results plots.

The enhanced tube used with R-123 is the Turbo BII-LP, and the following subsections explain the results of testing each tube bundle. Each bundle's results are presented with related conclusions, and the results are presented as plots of the effect of heat flux, mass flux, and quality. Following the results of the third bundle, the study compares the three bundles and concludes as to the effect of tube pitch on bundle performance.

7.2 P/D 1.167 results

Data were collected according to the proposed test matrix of the P/D 1.167 tube bundle based on a total of 23 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes and, local qualities, thus, 460 data points total as shown in Figure 7-1 over. Data is also compared to that of the single tube pool boiling of the Turbo BII-LP tube. At low heat flux range (minimum heat flux to 30 kW/m^2), all points show enhanced performance due to convective boiling. Moreover, as heat flux increases, bundle performance becomes lower than that of the single tube performance, with some points experiencing a sharp decline. Figure 7-2 compares the two saturation temperatures, showing no significant difference.

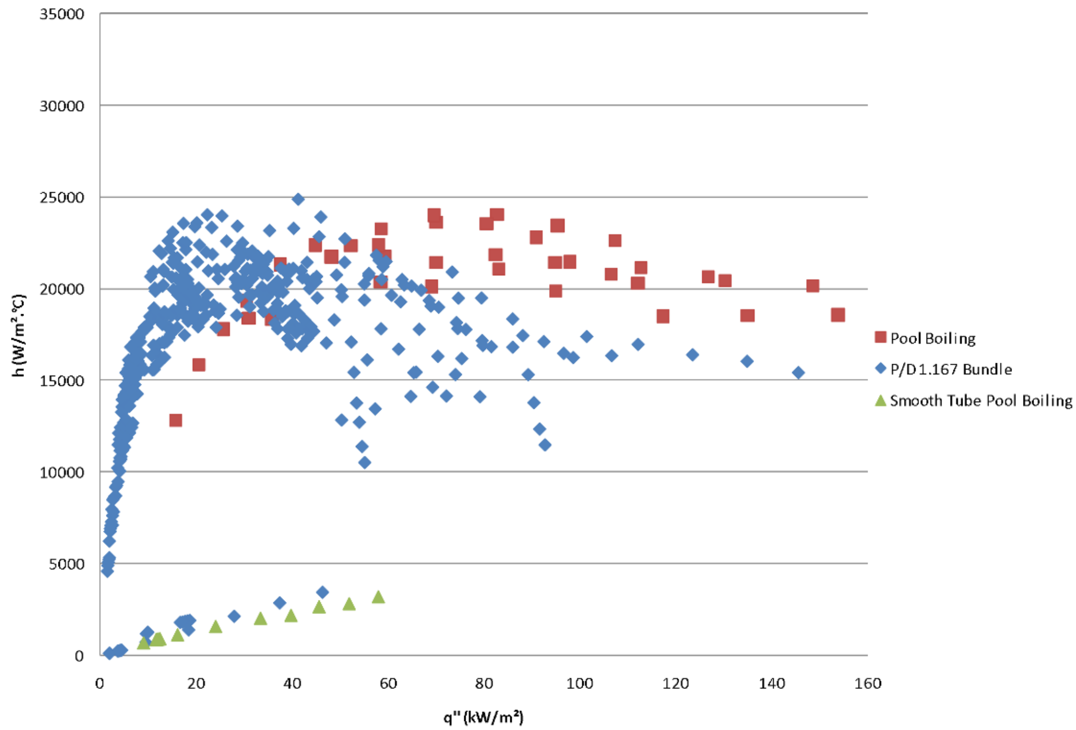

Figure 7-1 R-123 P/D 1.167 all data

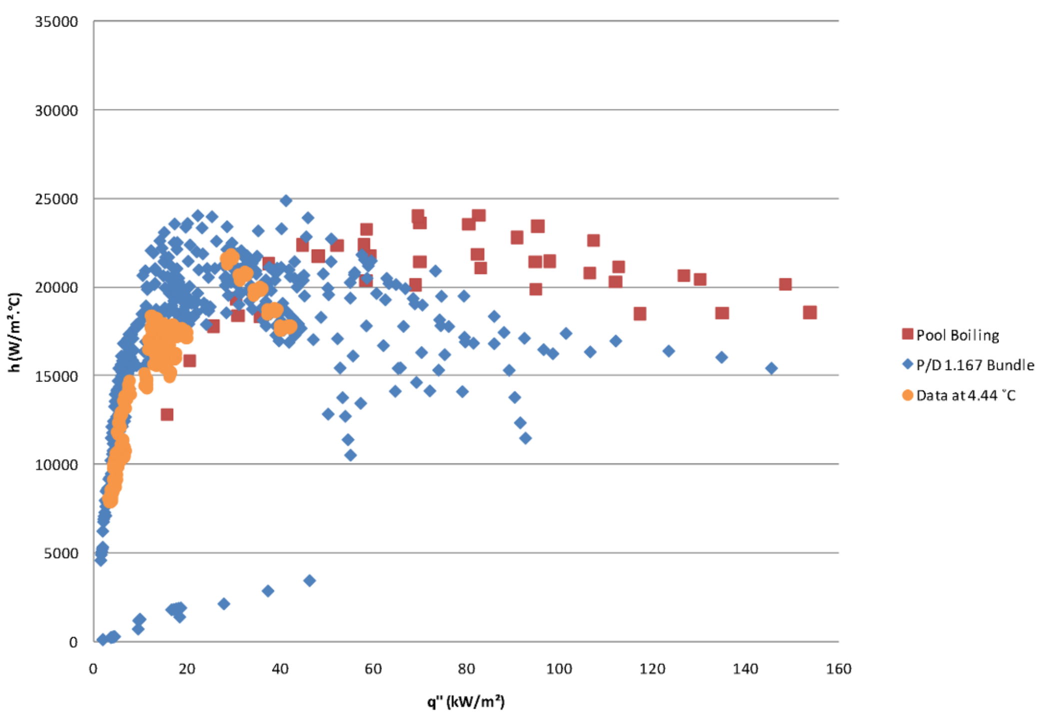

Figure 7-2 R-123 P/D 1.167 saturation temperature comparison

The data presented on the previous page were sorted by quality as shown in Figure 7-3. At low heat flux, all qualities show enhanced performance compared to that of the single tube, while at 50% Quality and beyond, performance declines and deteriorates; meanwhile, all the points above 30 kW/m² show a decreasing trend with increase in heat flux.

The points for 50-80% Quality at the bottom of the curve show performance similar to that of a smooth tube (see also Figure 7-1); their heat transfer coefficient is much lower than that of other points that share the same heat flux and quality. Those points are located at the top of the bundle, suggesting that this effect is due to flow pattern (spray flow). Also, this phenomenon occurs at high wall superheat $\left(T_{wall} - T_{sat}\right)$ and high bundle-average heat flux, so as the bundle average heat flux increases, the top of the tube bundle (water inlet) experiences tube enhancement dry-out at which point the water temperature difference becomes small; hence the low local heat flux of those points. This phenomenon was also observed by Arshad and Thome (1983).

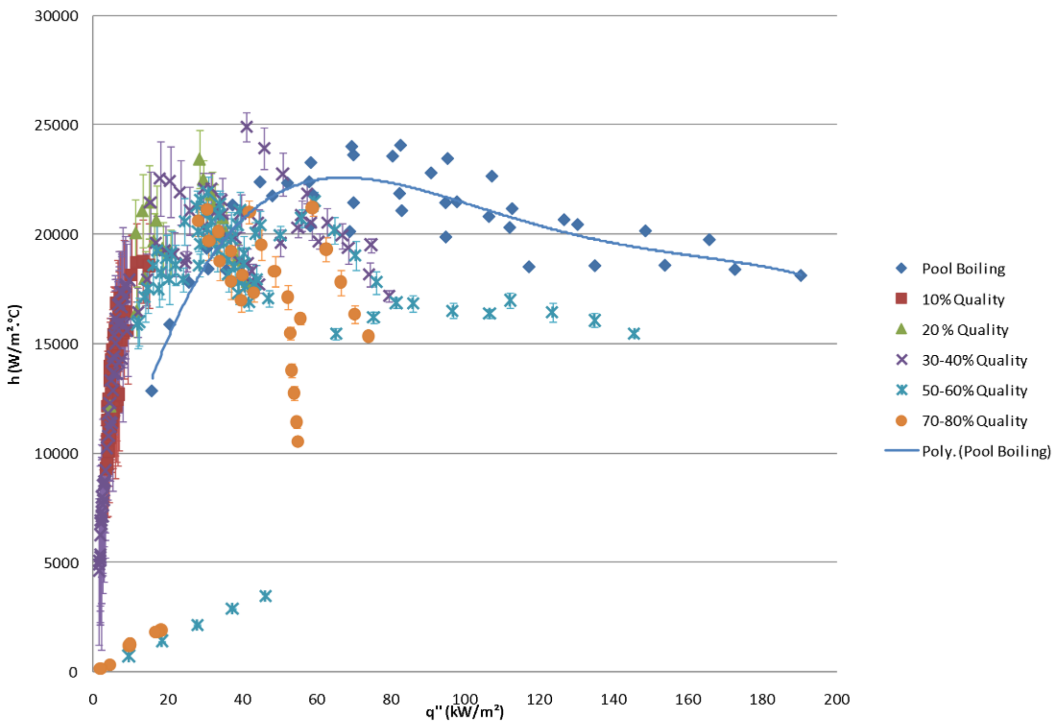

Figure 7-3 R-123 P/D 1.167 all data sorted by quality

7.2.1 Heat flux effect

Figures 7-4 through 7-7 show the change in the heat transfer coefficient with heat flux for different mass fluxes and different ranges of quality. In the first plot (10-15% Quality), the heat transfer coefficient increases with the increase in heat flux up to 25 kW/m² and then changes to a decreasing trend. The same trend persists for the 30-40% and 50-60% Quality plots (Figure 7-5 and Figure 7-6). Additionally, the performance of some points drops to that of a smooth tube for the 50-60% and 70-80% Quality plots.

These plots show that the heat transfer coefficient is dependent on heat flux, average bundle heat flux, and flow pattern. The dependency on flow pattern can be interpreted from Figure 7-6 and Figure 7-7 for 35 and 45 kg/m².s mass flux points, which show that for the same heat flux, two different values for the heat transfer coefficient exist. According to Collier and Thome (1996), flow pattern from bottom to top is described as single phase liquid, bubbly flow, bubble jet flow, chugging flow, and spray flow. At the top of the bundle and at high bundle-average heat flux, the flow pattern is likely to be spray flow, which can cause enhancement dry-out. This phenomenon is explained at length in the next chapter.

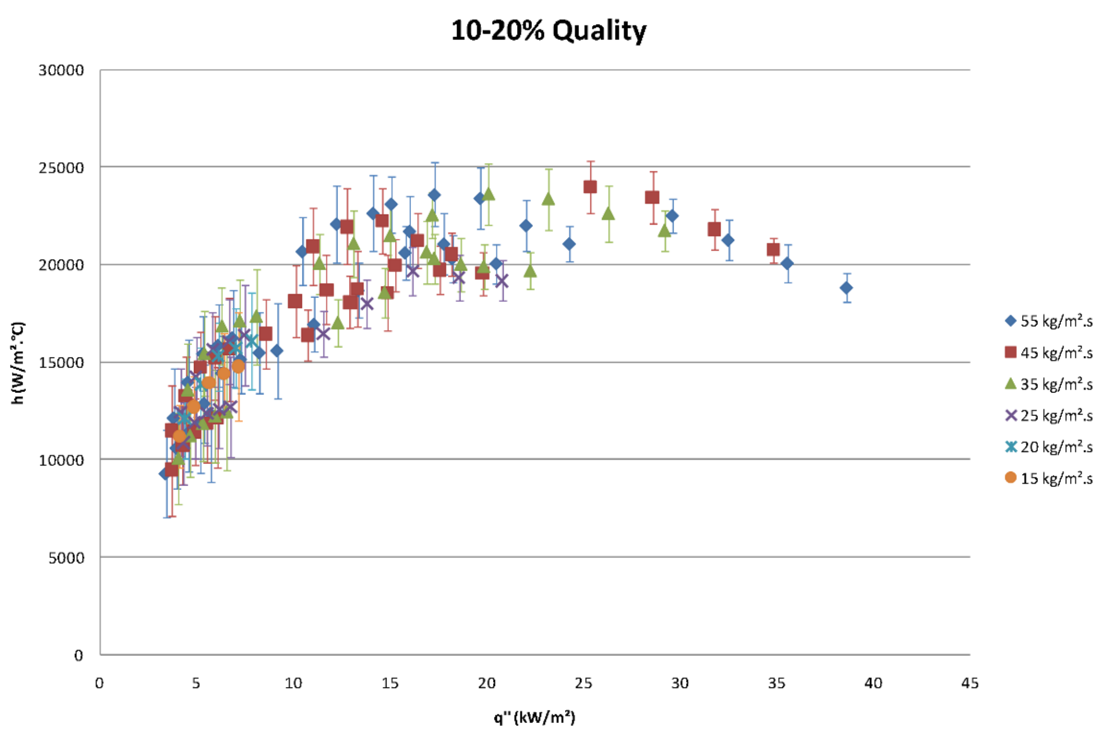

Figure 7-4 R-123 P/D 1.167 effect of heat flux at 10-20% Quality

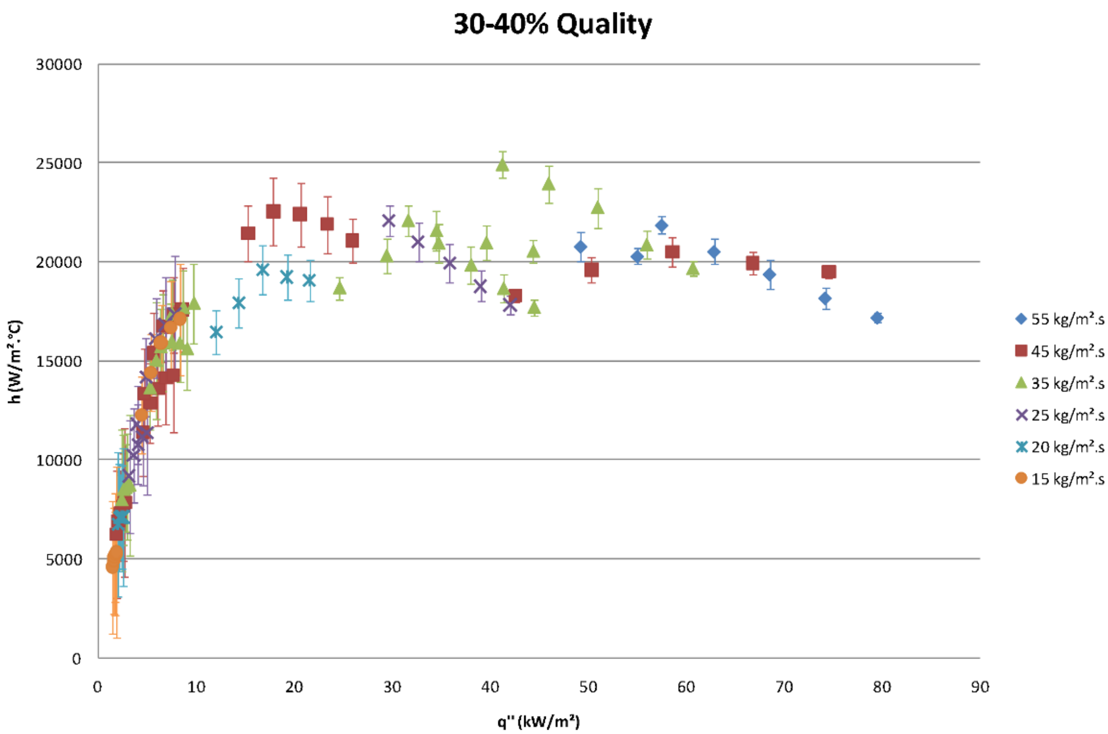

Figure 7-5 R-123 P/D 1.167 effect of heat flux at 30-40% Quality

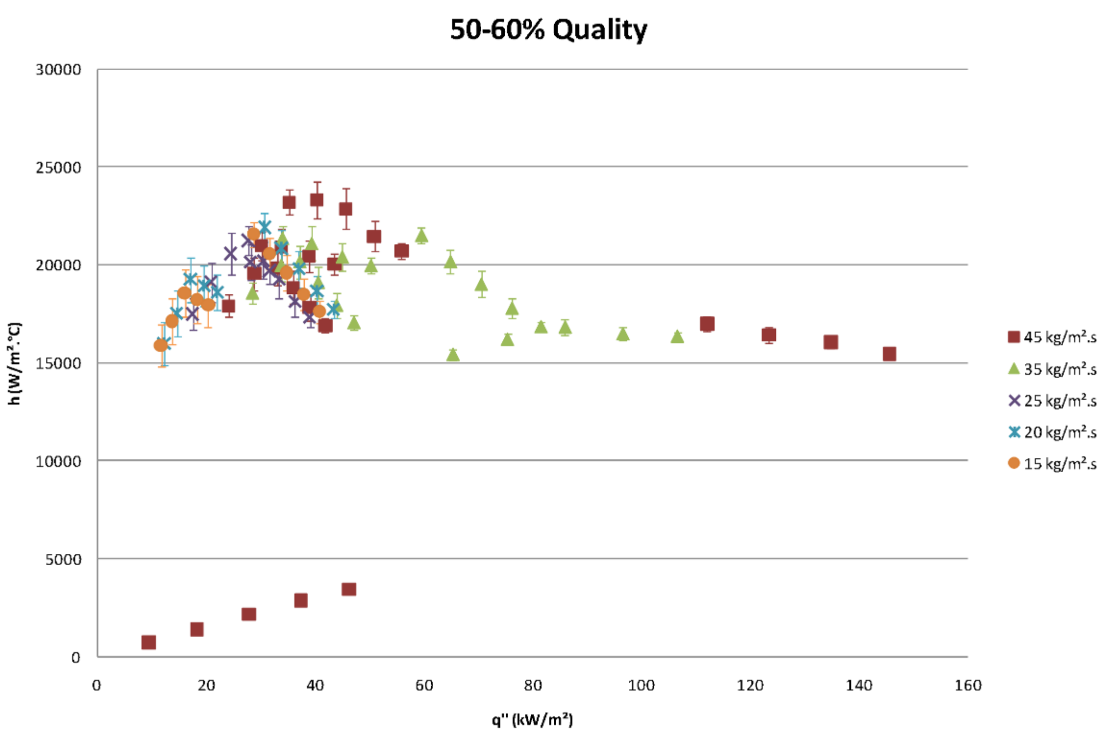

Figure 7-6 R-123 P/D 1.167 effect of heat flux at 50-60% Quality

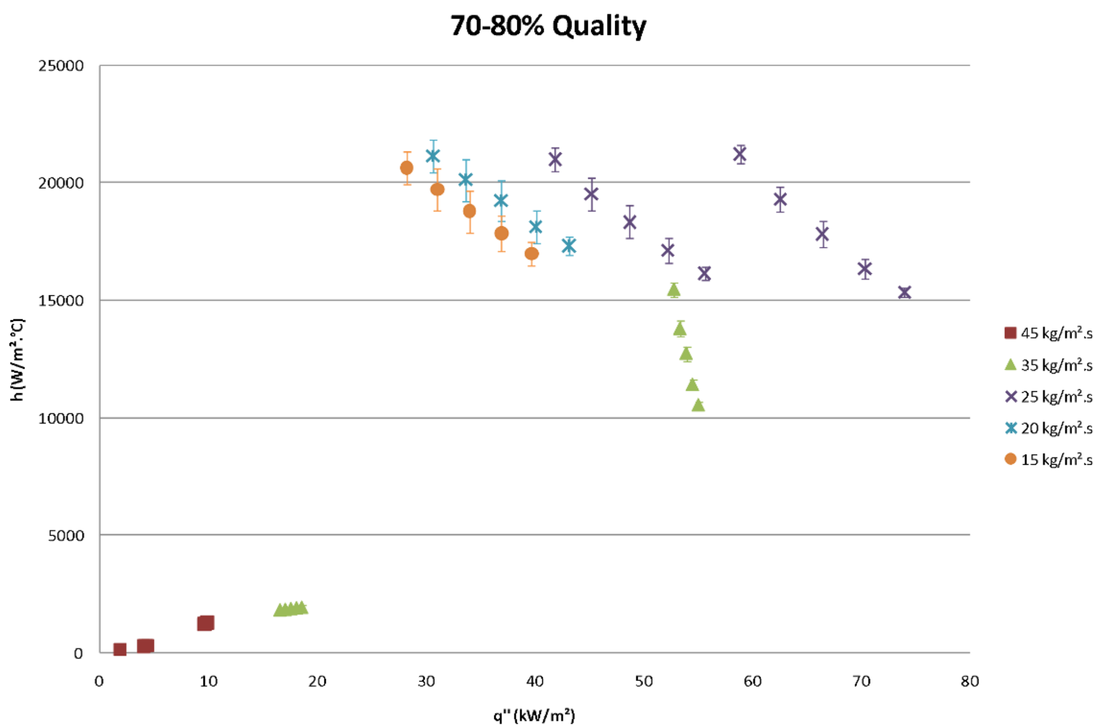

Figure 7-7 R-123 P/D 1.167 effect of heat flux at 70-80% Quality

7.2.2 Mass flux effect

The mass flux effect can also be interpreted from the previous set of plots. In Figure 7-4 (10-15% Quality), at the same heat flux, the heat transfer coefficient slightly increases with the increase in mass flux. For the higher quality plots, except 70-80% Quality, and taking into account the heat transfer coefficient uncertainty, hardly any change in the heat transfer coefficient registers for mass flux at the same heat flux. However, some points on Figure 7-7 show that mass flux has an effect on the heat transfer coefficient at high qualities, for as the mass flux increases, the heat transfer coefficient drops quickly.

7.2.3 Quality effect

The following plots (Figures 7-8 through 7-13) present the heat transfer coefficient vs. quality for each mass flux point of the test matrix over a narrow range of heat flux points. For 15, 20 and 25 kg/m².s mass fluxes for all heat flux ranges, the heat transfer coefficient doesn't significantly change with the increase in quality, whereas for higher mass fluxes, the heat transfer coefficient experiences a sharp decrease at 50% quality and higher. Therefore, the heat transfer coefficient shows a strong dependency on quality at high mass fluxes (the curve fits in the plots below are just to help the reader interpret the trend of the points). Figure 7-12 demonstrates that the heat transfer coefficient shows a slight increase with quality up to 50%, then sharply declines at higher qualities.

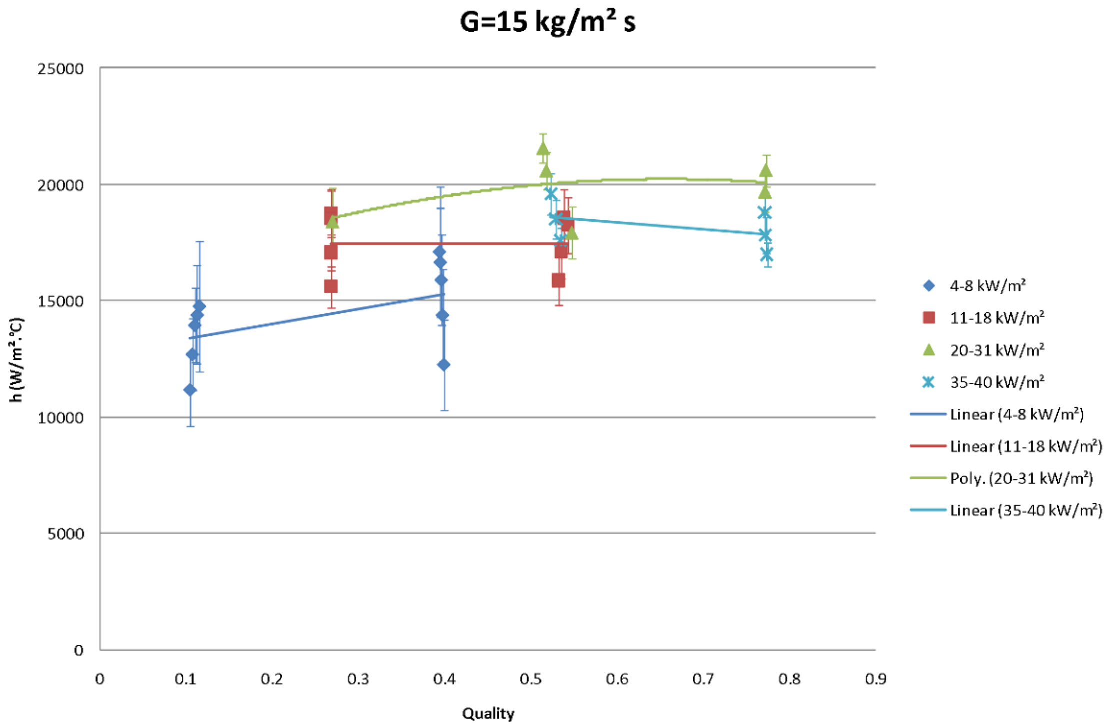

Figure 7-8 R-123 P/D 1.167 effect of quality at 15 kg/m².s

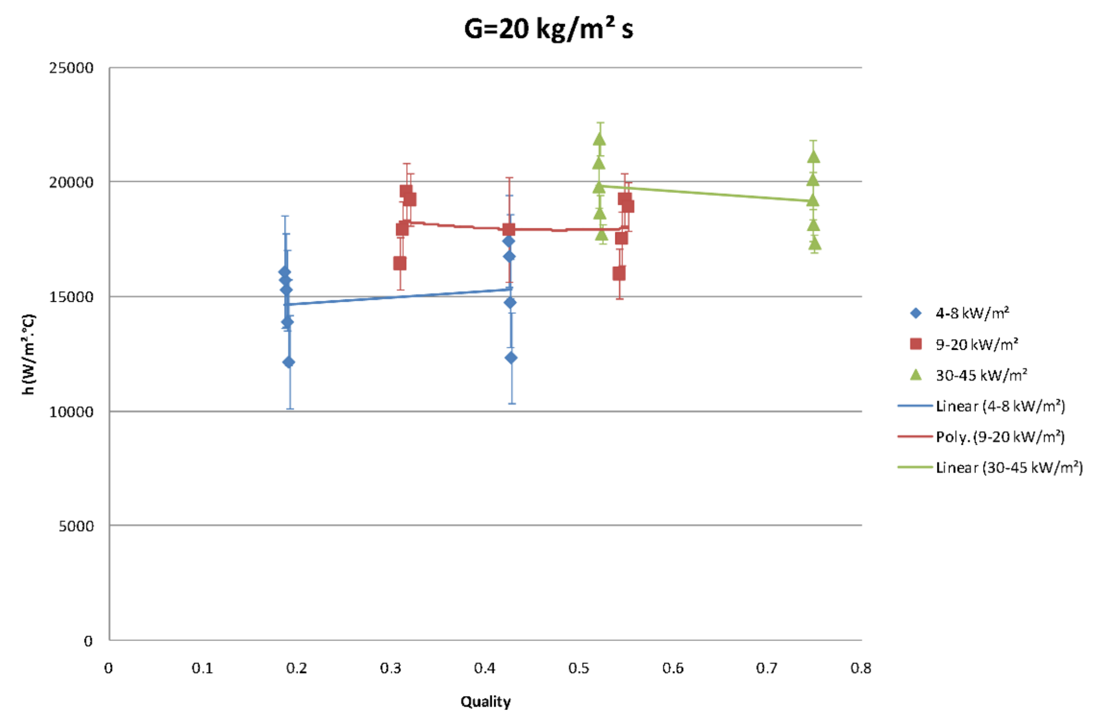

Figure 7-9 R-123 P/D 1.167 effect of quality at 20 kg/m².s

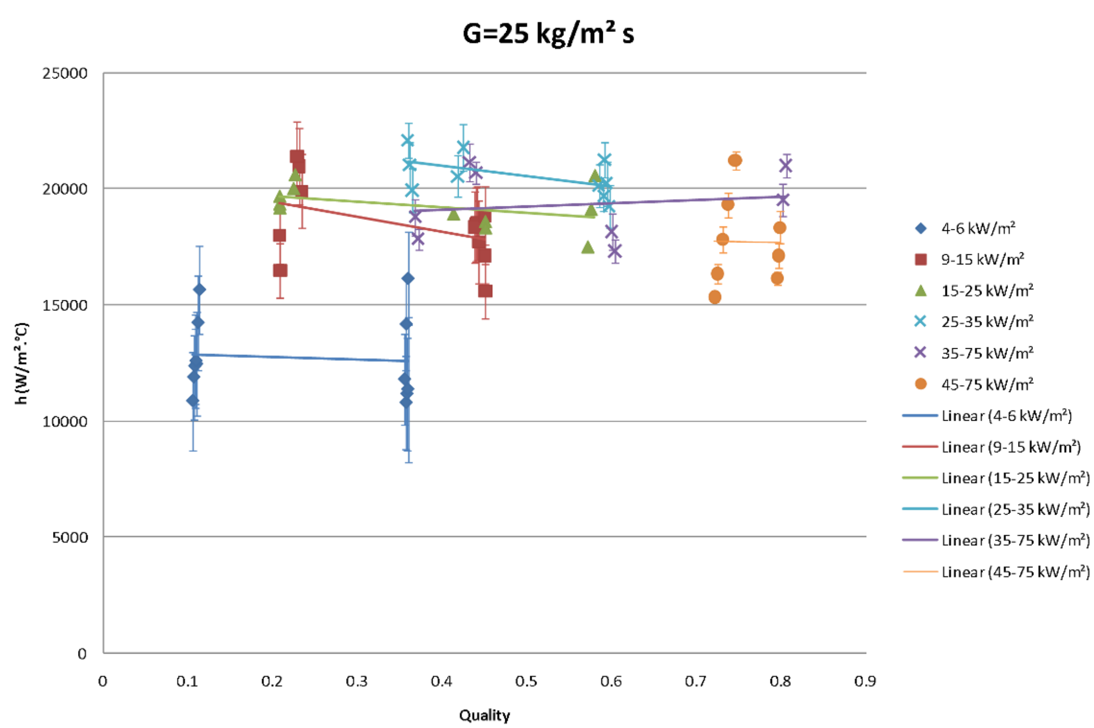

Figure 7-10 R-123 P/D 1.167 effect of quality at 25 kg/m².s

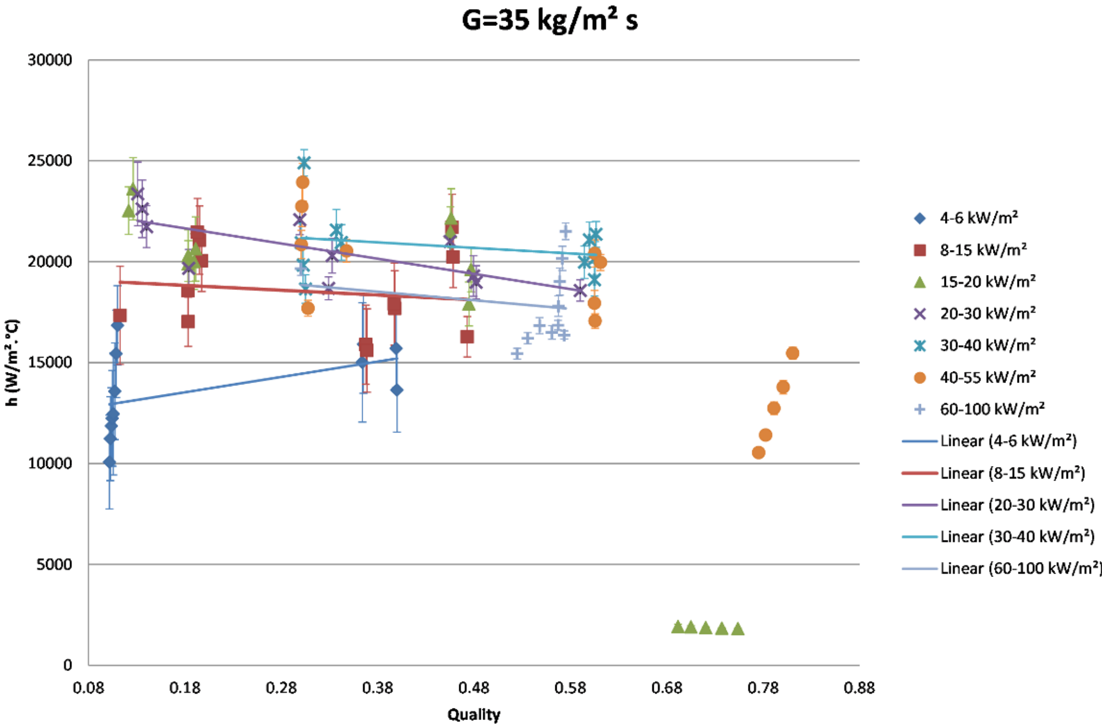

Figure 7-11 R-123 P/D 1.167 effect of quality at 35 kg/m².s

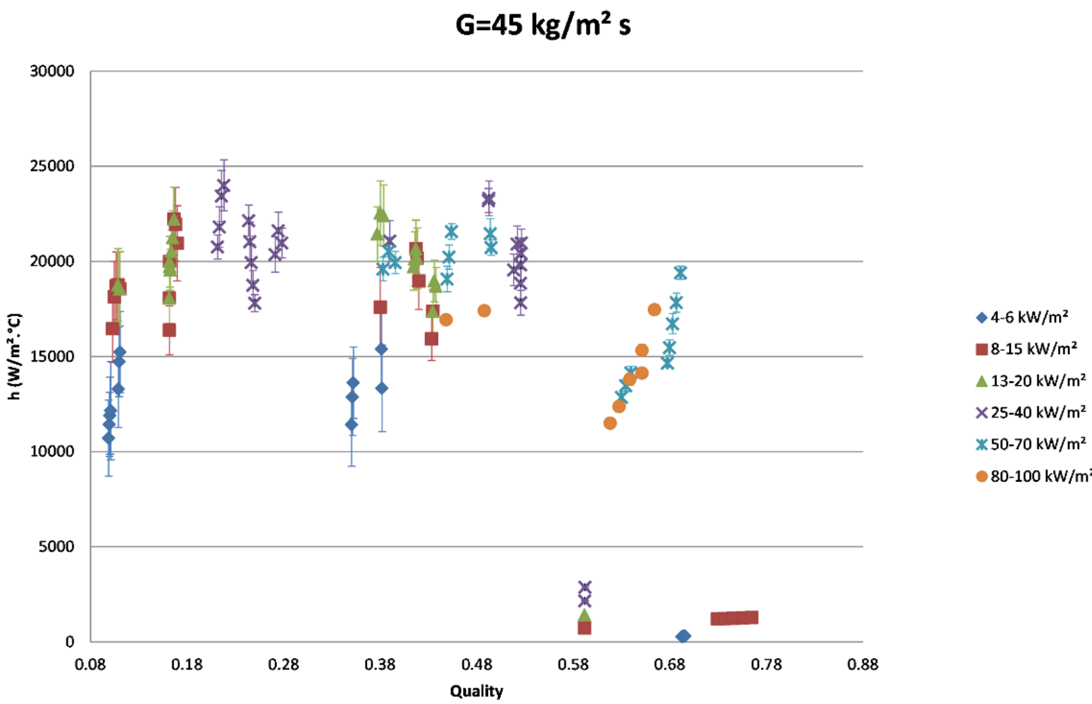

Figure 7-12 R-123 P/D 1.167 effect of quality at 45 kg/m².s

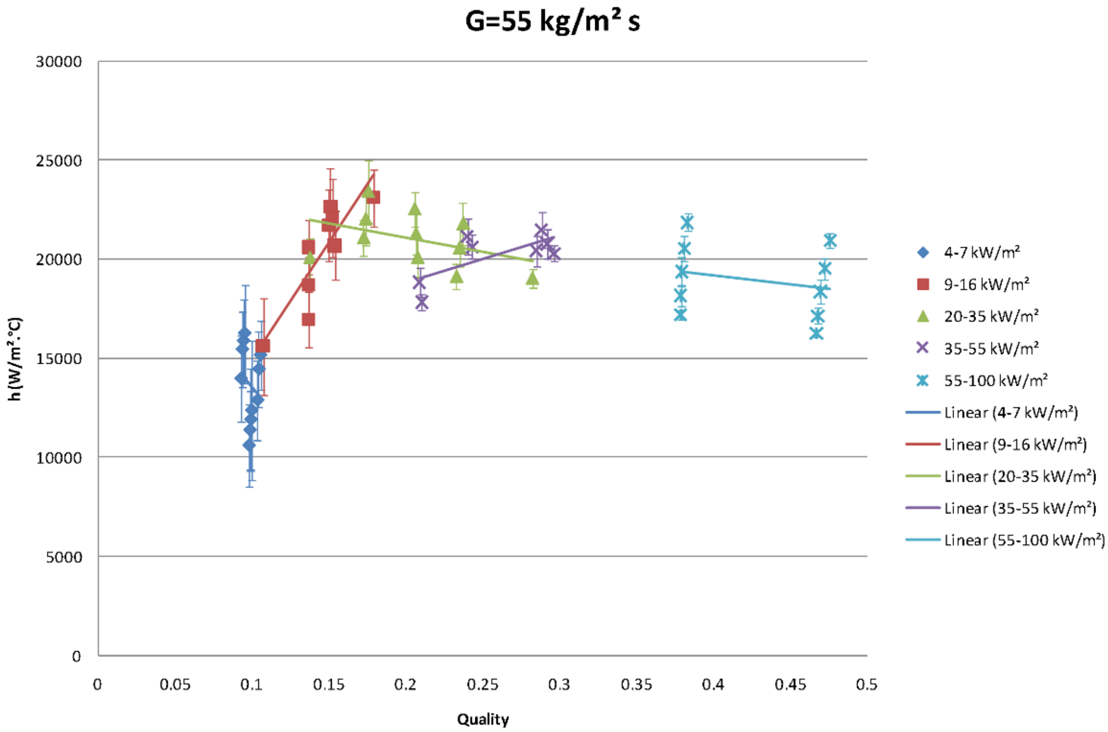

Figure 7-13 R-123 P/D 1.167 effect of quality at 55 kg/m².s

7.3 P/D 1.33 results

Data were collected according to the proposed test matrix of the P/D 1.33 tube bundle for a total of 22 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes, and local qualities, thus, 440 data points total as in Figure 7-14 below. The data is compared to that for the single tube pool boiling of the Turbo BII-LP tube. Ultimately, at low heat flux range (minimum heat flux to 30 kW/m²), all points show enhanced performance due to convective boiling. Finally, Figure 7-15 compares the two saturation temperatures, showing no significant difference.

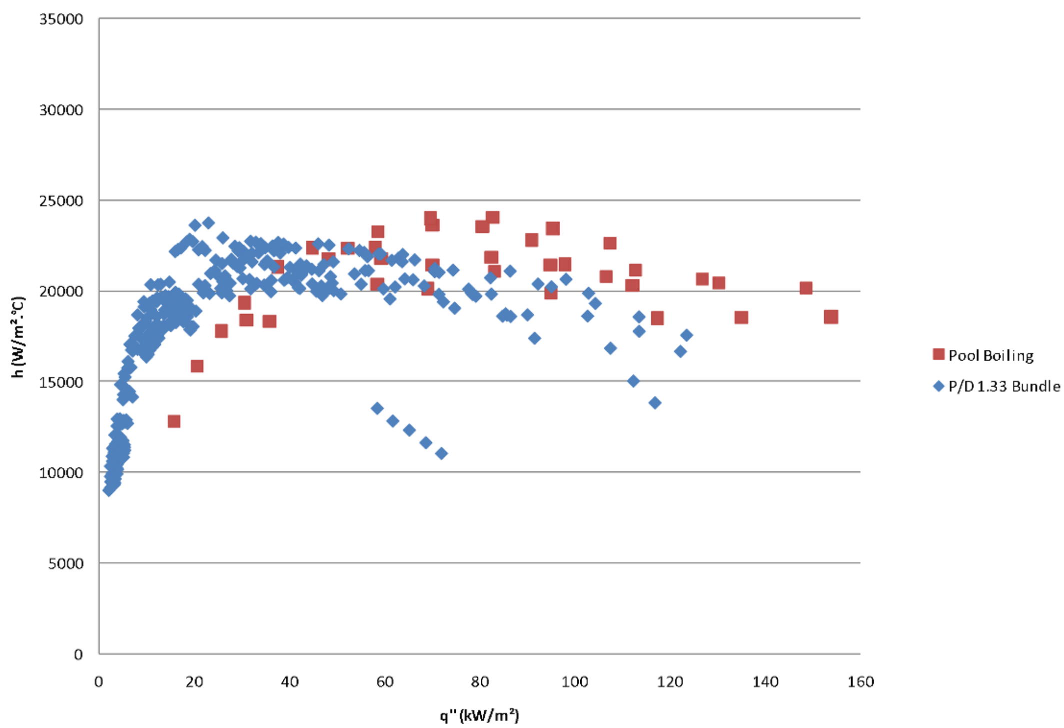

Figure 7-14 R-123 P/D 1.33 all data

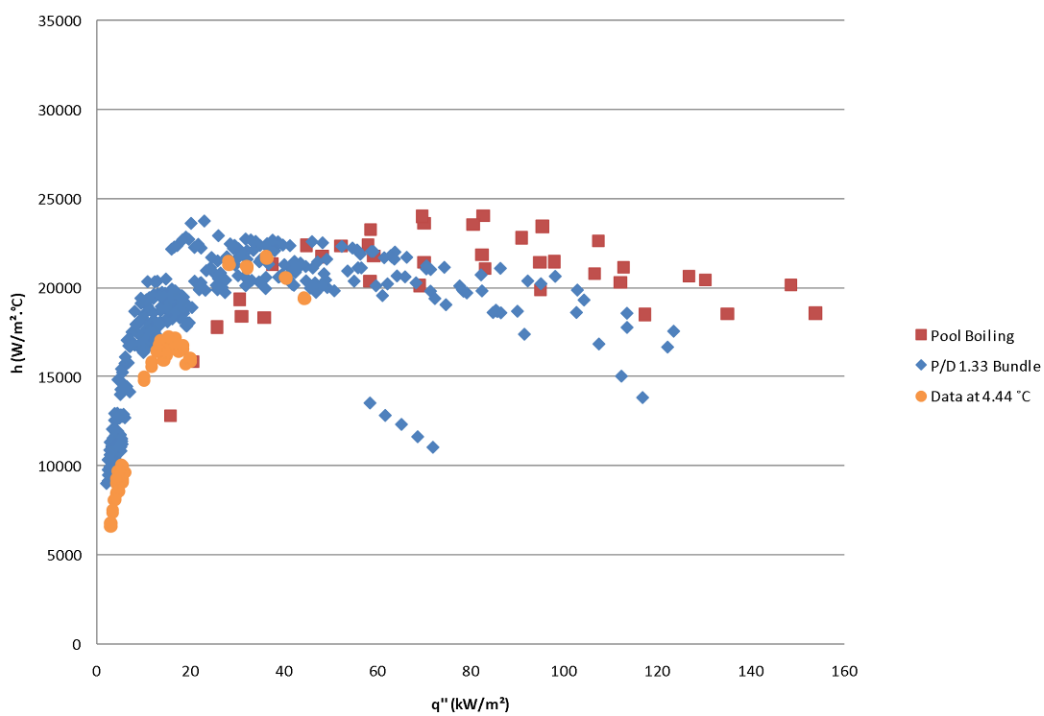

Figure 7-15 R-123 P/D 1.33 saturation temperature comparison

The data on the page before were sorted by quality as shown in Figure 7-16. At low heat flux, all qualities show enhanced performance compared to that of the single tube; however, at 50% Quality and beyond, the performance declines. Meanwhile, all the points above 30 kW/m² show a decreasing trend with the increase in heat flux; in fact, high quality points show a quick declining trend with the increase in heat flux. At medium and high heat fluxes, bundle performance is slightly lower than that of the single tube with some points overlapping.

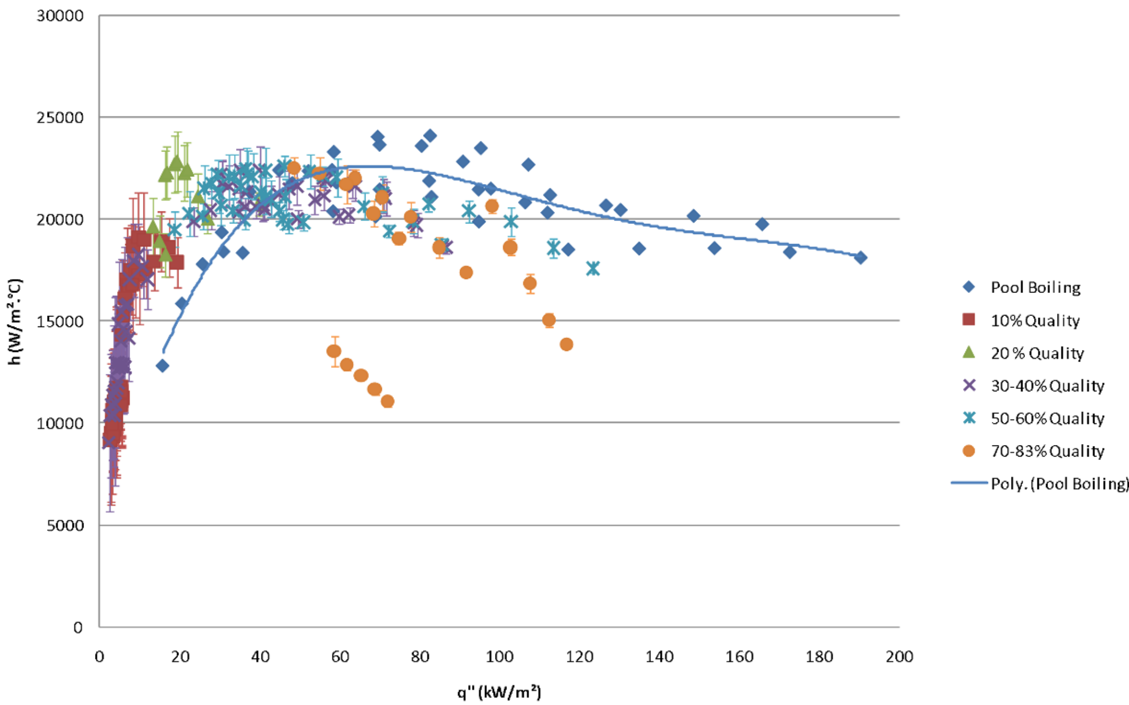

Figure 7-16 R-123 P/D 1.33 all data sorted by quality

7.3.1 Heat flux effect

Figures 7-17 through 7-20 show the change in heat transfer coefficient with heat flux for different mass fluxes and different ranges of quality. In the first plot (10-15% Quality), the heat transfer coefficient increases with the increase in heat flux up to 25 kW/m² and then changes to a near flat trend while the same trend persists for the 30-40% and 50-60% Quality plots; meanwhile, the 70-83% Quality plot shows that the heat transfer coefficient decreases with the increase in heat flux. Those plots show that the heat transfer coefficient is dependent on heat flux and flow pattern. Figure 7-20 demonstrates this flow pattern dependency.

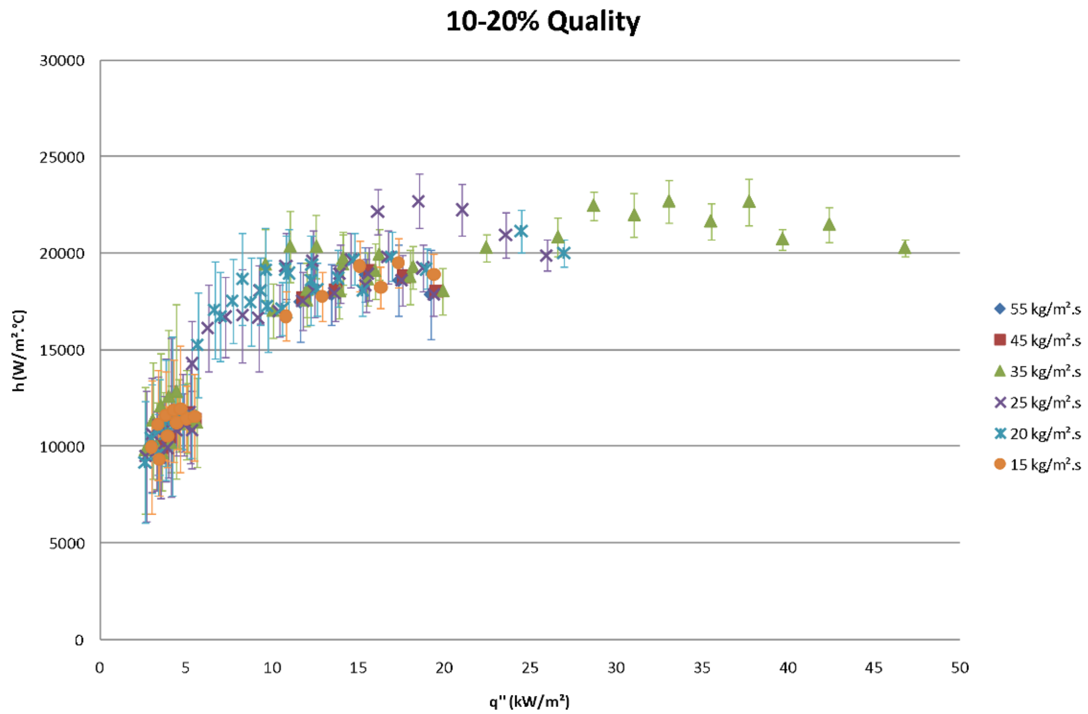

Figure 7-17 R-123 P/D 1.33 effect of heat flux at 10-20% Quality

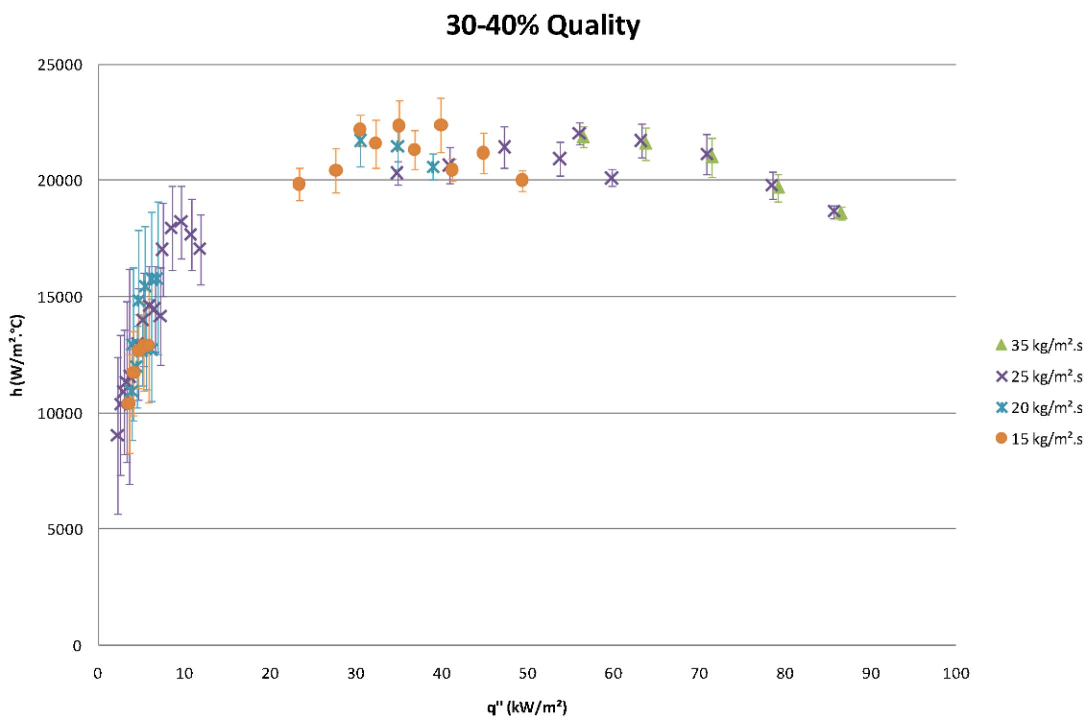

Figure 7-18 R-123 P/D 1.33 effect of heat flux at 30-40% Quality

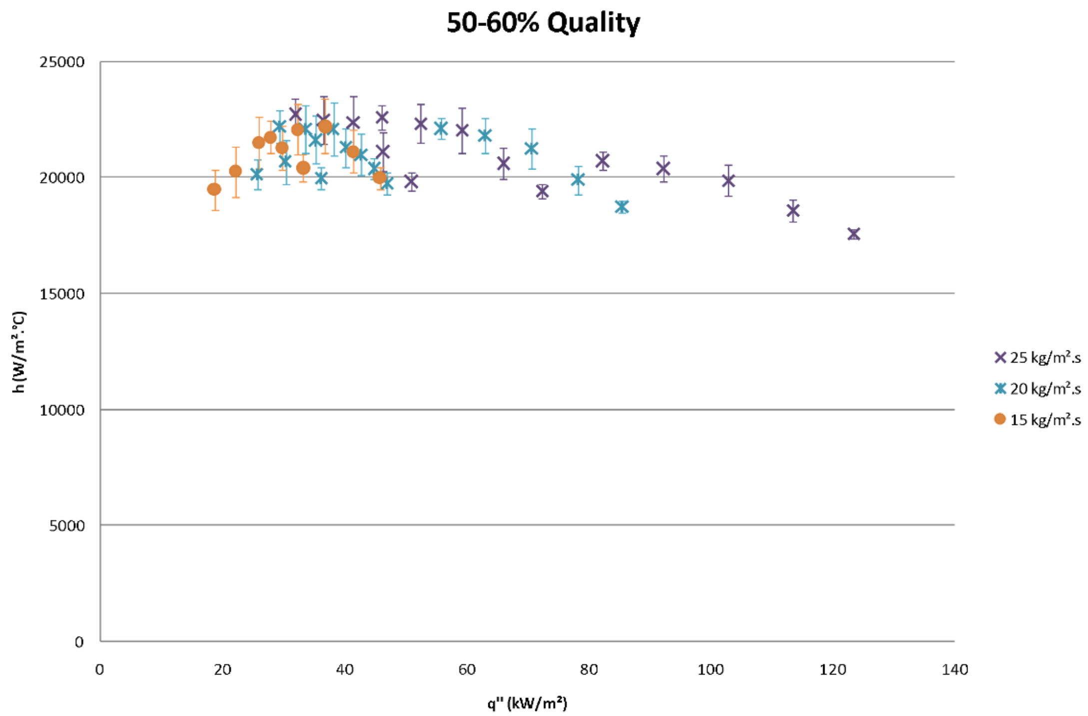

Figure 7-19 R-123 P/D 1.33 effect of heat flux at 50-60% Quality

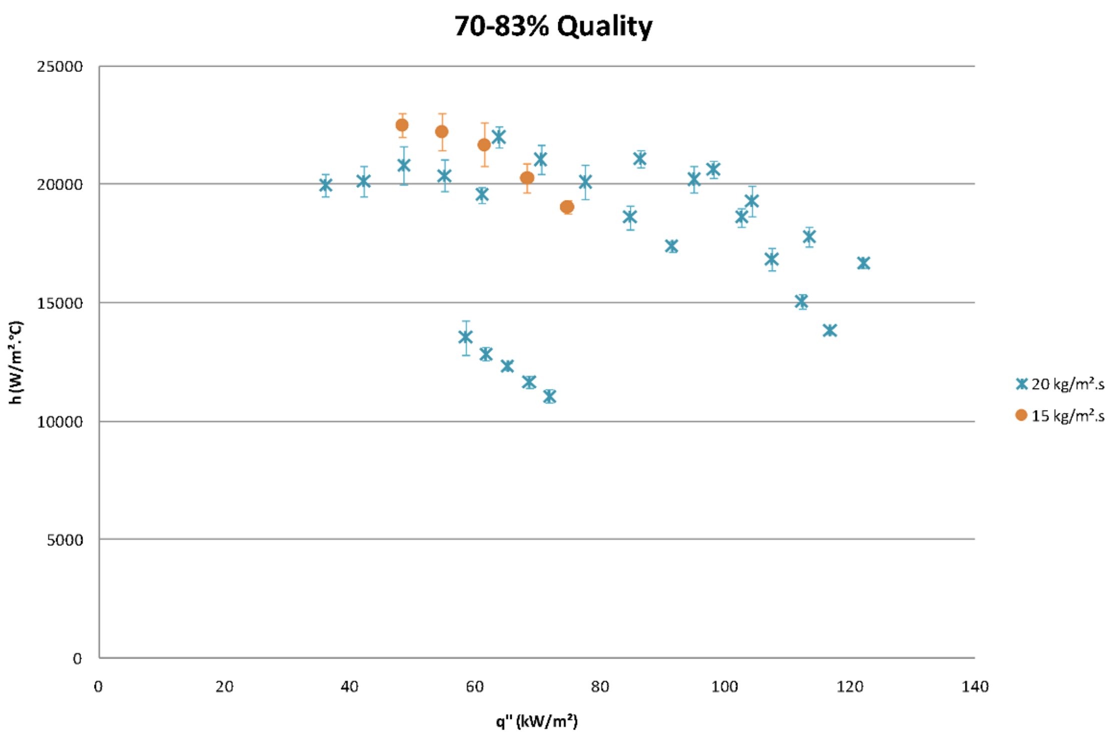

Figure 7-20 R-123 P/D 1.33 effect of heat flux at 70-83% Quality

7.3.2 *Mass flux effect*

The mass flux effect can also be interpreted from the previous plots (Figures 7-17 through 7-20) to show hardly any change in the heat transfer coefficient with mass flux at the same heat flux. Therefore, mass flux does not significantly affect performance.

7.3.3 *Quality effect*

For the effect of quality on bundle performance, the heat transfer coefficient was plotted against quality for each mass flux point of the test matrix over a narrow range of heat flux points as presented in Figures 7-21 through 7-23. For 15 kg/m^2.s mass flux (Figure 7-21) and for all heat flux ranges, the heat transfer coefficient doesn't significantly change with increase in quality. Specifically, for 20 kg/m^2.s mass flux (Figure 7-22), the heat transfer coefficient experiences a sharp decrease at 75% quality and higher. For 25 kg/m^2.s mass flux and given that the quality range is narrow compared to that for the other mass fluxes, the heat transfer coefficient doesn't significantly change with quality. For the rest of the mass fluxes (35, 45, and 55 kg/m^2.s), there were not enough data points from which to draw a strong conclusion. Ultimately, the plots presented over show that the heat transfer coefficient strongly depends on quality for 25 kg/m^2.s mass fluxes at high qualities.

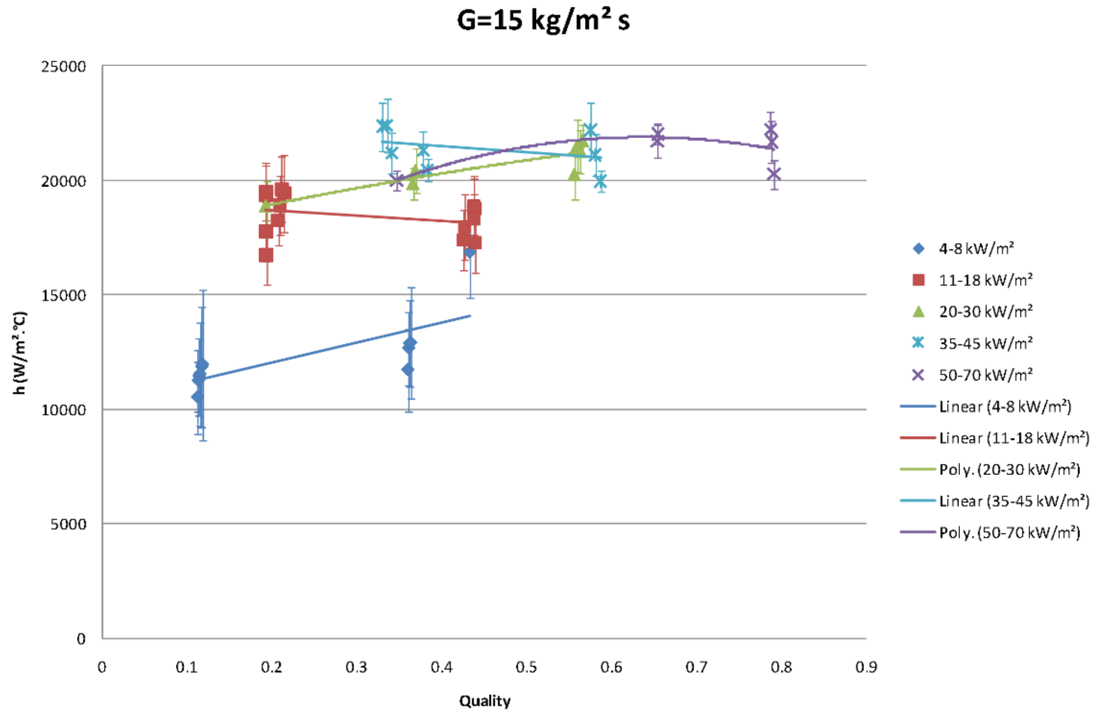

Figure 7-21 R-123 P/D 1.33 effect of quality at 15 kg/m².s

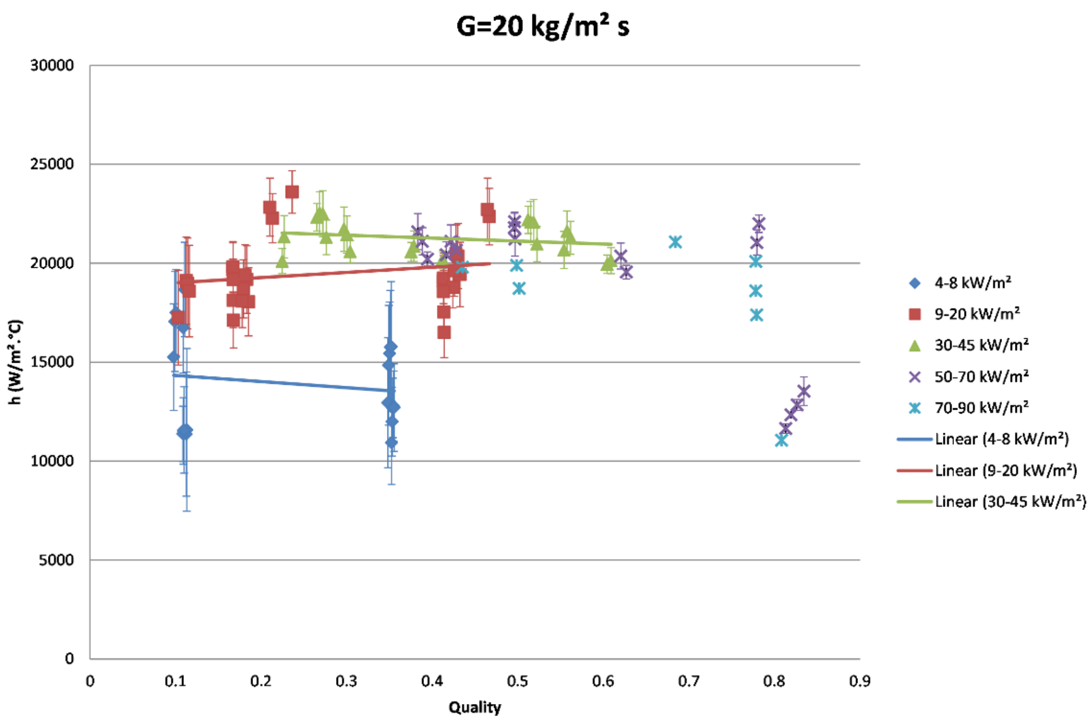

Figure 7-22 R-123 P/D 1.33 effect of quality at 20 kg/m².s

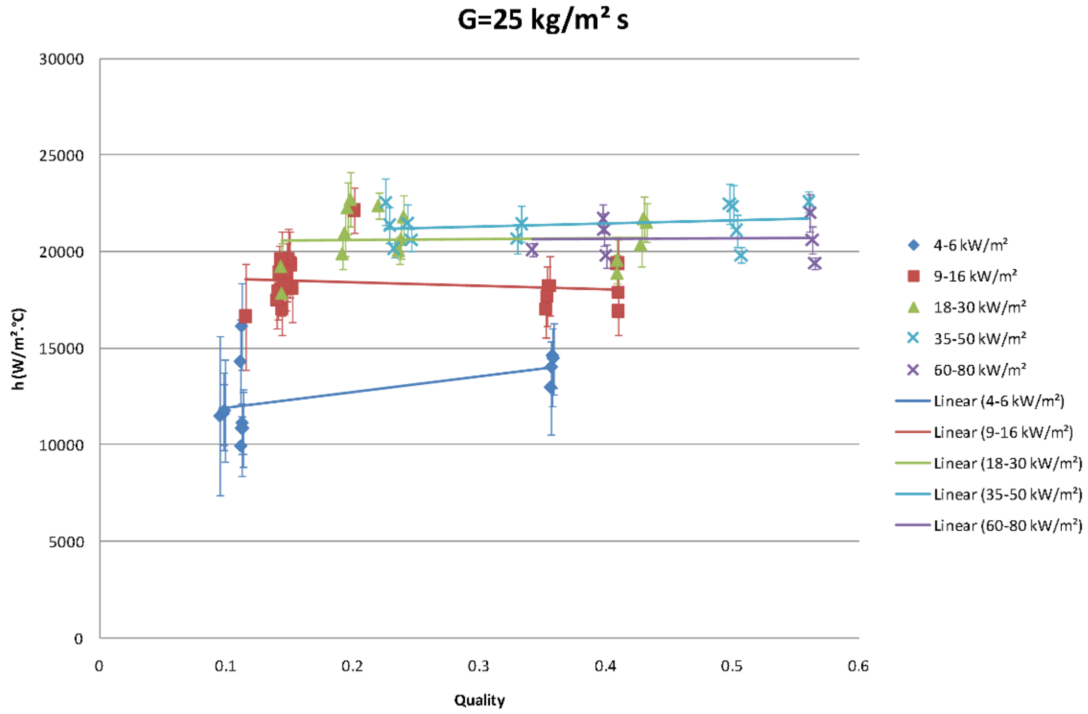

Figure 7-23 R-123 P/D 1.33 effect of quality at 25 kg/m².s

7.4 P/D 1.5 results

Data were collected according to the proposed test matrix of the P/D 1.33 tube bundle for a total number of 23 runs. Each run produces 20 data points of local heat transfer coefficients, local heat fluxes, and local qualities, thus, 460 data points total as in Figure 7-24. The data is compared to that for the single tube pool boiling of the Turbo BII-LP tube showing that at low heat flux range (minimum heat flux to 30 kW/m²), all points reveal enhanced performance due to convective boiling. Figure 7-25 compares the two saturation temperatures showing no significant difference.

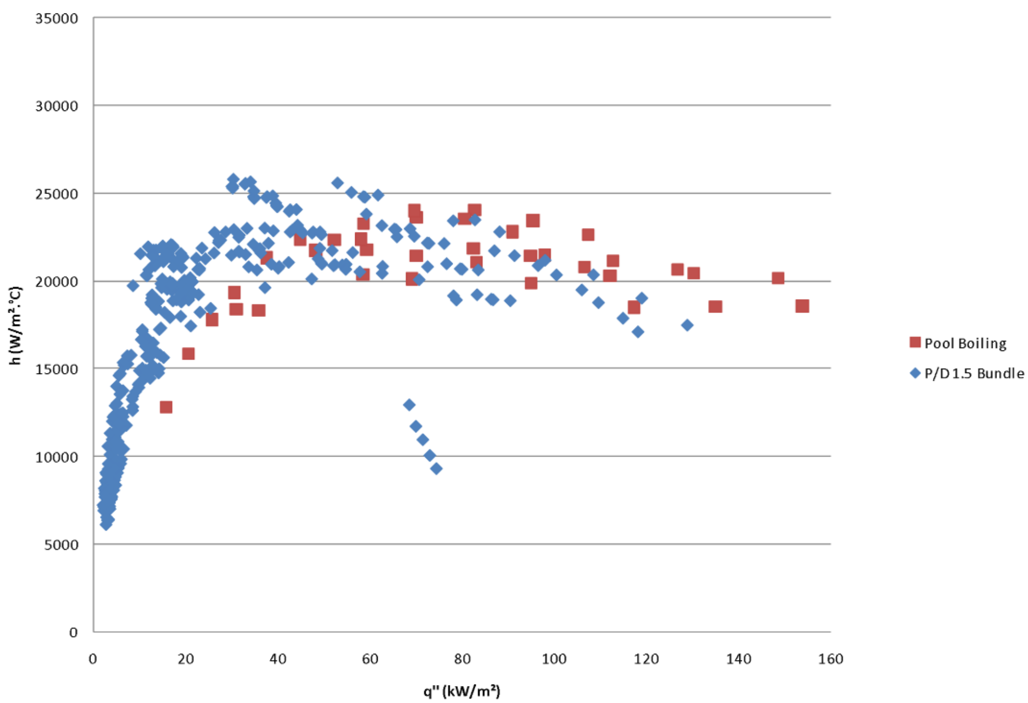

Figure 7-24 R-123 P/D 1.5 all data

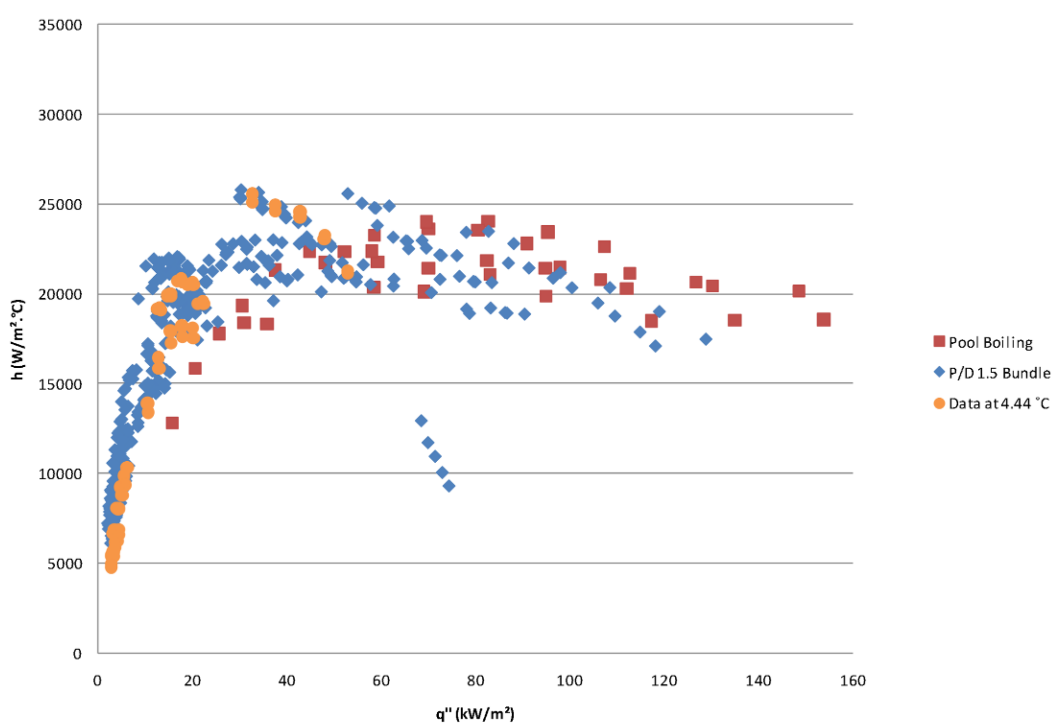

Figure 7-25 R-123 P/D 1.5 two saturation temperatures

The data on the previous page were sorted by quality as shown in Figure 7-26. At low heat flux, all qualities show enhanced performance compared to that of the single tube. Specifically, at 50% Quality and beyond, the heat transfer coefficient shows a decreasing trend, whereas at 70-84% Quality, the performance deteriorates faster. In fact, all the points above 30 kW/m² show a decreasing trend with the increase in heat flux. Finally, at medium and high the heat fluxes, the bundle shows performance similar to that of the single tube.

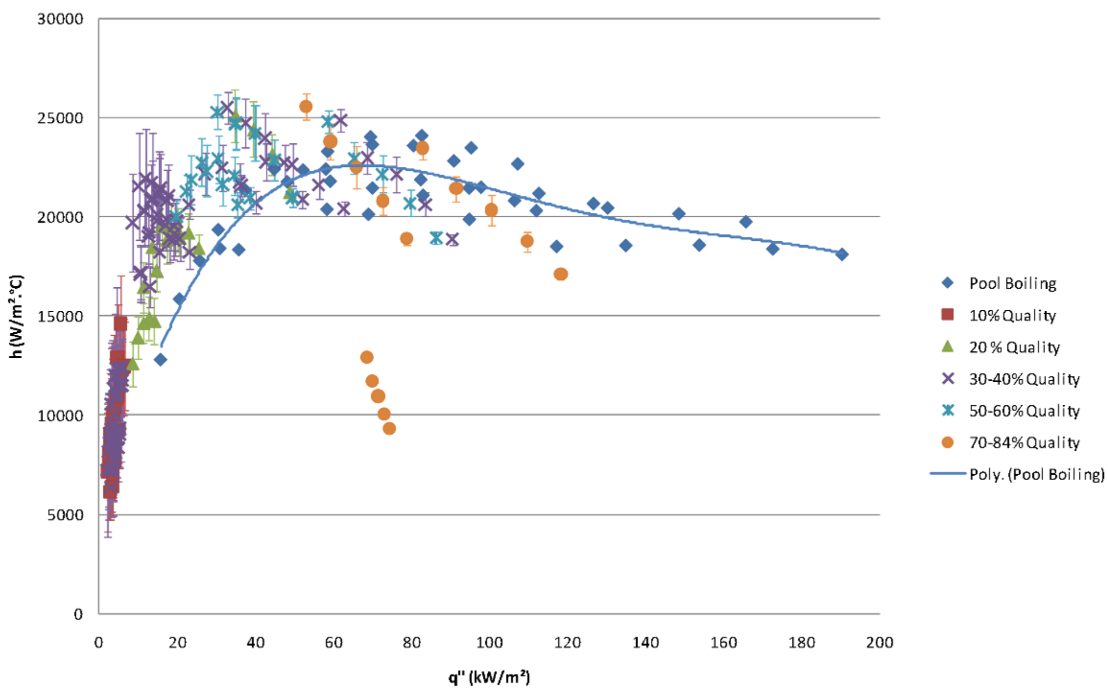

Figure 7-26 R-123 P/D 1.5 all data sorted by quality

7.4.1 Heat flux effect

Figures 7-27 through 7-30 present the change in the heat transfer coefficient with heat flux for different mass fluxes and different ranges of quality. In Figure 7-27 (10-20% Quality), the heat transfer coefficient increases with the increase in heat flux up to 25 kW/m² and then changes to a decreasing trend with the increase in heat flux, and the same trend persists for the 30-40% and 50-60% Quality plots (Figure 7-28 and Figure 7-29). Meanwhile, the 70-80% Quality plot shows that the heat transfer coefficient decreases quickly with the increase in heat flux. Finally, Figure 7-30 shows that at high quality, performance deteriorates faster as mass flux increases. It also shows a flow pattern dependency, as the heat transfer coefficient demonstrates two different values for the same heat flux and quality ranges.

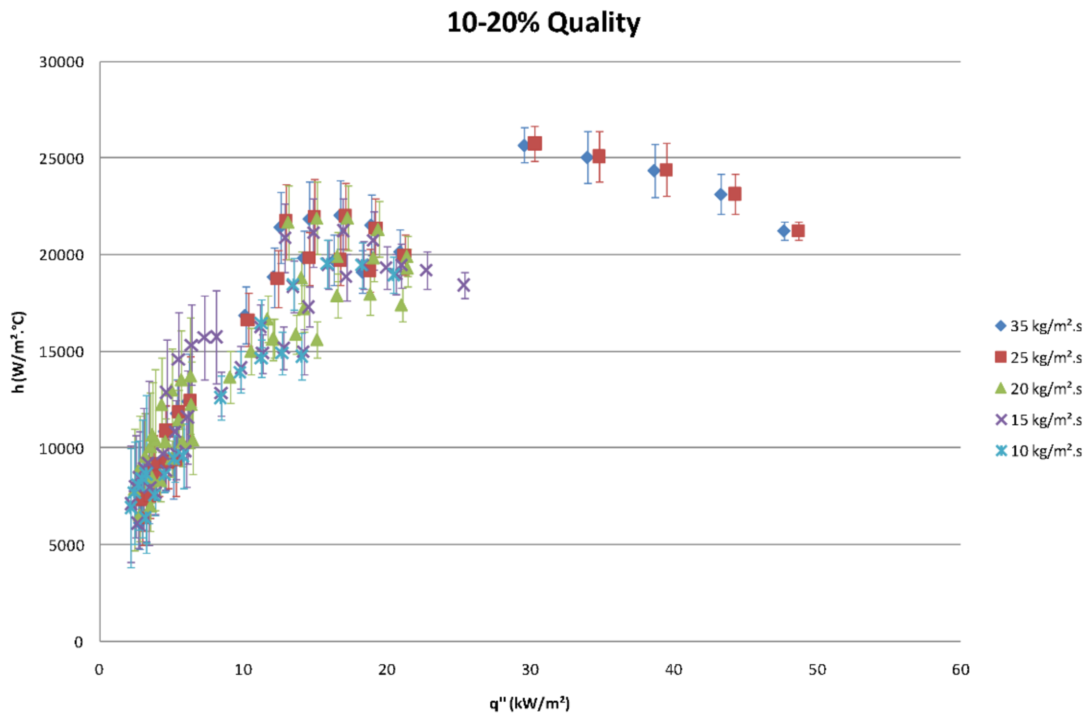

Figure 7-27 R-123 P/D 1.5 effect of heat flux at 10-20% Quality

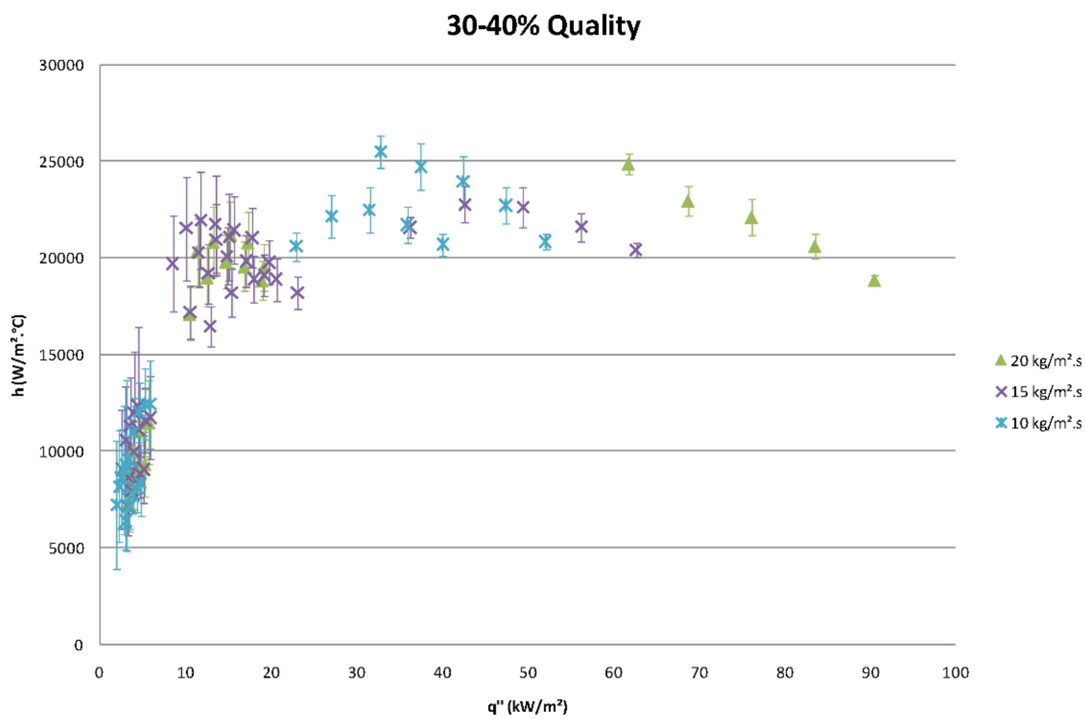

Figure 7-28 R-123 P/D 1.5 effect of heat flux at 30-40% Quality

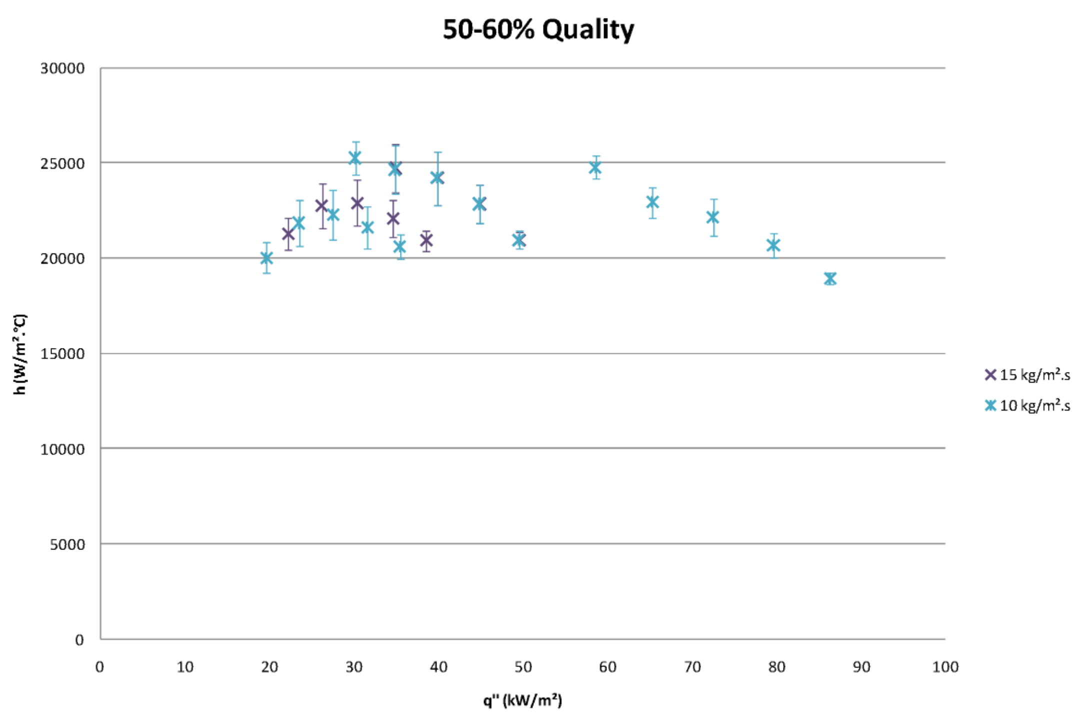

Figure 7-29 R-123 P/D 1.5 effect of heat flux at 50-60% Quality

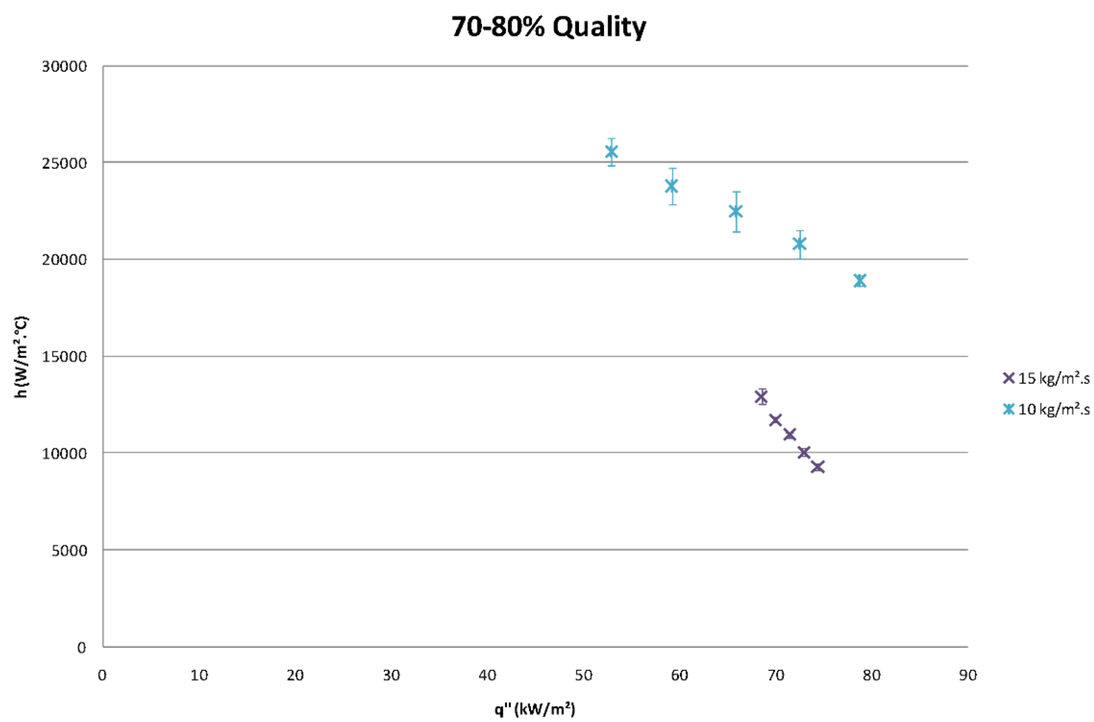

Figure 7-30 R-123 P/D 1.5 effect of heat flux at 70-80% Quality

7.4.2 Mass flux effect

The mass flux effect can also be interpreted from the plots in Figures 7-27 through 7-30. Primarily, hardly any change registers in the heat transfer coefficient with mass flux at the same heat flux. Indeed, except at 70-80% Quality, the mass flux does not significantly affect performance.

7.4.3 Quality effect

For the effect of quality on bundle performance, the heat transfer coefficient was plotted against quality for each mass flux point of the test matrix over a narrow range of heat flux points as presented in Figures 7-31 through 7-33. For 10 kg/m².s mass flux (Figure 7-31) and for all heat flux ranges, the heat transfer coefficient doesn't significantly change with the increase in quality. However, for 15 kg/m².s mass fluxes, the heat transfer coefficient experiences a sharp decrease at 75% quality and higher. Meanwhile, for 20 kg/m².s mass fluxes, and given that the quality range is narrow compared to that for the other mass fluxes, the heat transfer coefficient doesn't significantly change with quality. For the remaining mass fluxes (25, 35, 45, and 55 kg/m².s), there were not enough data points from which to draw a strong conclusion. The plots presented next show that the heat transfer coefficient is strongly dependent on quality for high mass fluxes at high qualities.

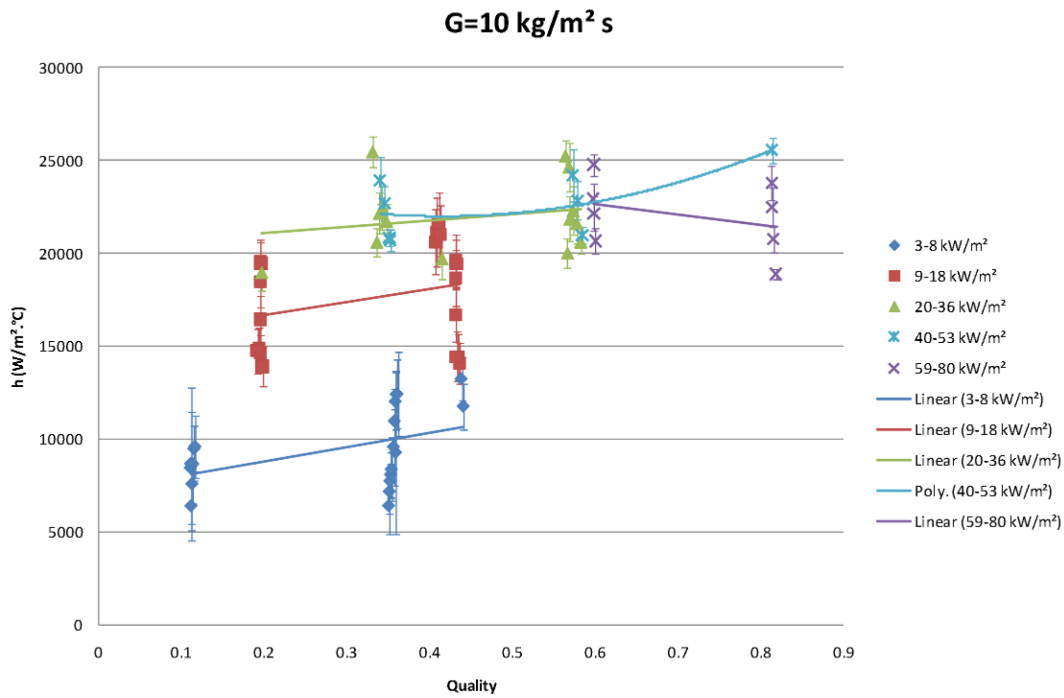

Figure 7-31 R-123 P/D 1.5 effect of quality at 10 kg/m².s

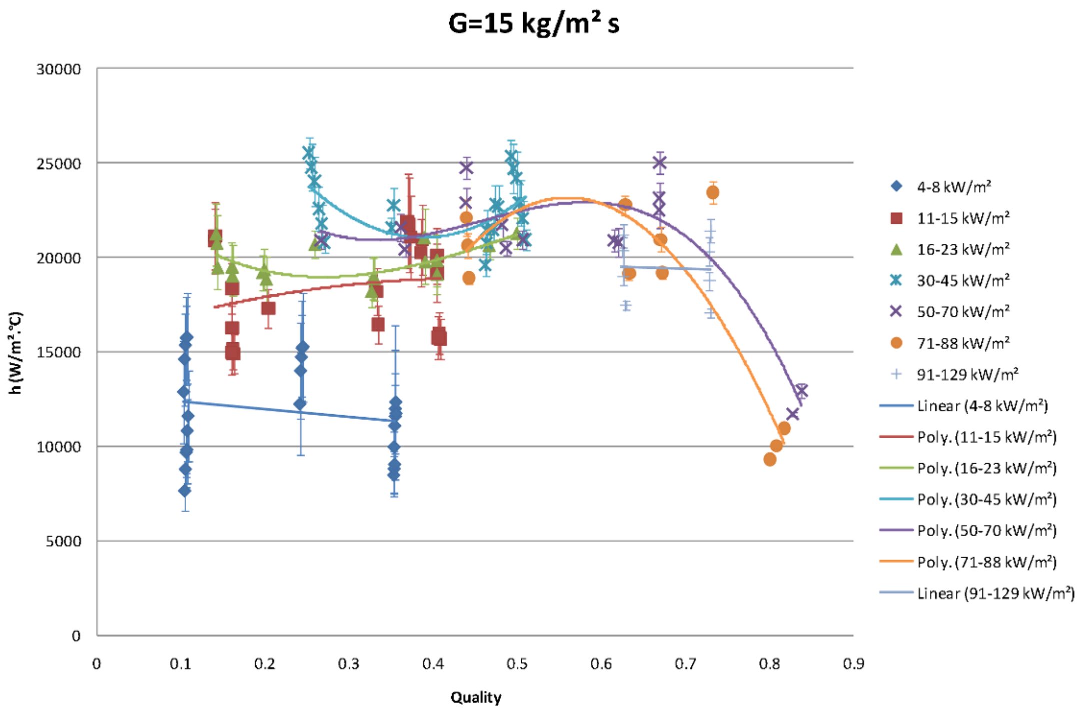

Figure 7-32 R-123 P/D 1.5 effect of quality at 15 kg/m².s

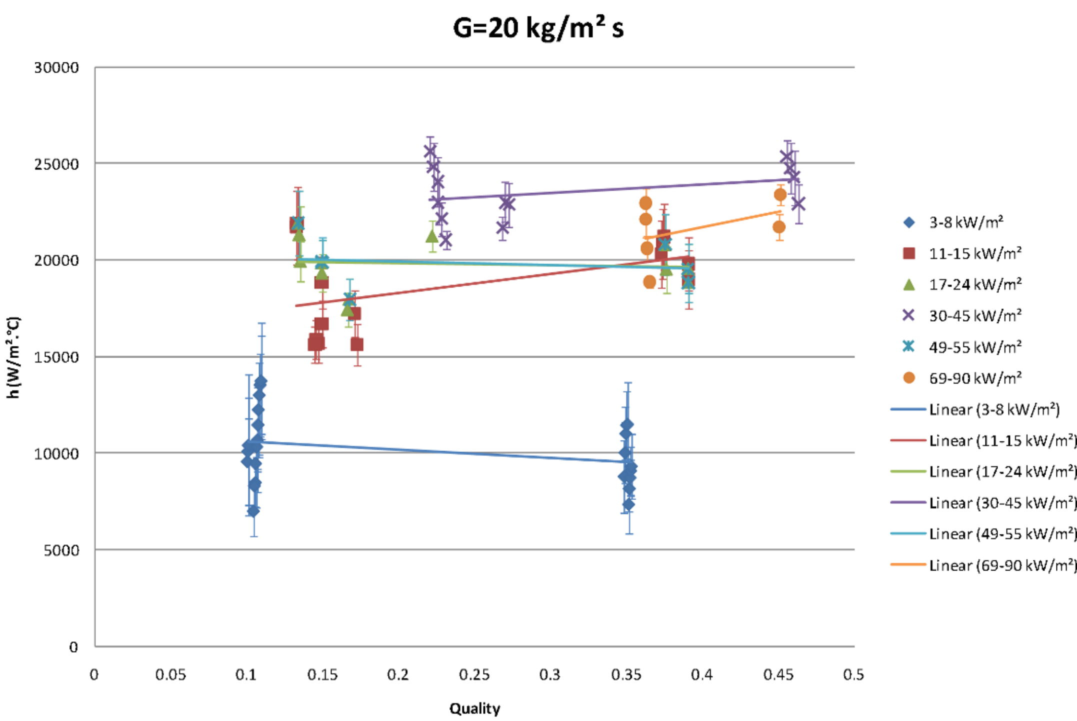

Figure 7-33 R-123 P/D 1.5 effect of quality at 20 kg/m².s

7.5 Saturation pressure change in the tube bundles

The following plots (Figures 7-34 through 7-36) show the saturation pressure change in the three tube pitches. The change in the saturation pressure is due to three components, hydrostatic pressure, dynamic pressure, and frictional loss. Each plot shows the saturation pressure (tube-average pressure) change at each height in the bundle starting from the inlet. Locations A4, A3, A2, and A1 refer to the different heights in the tube bundle (refer to Figure 3-5 in Page 23). Each plot includes the measured mass flux ranges; each mass flux represents a test point with the maximum change in quality. The trends show that the saturation pressure change in the bundle is insignificant (i.e. the pressure change within the tube bundle does not show a steady trend) even for the smallest tube pitch.

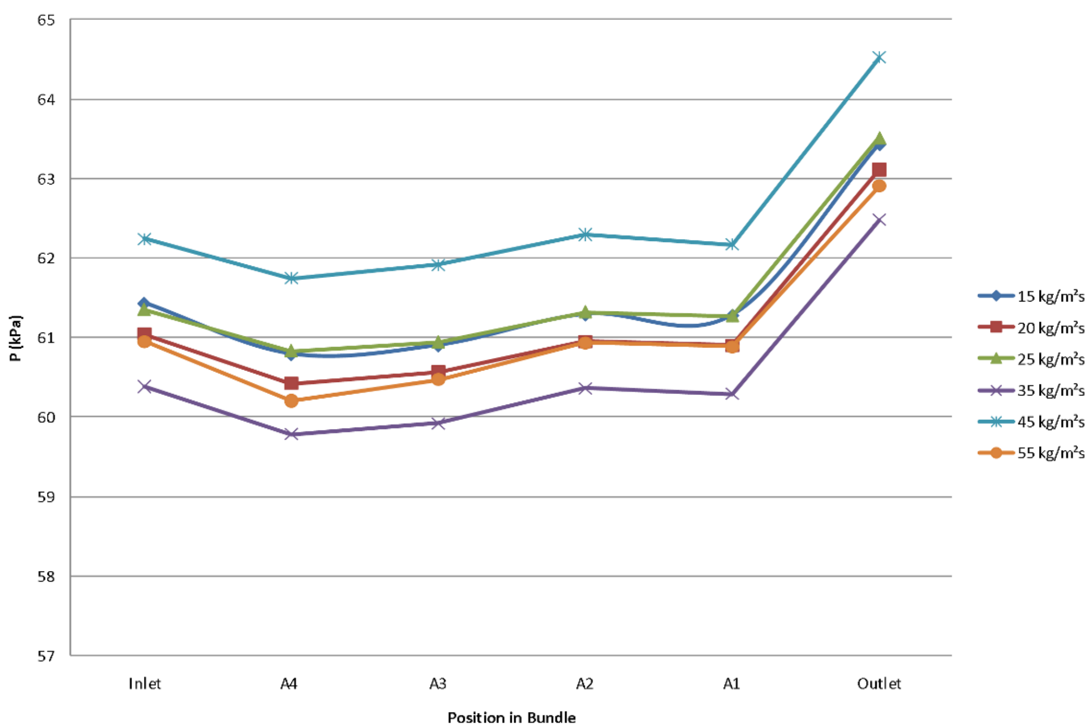

Figure 7-34 R-123 P/D 1.167 bundle saturation pressure

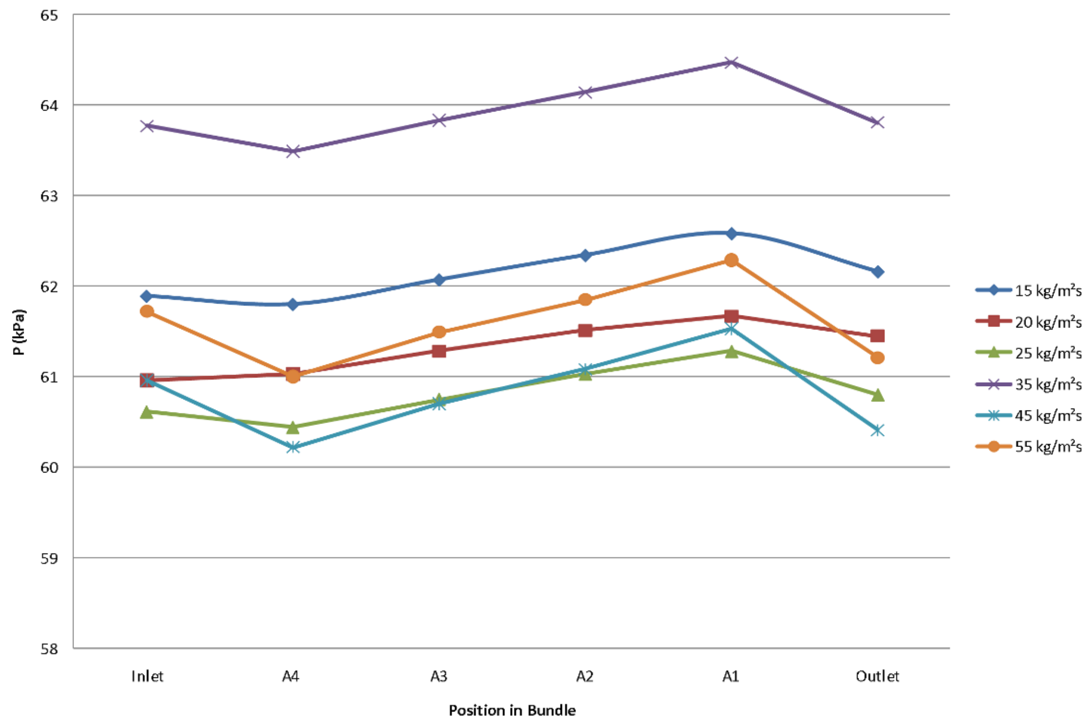

Figure 7-35 R-123 P/D 1.33 bundle saturation pressure

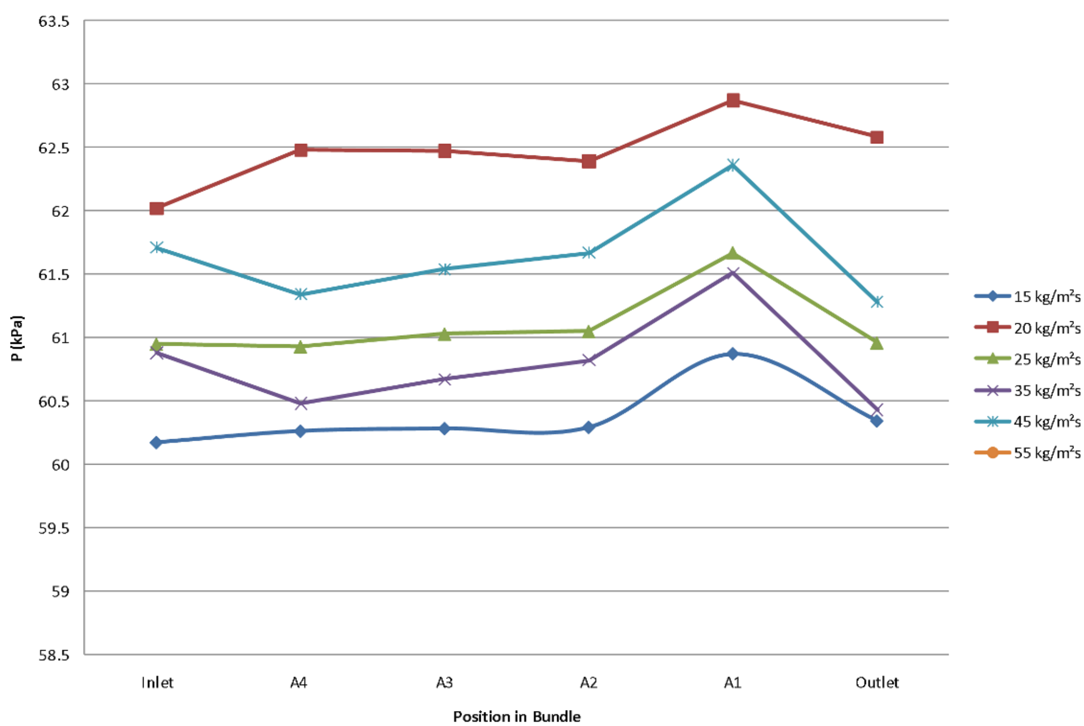

Figure 7-36 R-123 P/D 1.5 bundle saturation pressure

7.6 Heat transfer impact of varying the tube pitch

The main conclusion from the results of testing the three tube bundles is that the heat transfer coefficient is dependent on both heat flux and quality. The effect of quality, however, is not as dominant as the effect of heat flux, since it is only significant at some mass fluxes and when the quality exceeds 50% (in the case of the smallest tube pitch) and 75% (in the cases of the other two tube pitches). Therefore, comparing performance of tube pitch for the three bundles is done by plotting the heat transfer coefficient against the heat flux.

Aside from dry-out of the smallest tube pitch, all three bundles show very similar performance at low heat flux. At medium and high heat fluxes, there is a slight difference in performance among the three tube pitches since as the tube pitch increases, the performance gets closer to that of the single tube.

Just as the pool boiling curve experiences a peak in performance, so does bundle performance. Moreover, all three bundles experience a peak in performance at a lower heat flux than that of the single tube as presented in Figure 7-37. Concerning tube dry-out, only the smallest tube pitch experiences a drop in performance to that of a smooth tube at certain flow rates and high qualities. This phenomenon does not occur in the bigger tube pitches; only a quick decline in performance is experienced at high qualities. Also, the effect of flow pattern becomes significant at high qualities. This effect is noticeable for the points with two different values for the heat transfer coefficient for the same heat flux, mass flux, and quality.

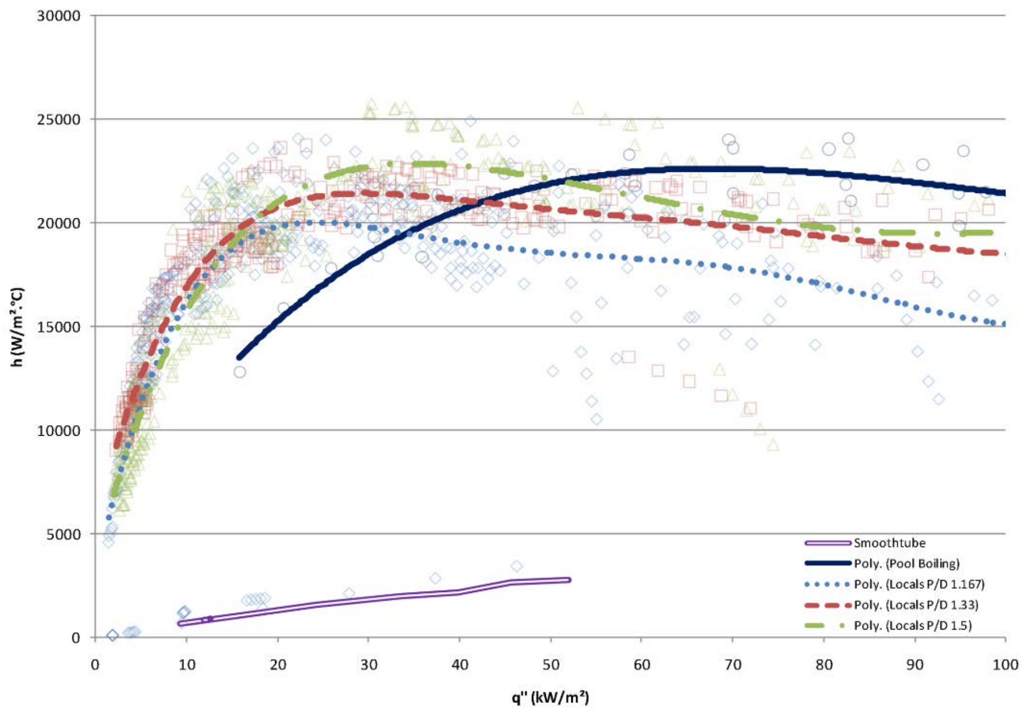

Figure 7-37 R-123 tube pitch comparison

The second step for assessing tube pitch performance is to compare the three tube pitches' heat transfer coefficient with respect to heat flux, quality, mass flux, and mass flow. Although flow rate comparison is not the focus of this study, it is somewhat important to understand the effect of switching a tube bundle to a bigger tube pitch in a flooded evaporator under the same operating conditions. Accordingly, Figure 7-38 and Figure 7-39 present the change in the heat transfer coefficient with respect to heat flux at the same mass flux for the three bundles. At low heat flux, the smallest tube pitch shows the highest performance, but taking into account the uncertainty of the points, predictably, the three bundles have the same performance. Also, the three bundles overlap at the range of 15-20 kW/m². Additionally, the biggest tube pitch shows the highest performance at the 30-50 kW/m² range; moreover, the same trends persist in Figure 7-40 and Figure 7-41, with the overlapping taking place at a higher heat flux.

Figures 7-42 through 7-46 show the change in the heat transfer coefficient with quality at the same heat and mass flux, and at the same heat flux and mass flow rate. Indeed, all plots show insignificant change in the heat transfer coefficient with change in quality except in Figure 7-46, where the heat transfer coefficient drops drastically for P/D 1.167 at high quality; this shows tube dry-out.

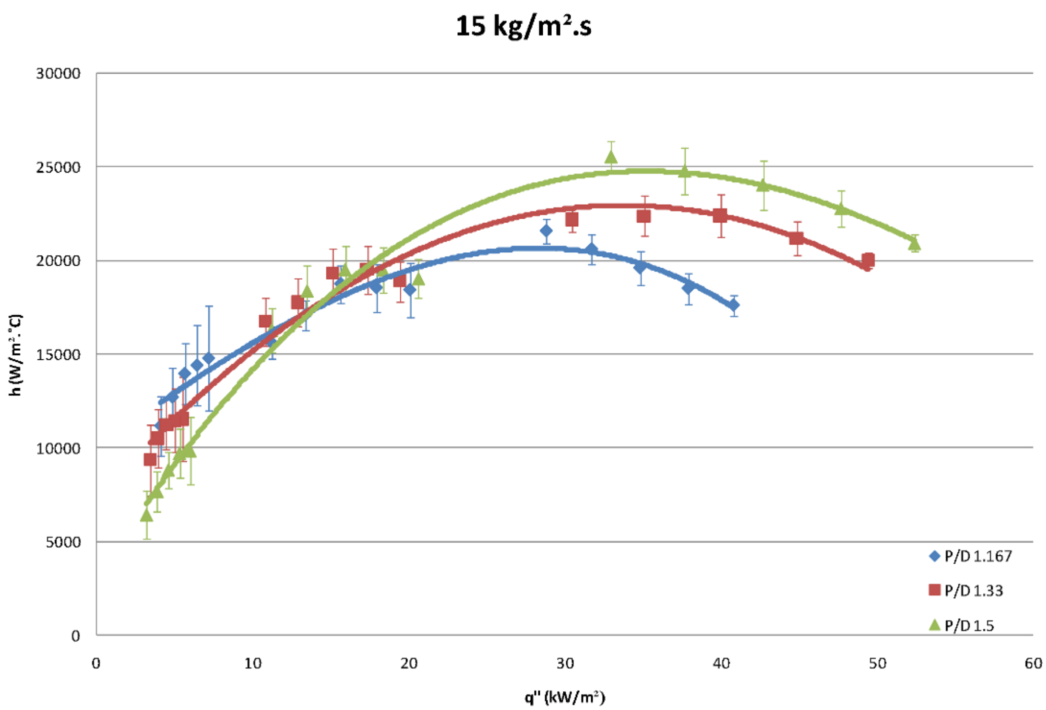

Figure 7-38 R-123 bundles comparison at 15 kg/m².s

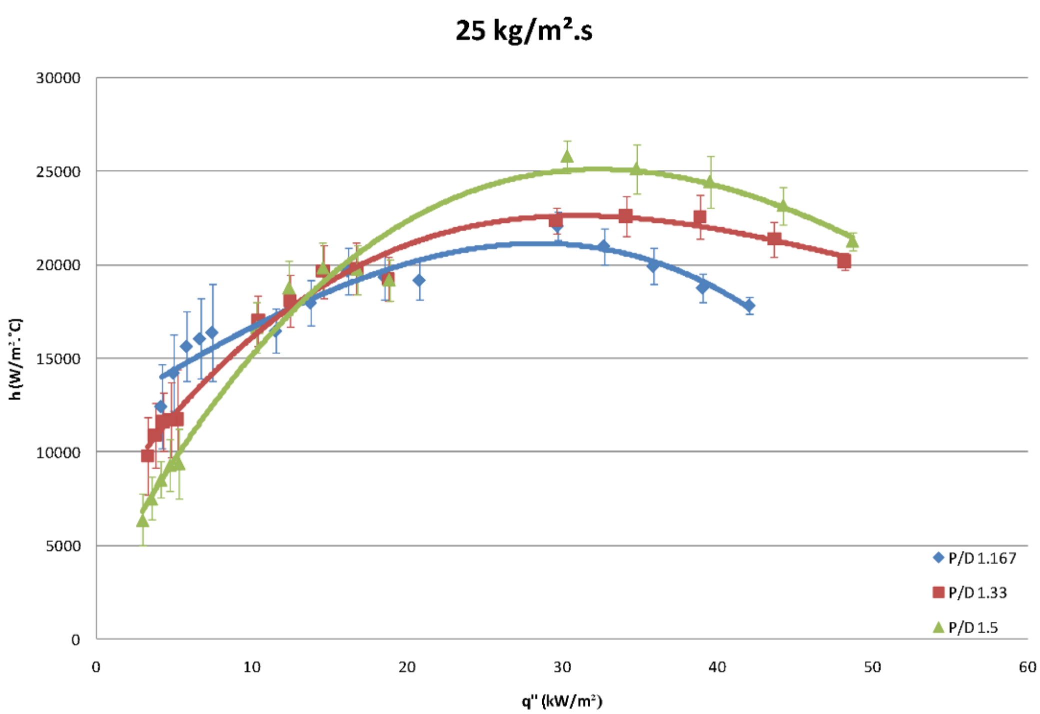

Figure 7-39 R-123 bundles comparison at 25 kg/m².s

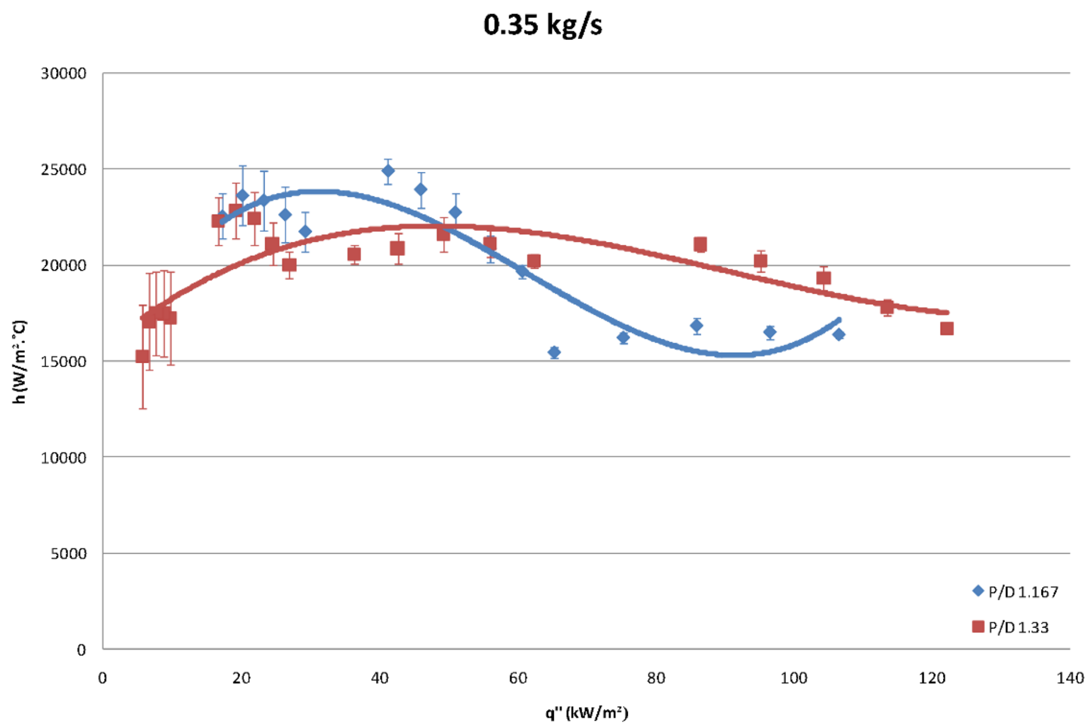

Figure 7-40 R-123 bundles comparison at 0.35 kg/s

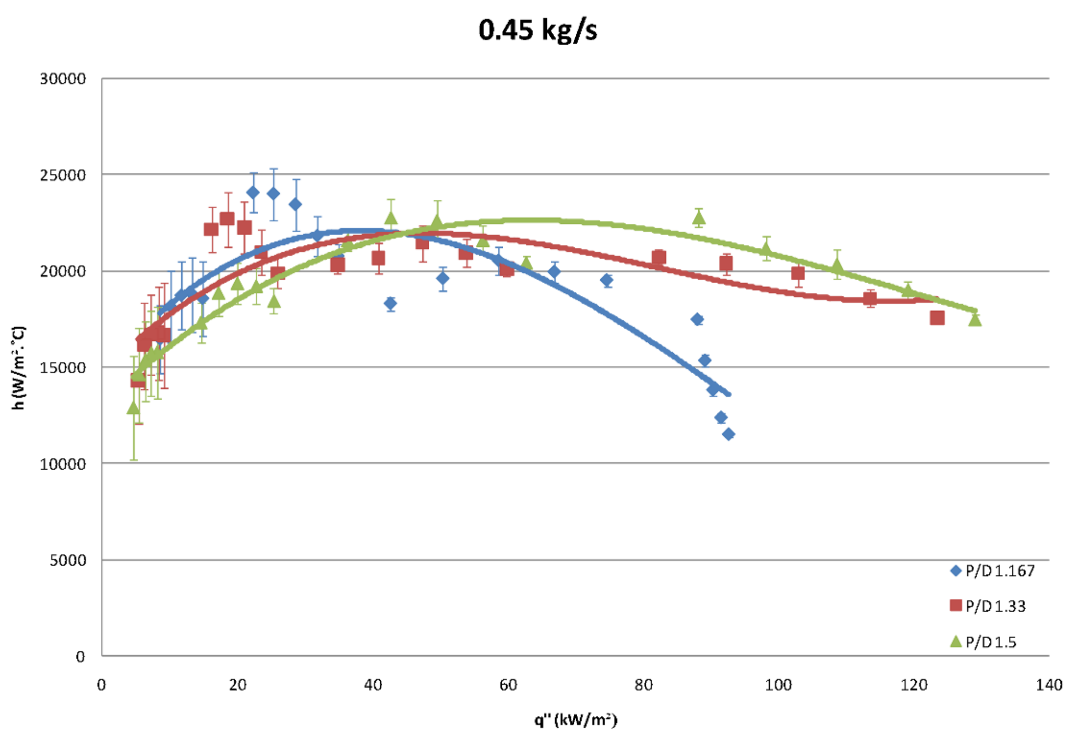

Figure 7-41 R-123 bundles comparison at 0.45 kg/s

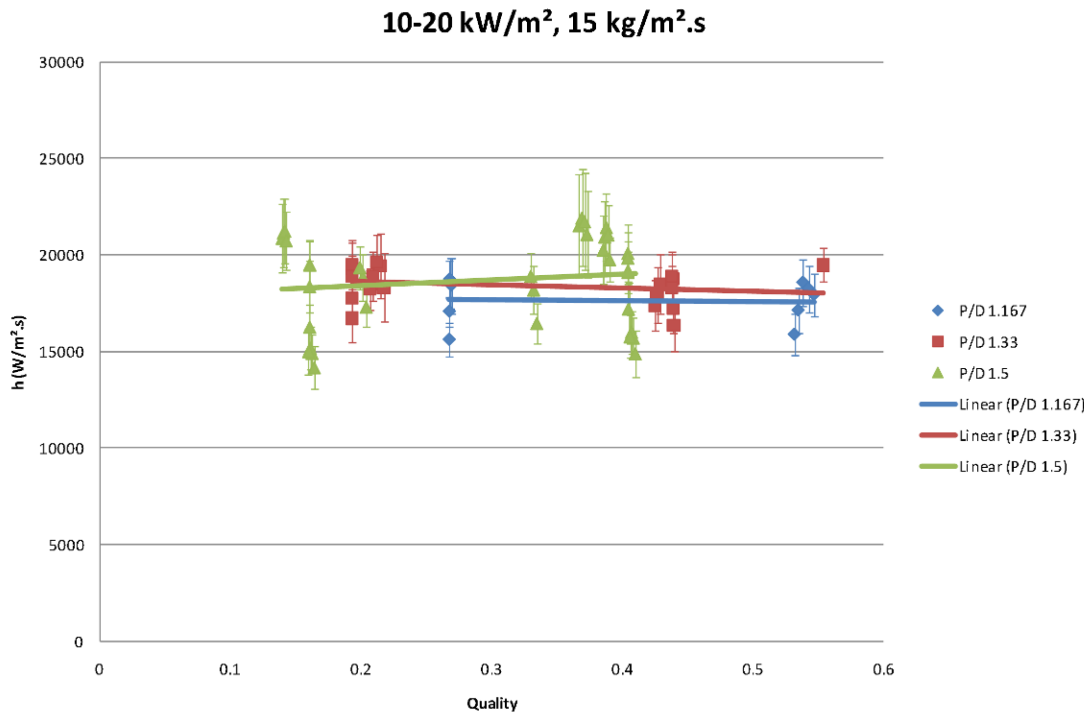

Figure 7-42 R-123 bundles comparison at 15 kg/m².s and 10-20 kW/m²

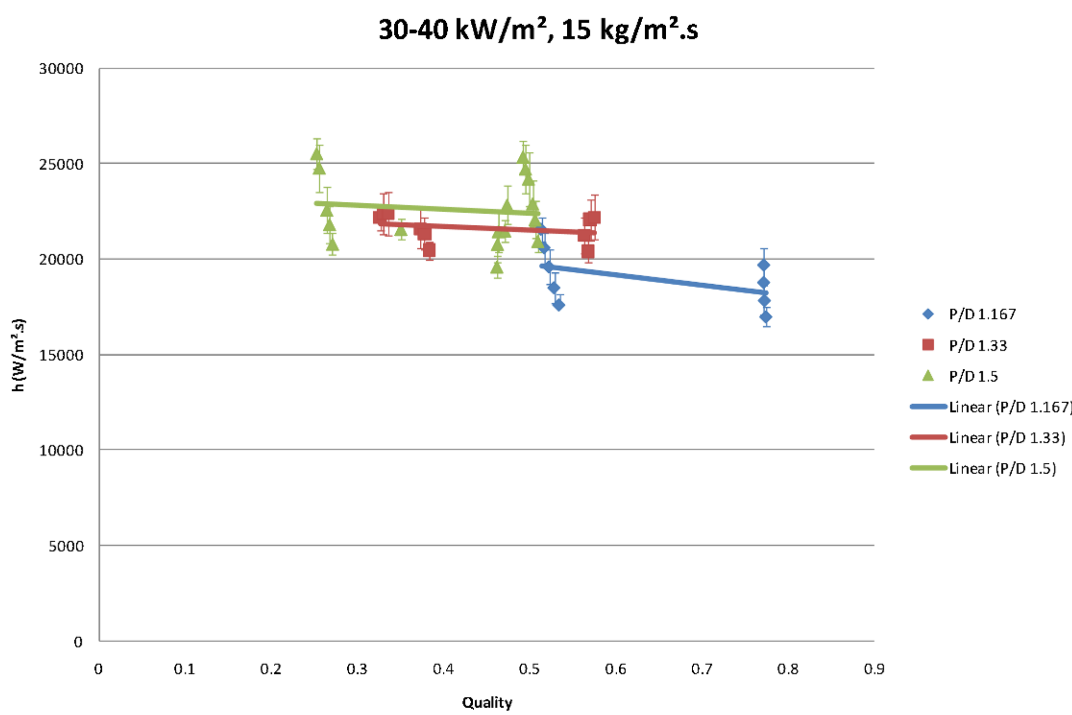

Figure 7-43 R-123 bundles comparison at 15 kg/m².s and 30-40 kW/m²

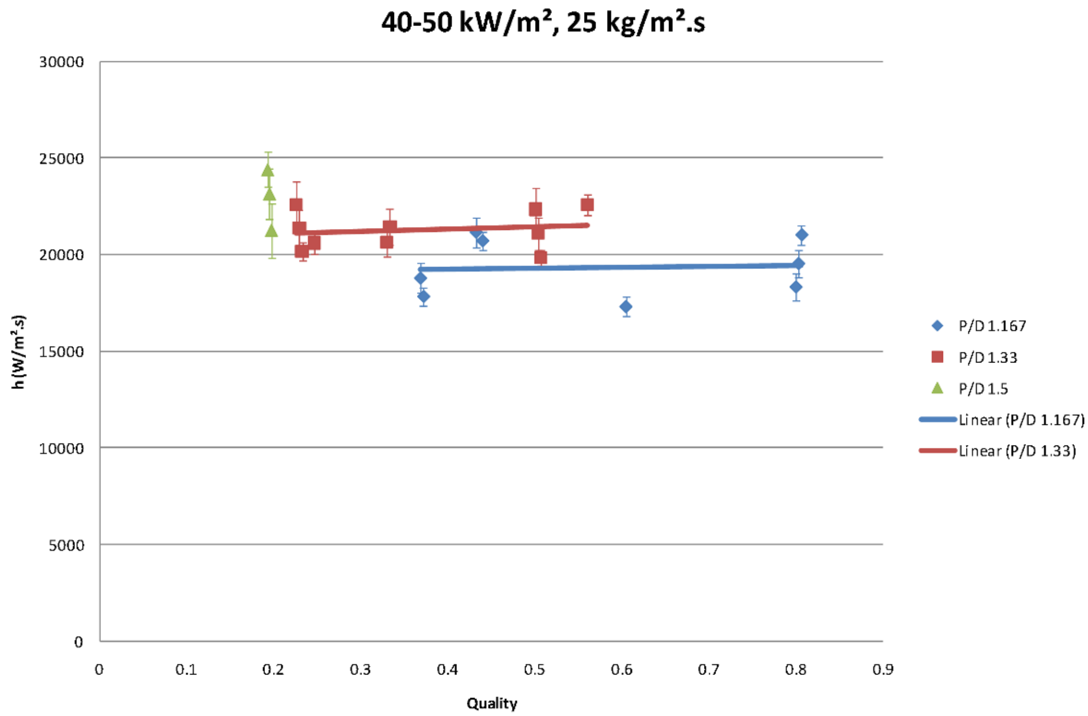

Figure 7-44 R-123 bundles comparison at 25 kg/m².s and 40-50 kW/m²

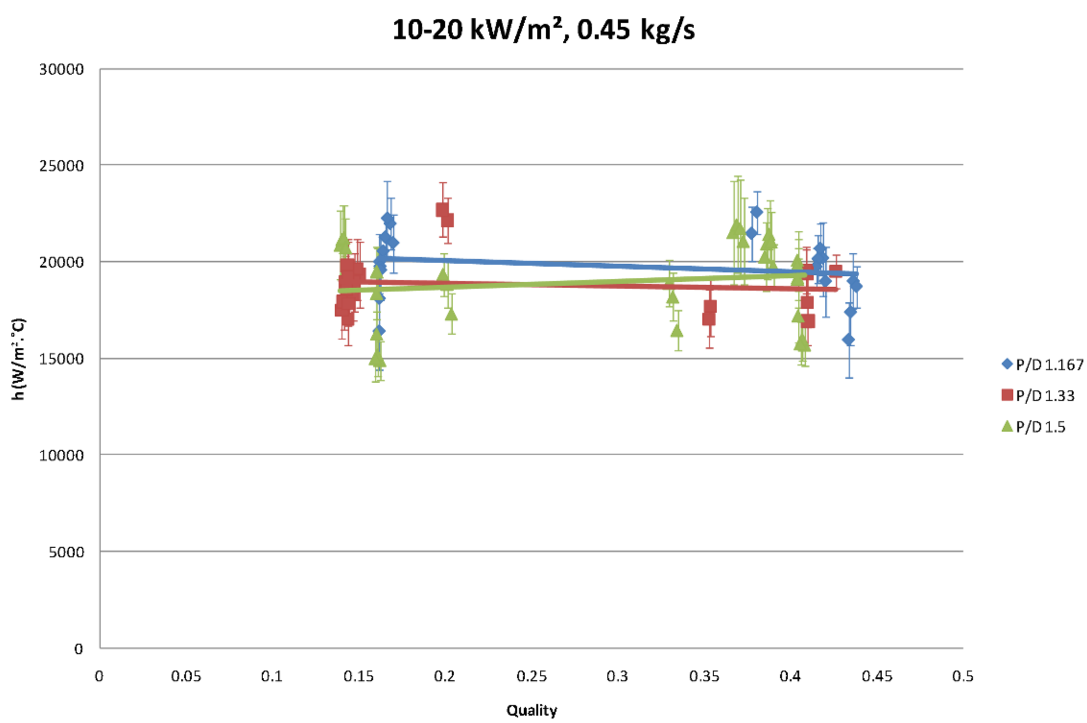

Figure 7-45 R-123 bundles comparison at 0.45 kg/s and 10-20 kW/m²

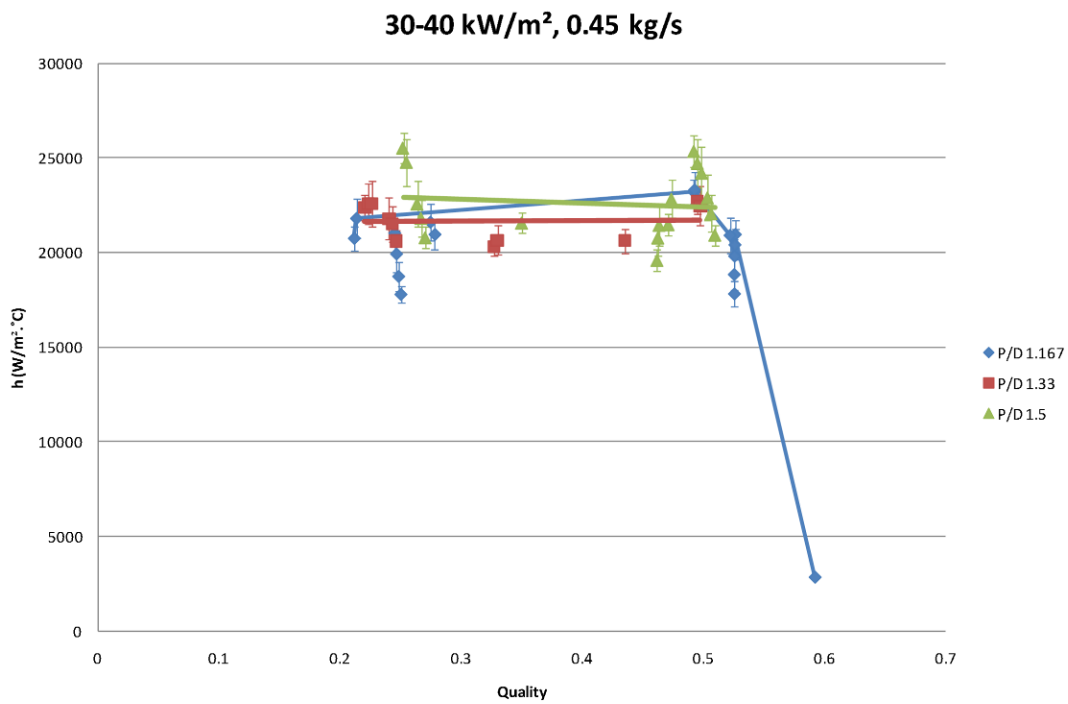

Figure 7-46 R-123 bundle comparison at 0.45 kg/s and 40-50 kW/m²

7.7 Conclusion

This chapter presented the experimental results of testing three tube pitches P/D 1.167, P/D 1.33, and P/D 1.5 for R-123 over Turbo BII-LP enhanced tube bundles. The most influential parameter affecting bundle performance is heat flux; next is quality. The effect of quality, however, is apparent only at certain flow rates and high qualities. Particularly, the flow pattern effect is noticeable for the points with two different values for the heat transfer coefficient for the same heat flux, mass flux, and quality. In general, all bundles show a similar performance at low heat flux, and evidently, the peak of the pool boiling curve exists in bundle boiling as well, but is shifted to the left (i.e. the curve peaks at a lower heat flux for convective boiling). Moreover, all tube bundles experience "the low heat flux enhancement" at the same heat flux; therefore, predictably, increasing the tube pitch beyond P/D 1.167 does not increase the low heat flux enhancement. Only the smallest tube pitch experiences a drop in performance at high qualities to that of a smooth tube. This phenomenon does not occur in the bigger tube pitches; there, only a quick decline in performance is experienced at high qualities. Also, the effect of flow pattern becomes significant at high qualities.

Chapter 8 Discussion

8.1 Introduction

This chapter interprets the trends observed in pool boiling and the different tube pitches, focusing mainly on the boiling mechanism in the tube enhancement and the flow patterns in a tube bundle. Examining the boiling mechanism can help clarify the different trends of pool as well as bundle boiling. In both pool and bundle boiling, three types of performance can be identified; rapid increase at low heat flux, decline at medium heat flux, and no change at high heat flux. These phenomena are explained at length in the coming sub-sections. As for bundle boiling, the factor of flow pattern is interconnected with the boiling mechanism and adds another level of complexity. This chapter also compares the two refrigerants and makes a recommendation based on the research results.

8.2 Boiling mechanism in enhanced tubes

Researchers usually use experiments with flow visualization capabilities to help explain the boiling mechanisms in enhanced tubes. In particular, pool boiling is the best condition under which flow visualization is beneficial. Figure 8-1 shows a microscopic photograph of the current enhanced tube surface configuration, revealing sub-surface tunnels with pores. Nakayama et al. (1980) Part I and Part II and Nakayama et al. (1982) are among the first to study the boiling mechanism and heat transfer modes of enhanced surfaces. Recalling that enhanced tubes, also called structured tubes, are essentially tunnels (sub-surface) with pores, they explained that in this configuration, boiling takes place in three phases as follows.

Figure 8-1 Microscopic picture of the tube surface

Phase I is called pressure build-up, and it occurs when the liquid inside the tunnels forms a meniscus; as the heat flux increases, the liquid starts evaporating, and the vapor pressure increases until a bubble starts to appear at the surface pore. In Phase II, as the heat flux continues to increase, the bubble continues to grow causing the pressure inside the tunnel to decrease; but due to the inertial force of the retreating immediate-liquid, the bubble growth increases, and the pressure in the tunnel decreases. In Phase III, once the pressure inside the tunnel decreases to below the pressure of the liquid pool, liquid enters the tunnel through inactive pores and closes all the pores by meniscus, and the cycle repeats.

Nakayama et al. (1980) Part II proposed that the enhanced tube heat flux for this cycle can be expressed as the summation of tunnel and external heat fluxes as expressed in Equation (8-1). The heat transfer taking place in the tunnels is due to liquid evaporation (latent heat), while the heat transfer taking place outside the tunnel is due to bubble agitation on the surface (convective heat). This can be expressed as

$$q'' = q''_{tunnel} + q''_{external} \,. \tag{8-1}$$

They reported that the liquid evaporation in the tunnels causes most of the performance enhancement rather than the bubble convection on the outer surface. In other words, q''_{tunnel} outweighs $q''_{external}$ due to evaporation of the liquid presence in the tunnels.

8.3 Pool boiling trend analysis

Recalling the pool boiling performance of R-134a on Turbo BII-HP and R-123 on Turbo BII-LP, the pool boiling curve can be divided into three regions (I, II, and III) as illustrated in Figure 8-2 and Figure 8-3. Region I is characterized by an increase in performance at low heat flux, while Region II is characterized by a slight decrease in performance; meanwhile, Region III is characterized by an insignificant change in performance with heat flux. The interpretation of the three regions follows, starting with the first.

- Inactive pores start to activate by evaporating the excess liquid in the tunnels; this process continues until the number of active pores reaches its maximum.
- As the heat flux continues increasing, another factor comes into play, the rate of liquid supply to the tunnels. Specifically, as the surface temperature increases, liquid supply to the tunnels decreases; thus, the performance starts to decrease.
- The flat region is considered one of the most controversial trends, and, to the author’s best knowledge, it has not been observed or studied in literature. In this region, the increase in the surface temperature does not affect the tube performance. One interpretation could be that as surface temperature continues increasing, the liquid amount entering the tunnels continues to go down, but some enters the tunnels by capillary action, even at high bubble density.

One can summarize this hypothesis as the change in trend being due mainly to liquid feed to the tunnels. Therefore, too much or not enough liquid in the tunnels can greatly affect the performance. This problem can be expressed as tunnel liquid flow optimization. At higher surface temperatures, the capillary action keeps the tunnels wet, which helps maintain a flattened trend for the heat transfer coefficient.

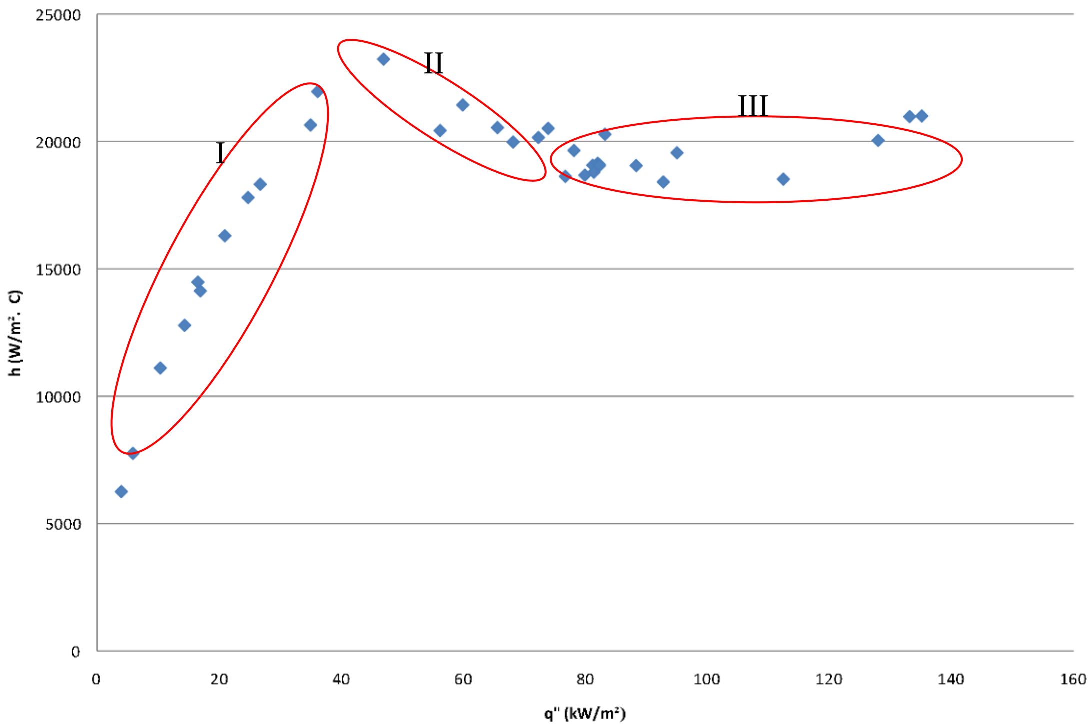

Figure 8-2 Pool boiling of R-134a on Turbo BII-HP

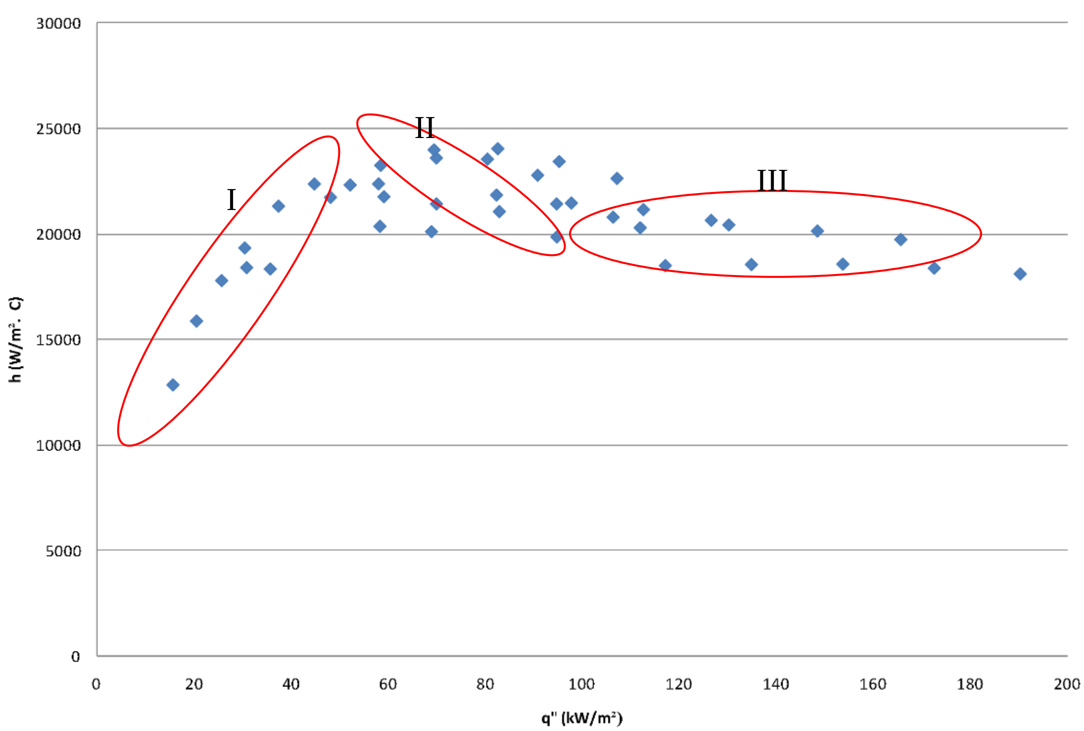

Figure 8-3 Pool boiling of R-123 on Turbo BII-LP

8.4 Bundle boiling trend analysis

Usually, convection on tube bundles increases the heat transfer performance for smooth tube bundles. But for enhanced tube bundles, this is not necessarily the case. One of the striking facts about boiling on enhanced tube bundles is that mass velocity has an insignificant effect on the bundle performance; this was observed in this study and elsewhere in literature. Furthermore, the effect of mass velocity is slightly significant at the low heat flux range (also low vapor qualities) only.

In general, the mass flux range for flooded evaporators is much smaller than that for in-tube boiling; hence, the pressure drop across the bundle is due mainly to static pressure rather than for friction pressure. For enhanced tube bundles, the current study showed that the pressure change across the bundle is insignificant for all studied tube pitches, mass velocities, and refrigerants. This reinforces the conclusion that frictional pressure drop is insignificant in enhanced tube bundles, hence the trivial effect due to flow convection. Therefore, neither static pressure nor mass velocity affects the bundle performance.

In all tested tube bundles, the following themes are observed; the steep rise in performance at low heat flux, performance decrease at medium heat flux, and flat trend at high heat flux. Given the pool boiling discussion of pore activation, the low heat flux enhancement in bundle performance is due to pore activation rather than flow convection. Pore activation takes place at a lower heat flux as a result of an impinging two-phase flow on the tube pores.

The performance declines at medium heat flux due to the decrease in liquid flow to the tunnels. Also, the bubble movement in the bundle as well as the tube bubble growth at medium heat flux causes the decrease in liquid flow to the tunnels, which is not as apparent in pool boiling because of the slight bubble convection.

At high heat flux range, the liquid feed becomes more restricted, but liquid is able to penetrate the pores by capillary action to keep the tunnels wet, producing an even heat transfer coefficient. In the case of high quality points and spray flow pattern, liquid depletes faster, and the tunnels start to dry-out causing the performance to revert to that of a smooth tube.

8.4.1 R-134a bundles' trend analysis

In the all bundles comparison plot (Figure 8-4), the low heat flux enhancement for the two higher pitches is much greater than for the lowest tube pitch. One plausible explanation is better pore activation caused by less restricted bubble impingement on inactive pores. Given that at P/D 1.33 the low heat flux enhancement reaches its maximum, beyond this tube spacing, the heat transfer coefficient does not show a significant increase. However, the tightest tube pitch (P/D 1.167) presents an unexpected trend. One assumption for this behavior could be that as bubbles travel in tight spaces, they restrict the growth of bubbles from the adjacent tubes. Ultimately then, restriction of flow of liquid to the tunnels seems to be responsible for the drop in performance of the smallest tube pitch.

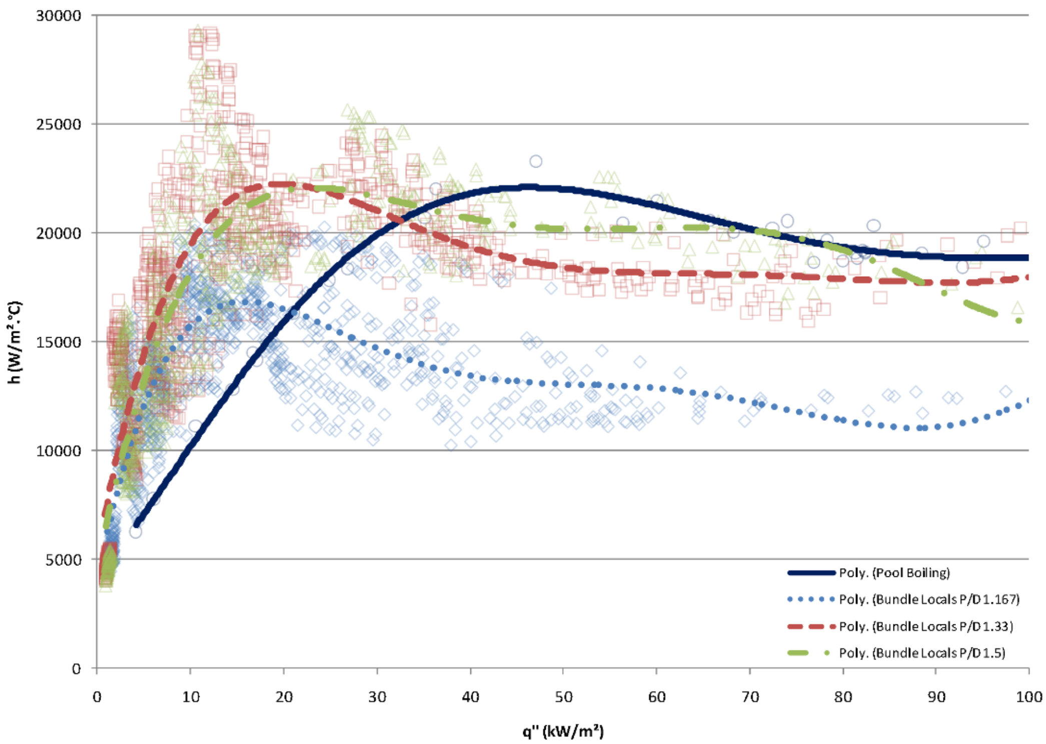

Figure 8-4 R-134a tube pitch comparison

8.4.2 R-123 bundles' trend analysis

Similar to the case of R-134a, this trend analysis shows significant enhancement at low heat flux as presented in Figure 8-5. The smallest tube pitch experiences a quick drop in performance similar to that of a smooth tube at high qualities. This is due to tunnel dry-out, a phenomenon reported in literature. The tunnel dry-out supports the hypothesis that liquid feed to the tunnels plays a major role in dictating the tube performance. It also supports the flow pattern effect being significant in that case. At the top of the bundle, the observed flow pattern is spray flow. The study also shows that although the bigger tube pitches show a quick drop in performance, such a drop in performance is not as severe as for the tightest tube pitch.

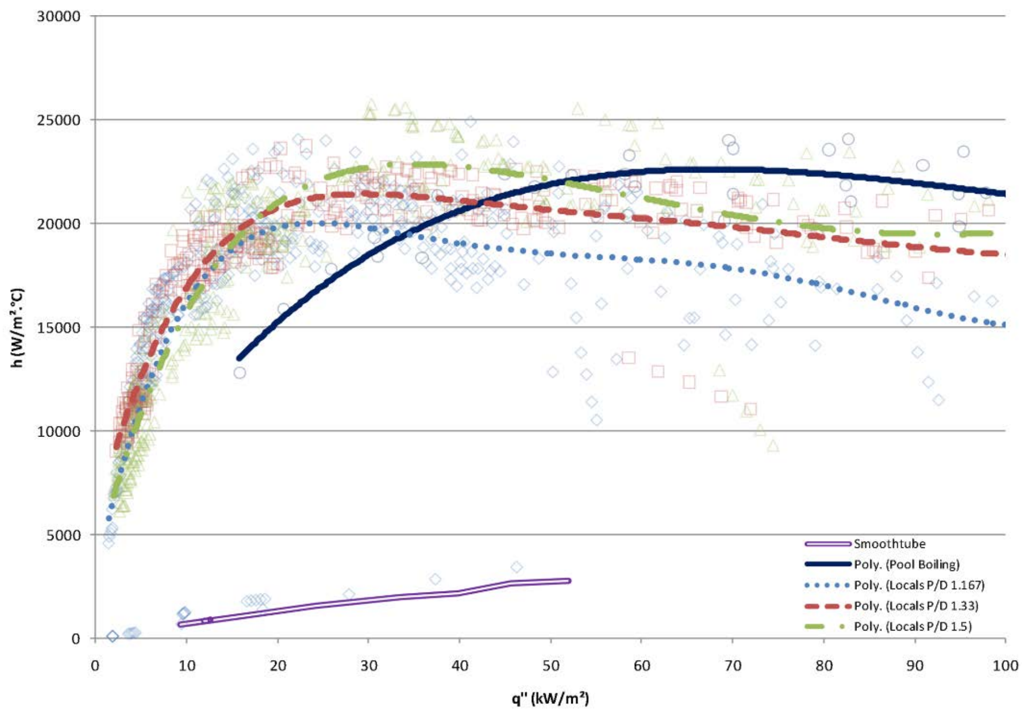

Figure 8-5 R-123 tube pitch comparison

8.4.3 The two refrigerants comparison

For the high heat flux range in all bundles, the increase in tube pitch causes the performance to approach that of pool boiling. This can be due to bubbles' free travel in wider spaces, which makes bubbles on the tubes form without much restriction. Also, all cases show a low heat flux enhancement. Notably, the P/D 1.167 tube pitch in the R-134a and R-123 shows the special behaviors explained previously.

Obviously, from the heat transfer point of view, P/D 1.5 shows the best results, but P/D 1.33 shows almost comparable performance. However and just as in a lot of engineering applications, the improvement of one variable causes a drawback in another; for with the increase in tube spacing comes the increase in refrigerant charge. For an optimum refrigerant charge, then, the P/D 1.33 seems to present the best results for the two refrigerants.

8.5 Conclusion

Based on the understanding of the boiling mechanism in tube enhancement and flow pattern in tube bundles, the trends of pool boiling and different bundle pitches can be clarified. Indeed, the persistent trend in all studied cases can be described as follows: the heat transfer coefficient experiences steep increase at low heat flux, decline at medium heat flux, and no change at high heat flux. Liquid feed to the tube tunnels seems to be a strong reason for this phenomenon. Excess liquid in the tunnels causes a performance decrease, and the tunnel dry-out causes the performance to revert to that of a smooth tube. Meanwhile, in tube bundles, the mass velocity has an insignificant effect on the performance. The smallest tube pitch for the two refrigerants shows the most varied behavior of all tested bundles. Additionally, flow restriction in the smallest tube pitch in both cases seems to be the reason for the significant low performance in R-134a, and tunnel dry-out for R-123. Therefore, P/D 1.33 seems to be the tube pitch offering optimum performance for the two refrigerants.

Chapter 9 Conclusion

The current research, funded by ASHRAE, addresses the experimental investigation of the heat transfer impact of tube pitch on highly enhanced tube bundle, which is particularly applicable for flooded evaporators. This study, considered the first to address the effect of tube pitch on enhanced tube bundles under convective heat transfer, focused on three tube pitches (P/D 1.167, 1.33, and 1.5) and two refrigerants (R-134a and R-123). The types of tubes are Turbo BII-HP for R-134a and Turbo BII-LP for R-123. The test section utilized 20 staggered tubes, designed as a four passes heat exchanger. Also, tube diameter and length are 0.01905 (0.75 inches) and 1 m (39.37 inch), respectively.

The water passage of the middle four tubes was instrumented with thermistors for measuring the local temperature; each tube carried seven thermistors, two for measuring tube inlet and outlet and five local thermistors. Water pressure measurement was also included. Also, refrigerant pressure and temperature were measured at each height of the bundle. Additionally, a pre-boiler was installed upstream of the test section for controlling the inlet vapor quality, and the test section and the pre-boiler were water heated.

The data analysis in this research is local to one location in the tube bundle and included determining the local heat transfer coefficient, local heat flux, and local quality. The tube average heat transfer coefficient was also determined. Next, water pressure was taken into account when determining the local and average heat flux. This introduced a new method called the Enthalpy Based Heat Transfer analysis or "EBHT," which replaced the Log Mean Temperature or "LMTD", as the former also accounts for energy added due to friction.

A Modified Wilson plot method was performed to determine the water-side heat transfer coefficient yielding the determined temperature measurement uncertainty as low as ±0.015 °C. Also, a Monte Carlo-based simulation was devised for determining the uncertainty in the temperature slope, and the heat transfer coefficient uncertainty was calculated for each data point.

For the six tube bundles were tested, and before data collection began for each bundle, an energy balance between the water side and the refrigerant side was conducted to verify instrument accuracy. Then, data was collected according to a test matrix based on three controlling variables: heat flux, mass flux, and inlet quality. The range of each variable was fixed for all six bundles to produce data helpful for comparison among the three bundles.

Pool (nucleate) boiling investigation was part of this study for which the trend of the heat transfer coefficient vs. heat flux was produced for each refrigerant-tube combination. Bundle results were presented as outcomes of the effect of heat flux, mass flux, and local quality on the heat transfer coefficient and bundle data were compared to the single tube data. All bundles results showed that flow convection has an insignificant effect on performance.

For R-134a results, the data showed that the performance is dominated mainly by heat flux. The smallest tube pitch (P/D 1.167) presented significantly lower results than did P/D 1.33 and P/D 1.5. Also, at low heat flux, all three tube bundles showed more enhancement than did nucleate boiling. Finally, the results for P/D 1.5 are slightly higher than for P/D 1.33. For R-123 results, all three bundles showed performance enhancement at low heat flux. Moreover, both heat flux and local quality have a significant effect on the bundle performance, with the effect of heat flux outweighing the effect of quality. At high qualities and for certain flow patterns, the P/D 1.167 bundle showed a rapid decrease in performance, reaching that of the smooth tube. This does not appear to be the case for the bigger tube pitches.

The trends in these results reveal that all bundles experience an increase in performance at low heat flux, a decrease at medium heat flux, and even trend at high heat flux. An interpretation for those trends according to flow mechanism in enhanced tubes and bundle flow pattern shows that the rate of liquid feed to the tunnels could be the main cause. Also, excess liquid in tunnels and tunnel dry-out have a negative effect on the tube performance. The rapid increase in performance in tube bundles is understood to be the result of faster pore activation caused by impinging two phase flow on the tubes. Ultimately, for optimum refrigerant charge, P/D 1.33 is the best tube pitch for optimal performance for both refrigerants.

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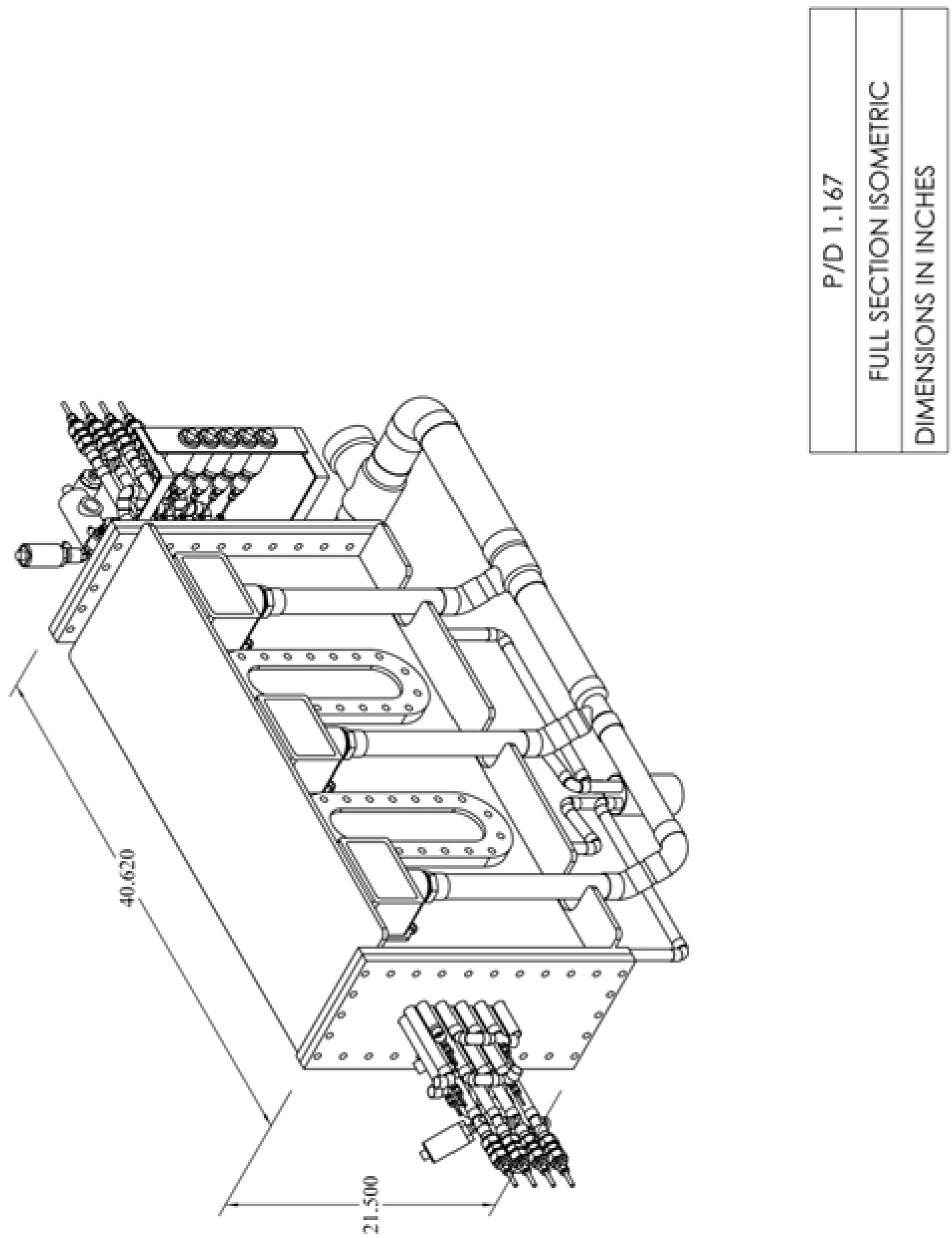
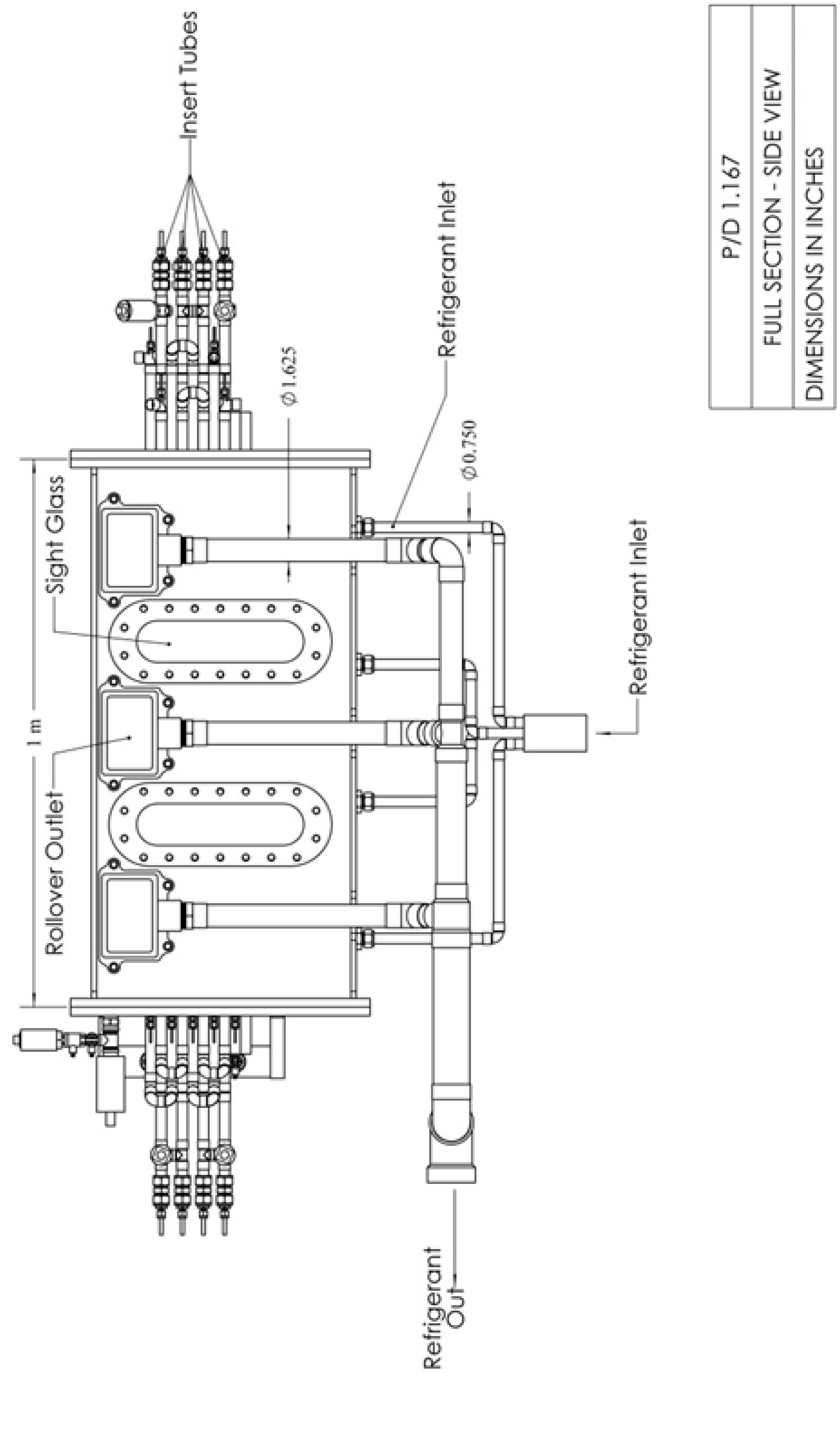
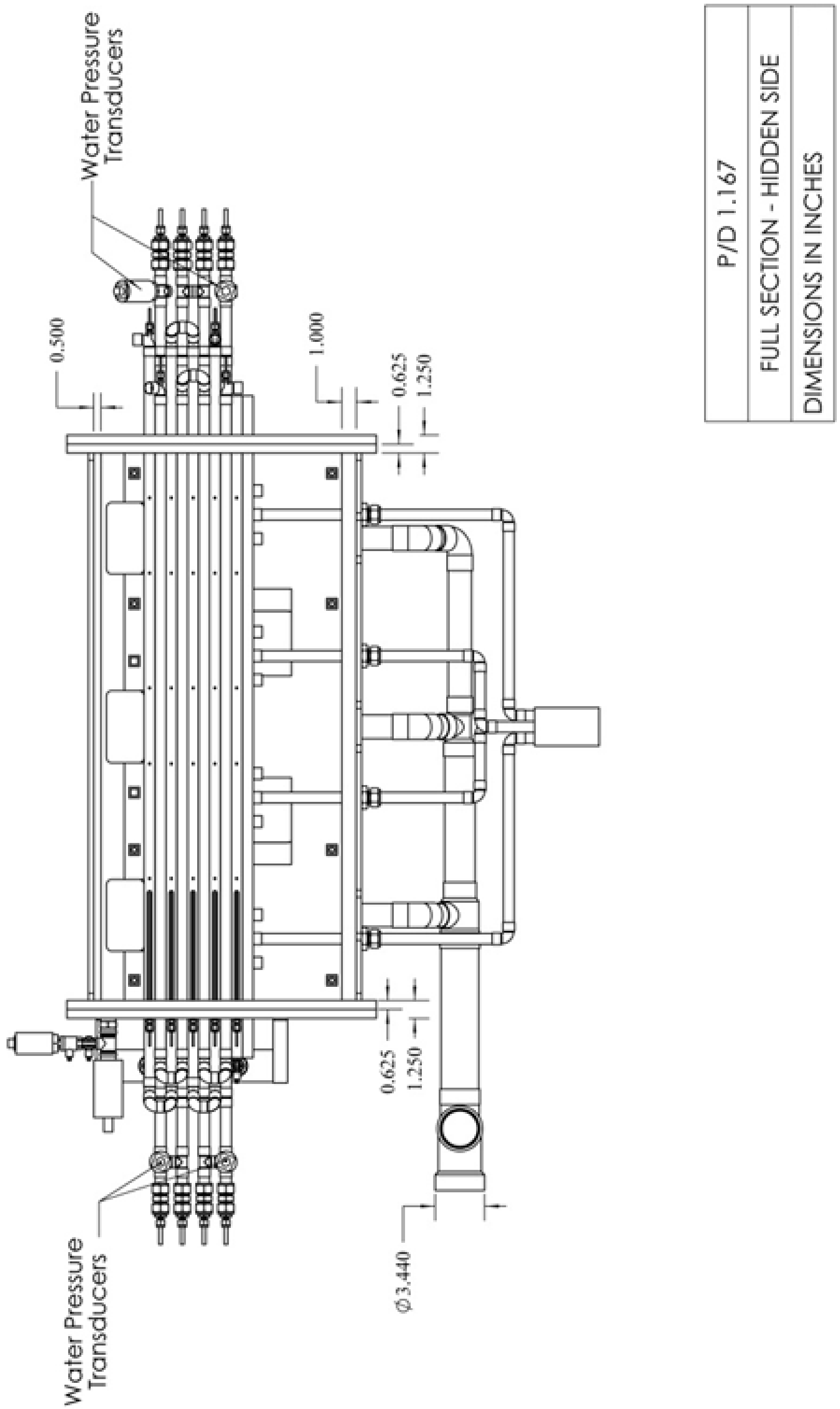
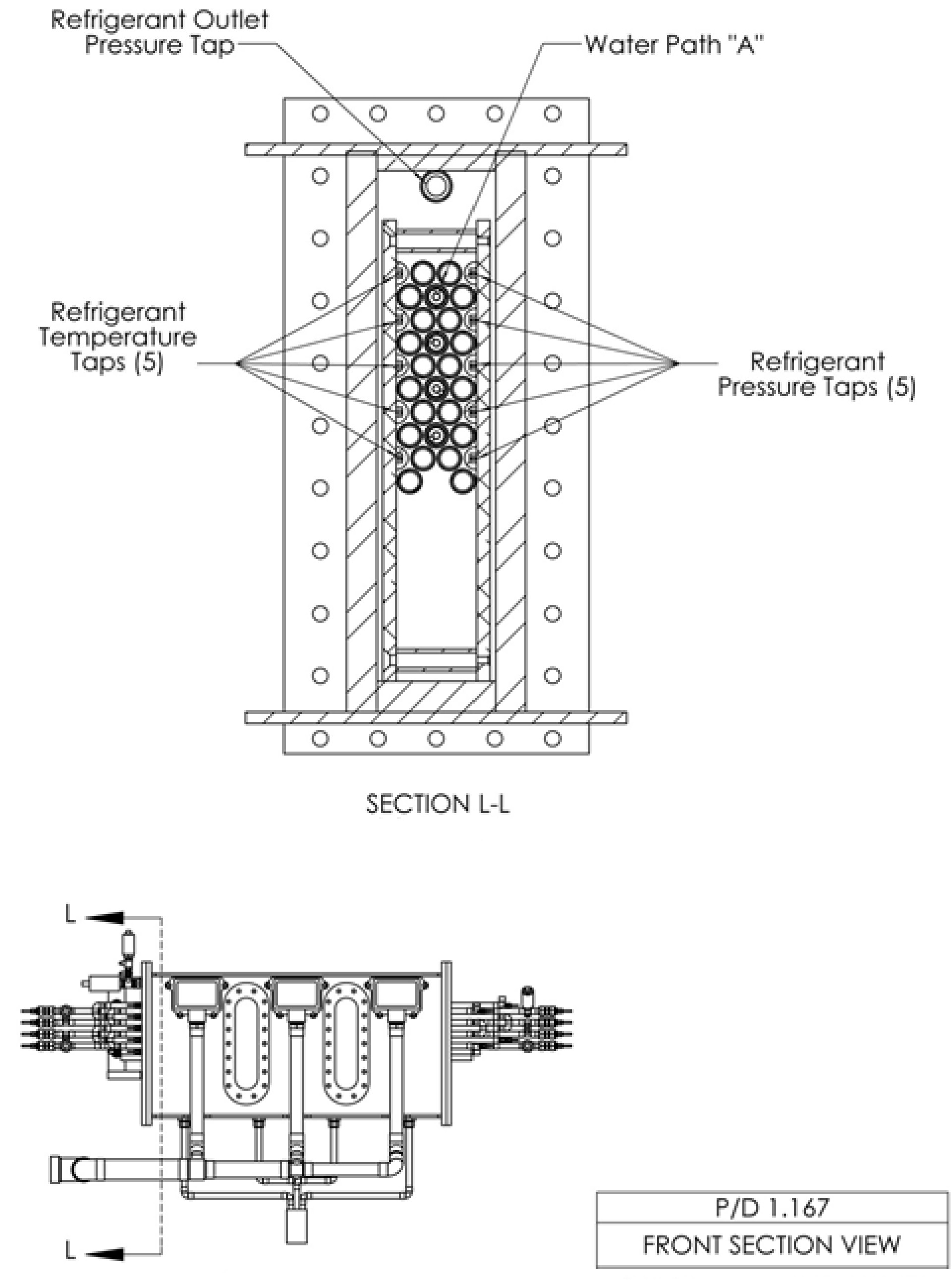
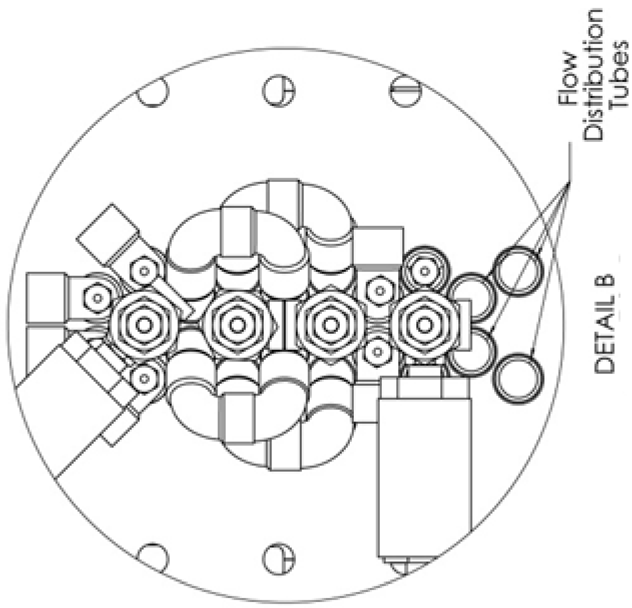
Appendix A Test Section Drawings

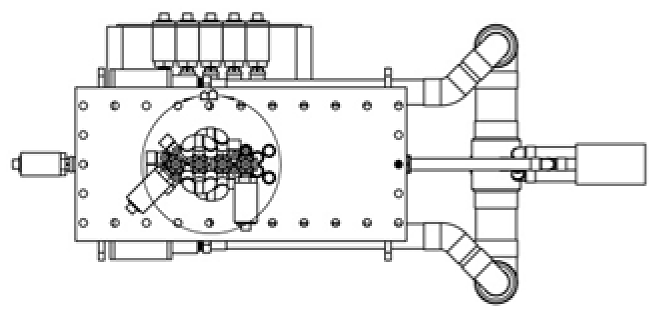

40.620
21.500
P/D 1.167
FULL SECTION ISOMETRIC
DIMENSIONS IN INCHES


Insert Tubes
Refrigerant Inlet
Refrigerant Inlet
Sight Glass
Rollover Outlet
1 m
Ø 1.625
Ø 0.750
Refrigerant Out
P/D 1.167
FULL SECTION - SIDE VIEW
DIMENSIONS IN INCHES


Water Pressure Transducers
0.500
1.000
0.625
1.250
0.625
1.250
Ø3.440
Water Pressure Transducers
P/D 1.167
FULL SECTION - HIDDEN SIDE
DIMENSIONS IN INCHES


Refrigerant Outlet Pressure Tap
Water Path "A"
Refrigerant Temperature Taps (5)
Refrigerant Pressure Taps (5)
SECTION L-L
L
L
P/D 1.167
FRONT SECTION VIEW

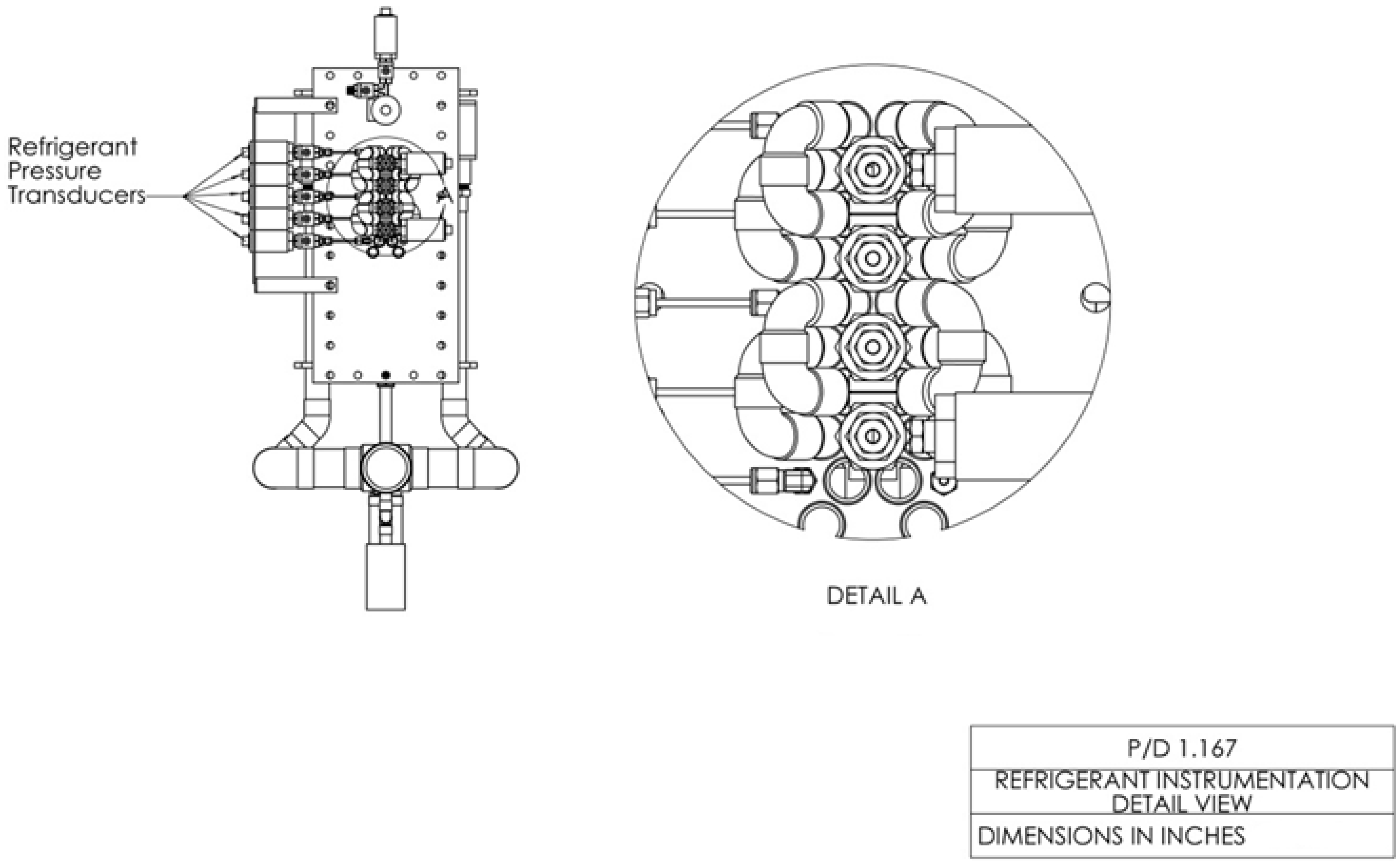


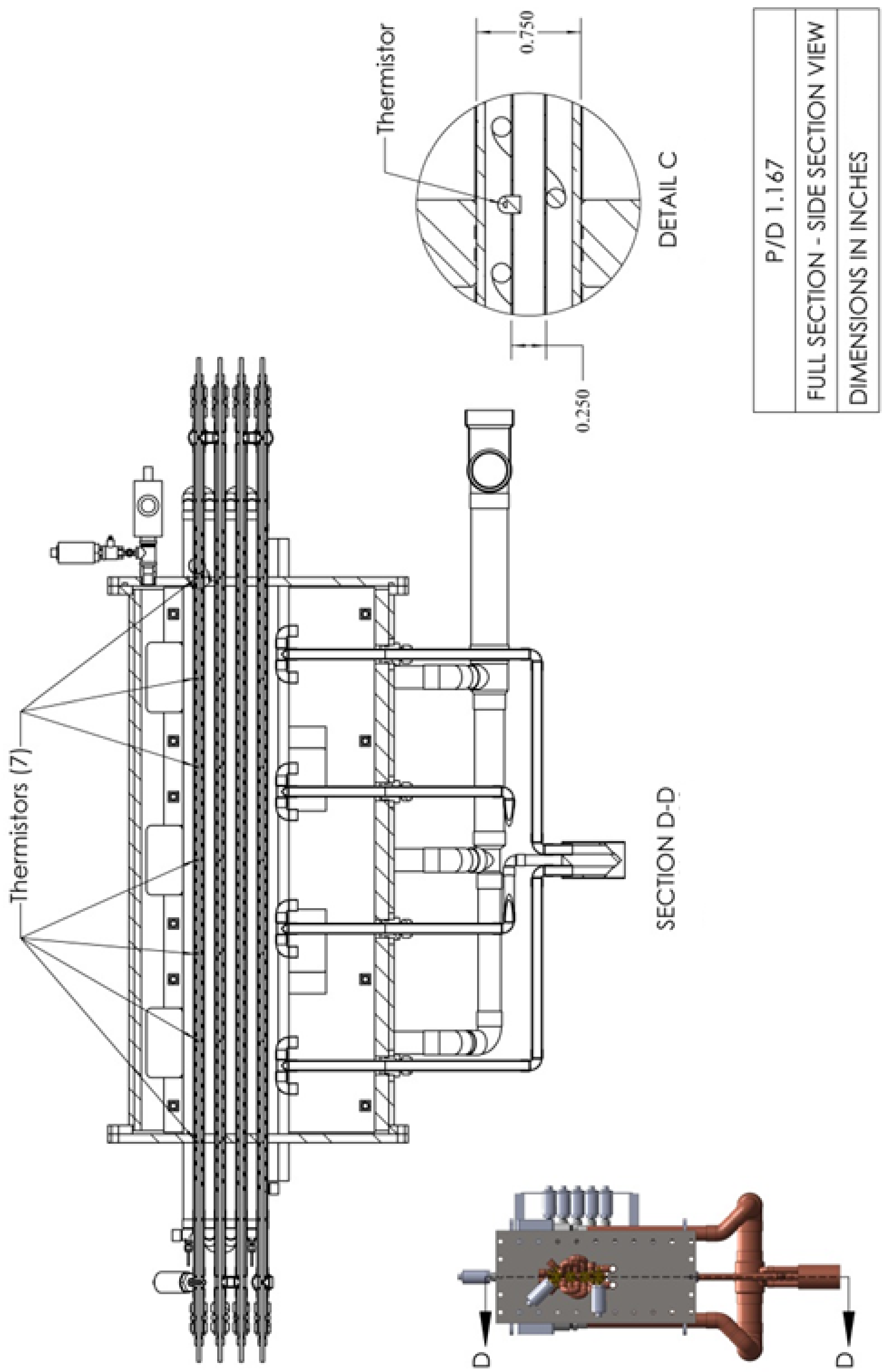


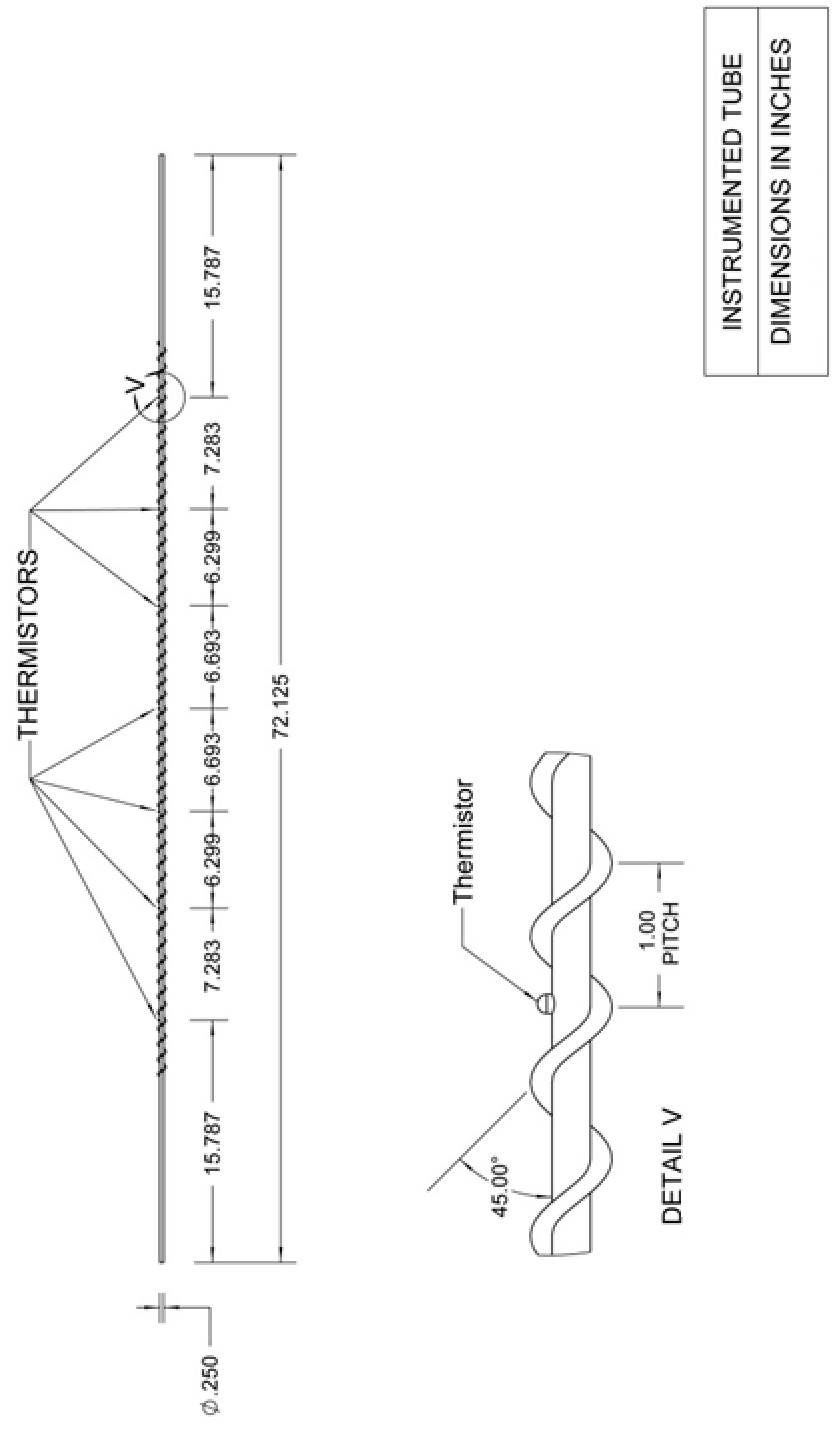
P/D 1.167

WATER INLET DETAIL VIEW

DIMENSIONS IN INCHES


Refrigerant
Pressure
Transducers
A
DETAIL A
P/D 1.167
REFRIGERANT INSTRUMENTATION
DETAIL VIEW
DIMENSIONS IN INCHES


Thermistors (7)
Thermistor
0.750
0.250
DETAIL C
SECTION D-D
P/D 1.167
FULL SECTION - SIDE SECTION VIEW
DIMENSIONS IN INCHES
D
D


INSTRUMENTED TUBE
DIMENSIONS IN INCHES
THERMISTORS
V
15.787
7.283
6.299
6.693
6.693
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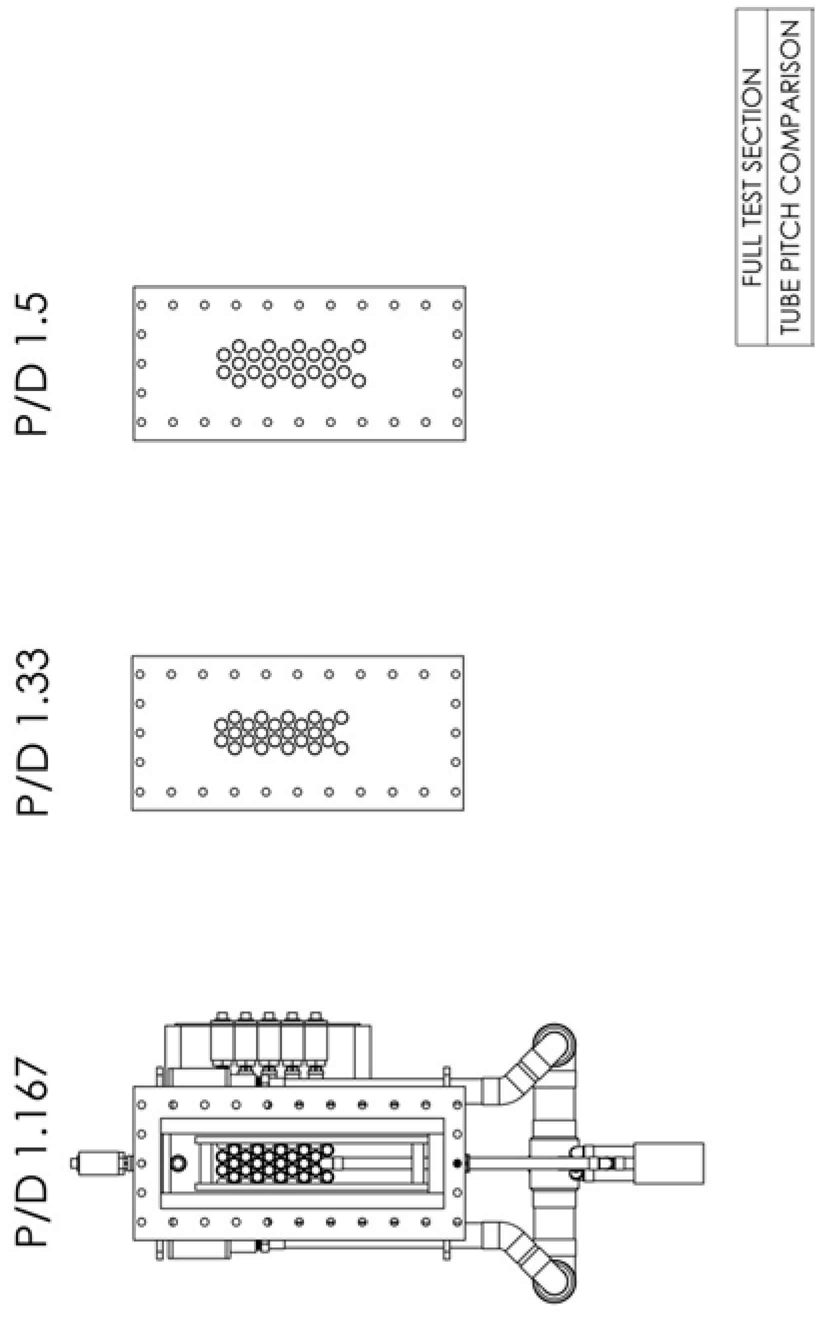
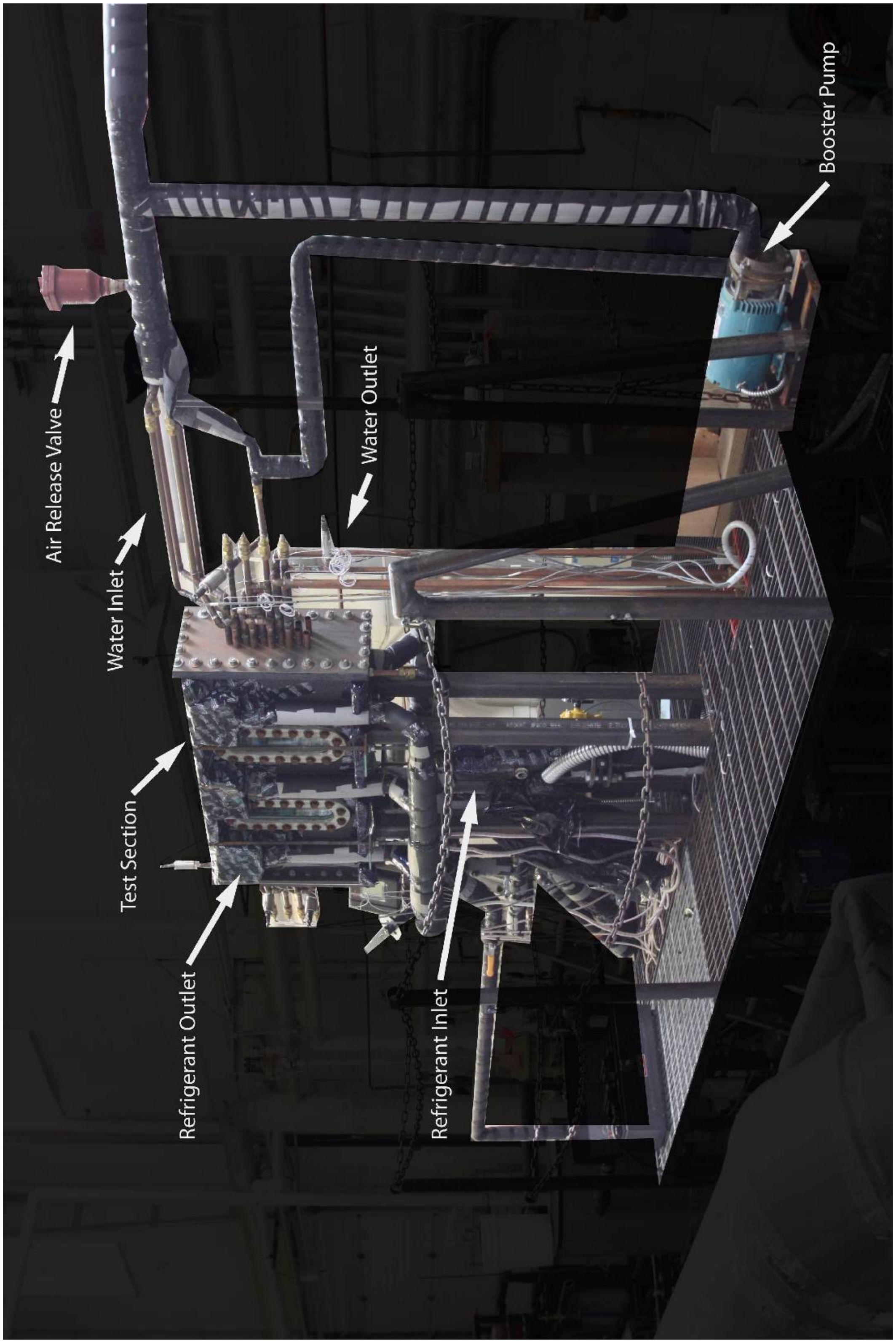
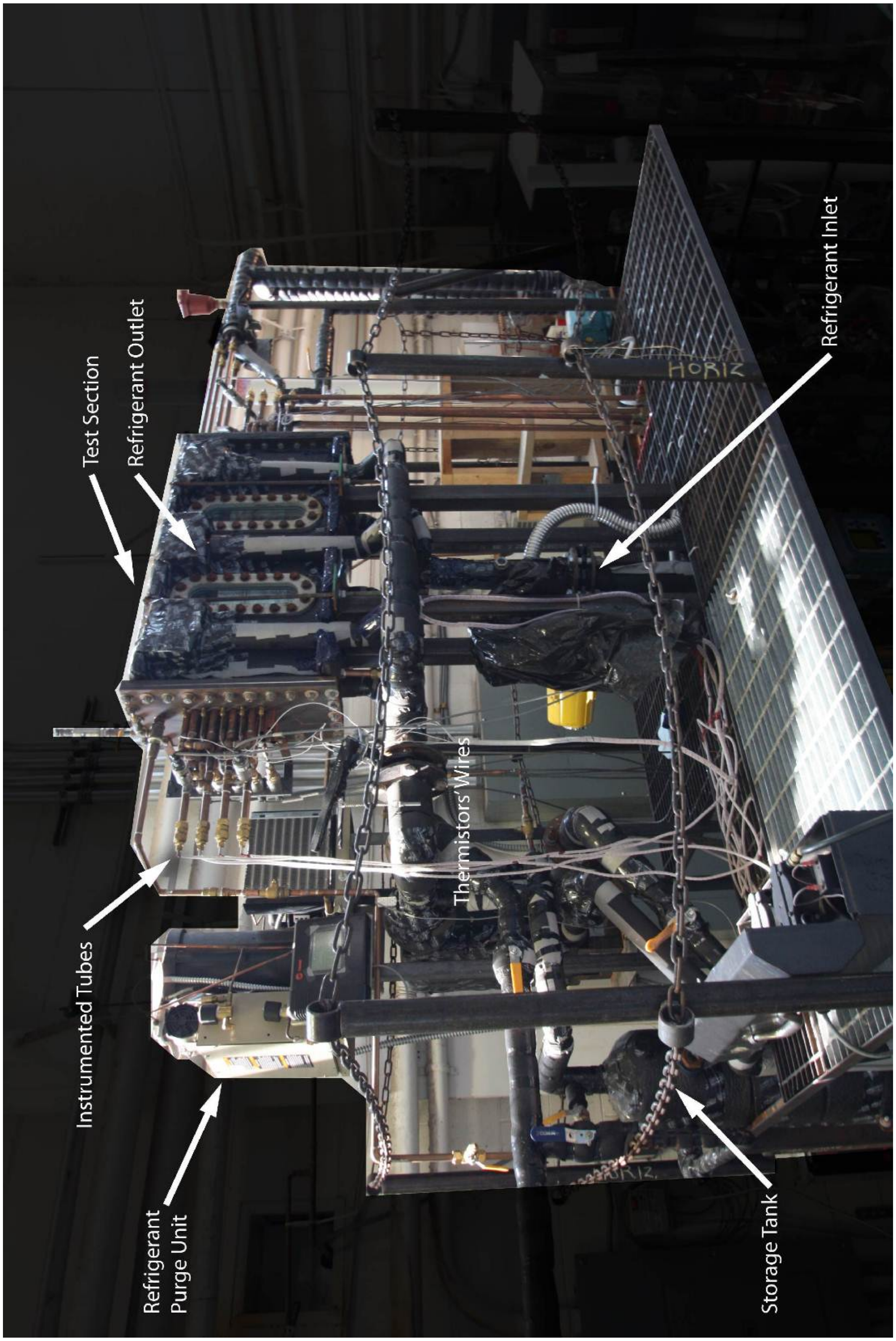
7.283
15.787
72.125
∅.250
Thermistor
1.00
PITCH
45.00°
DETAIL V

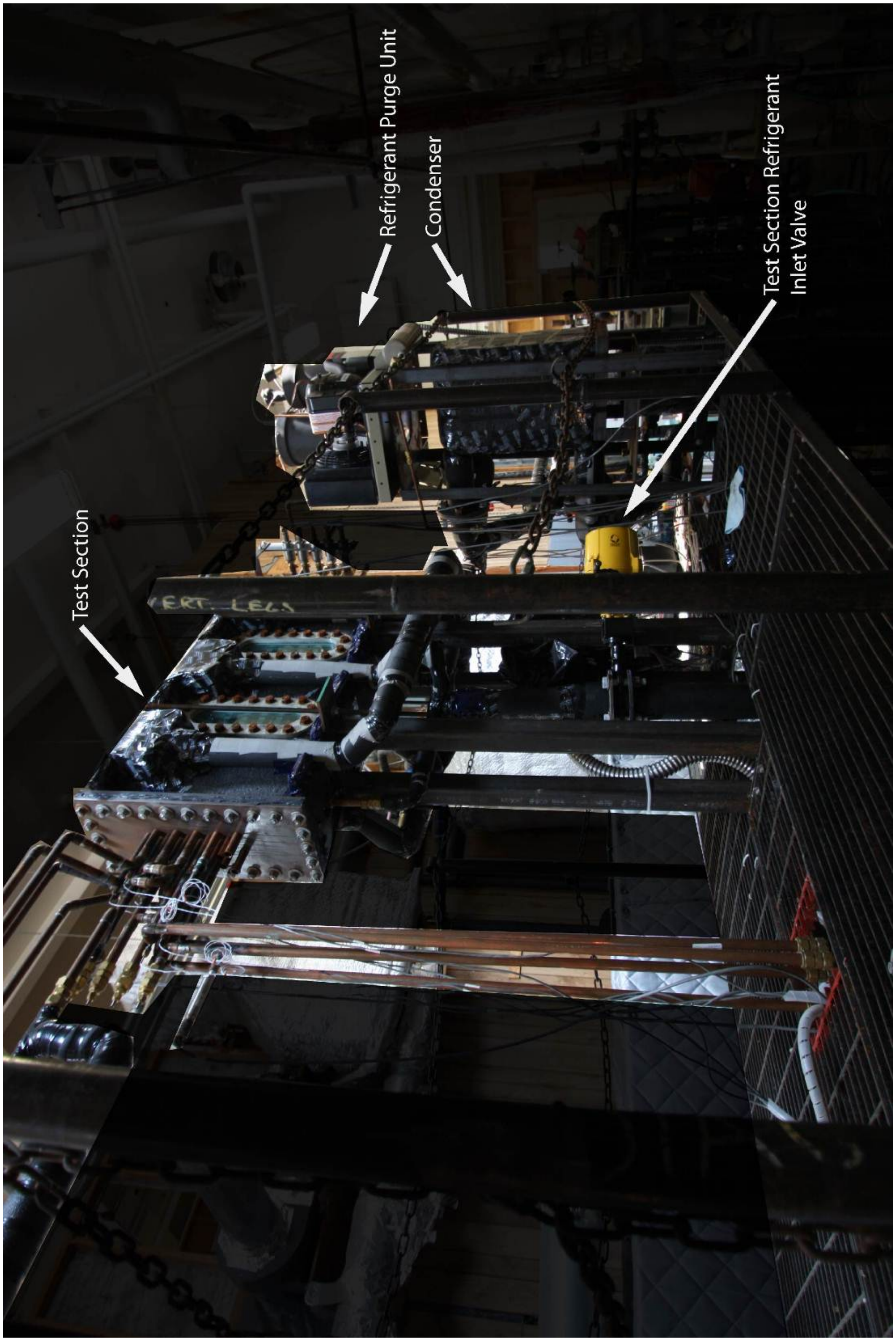


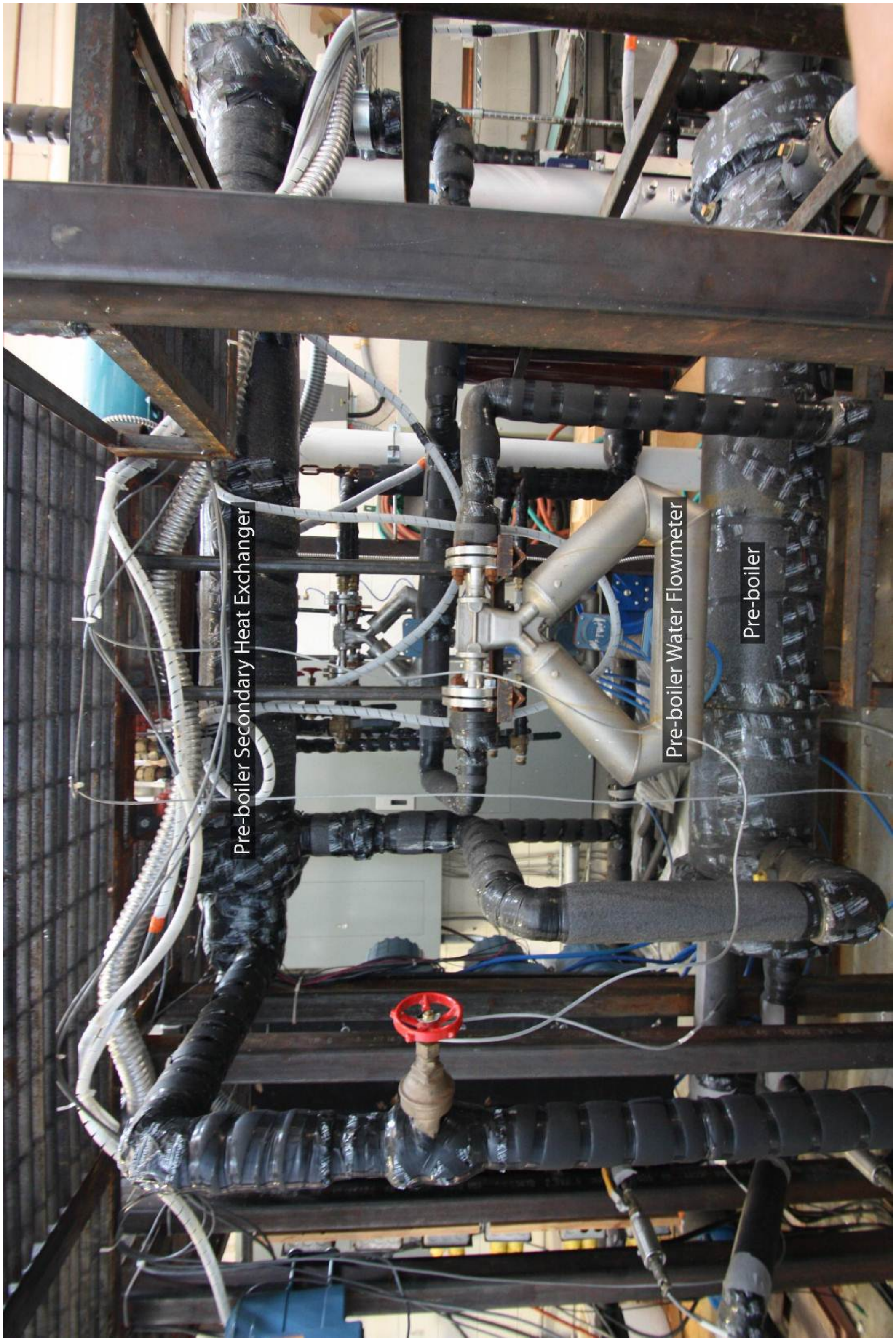
P/D 1.5
P/D 1.33
P/D 1.167
FULL TEST SECTION
TUBE PITCH COMPARISON

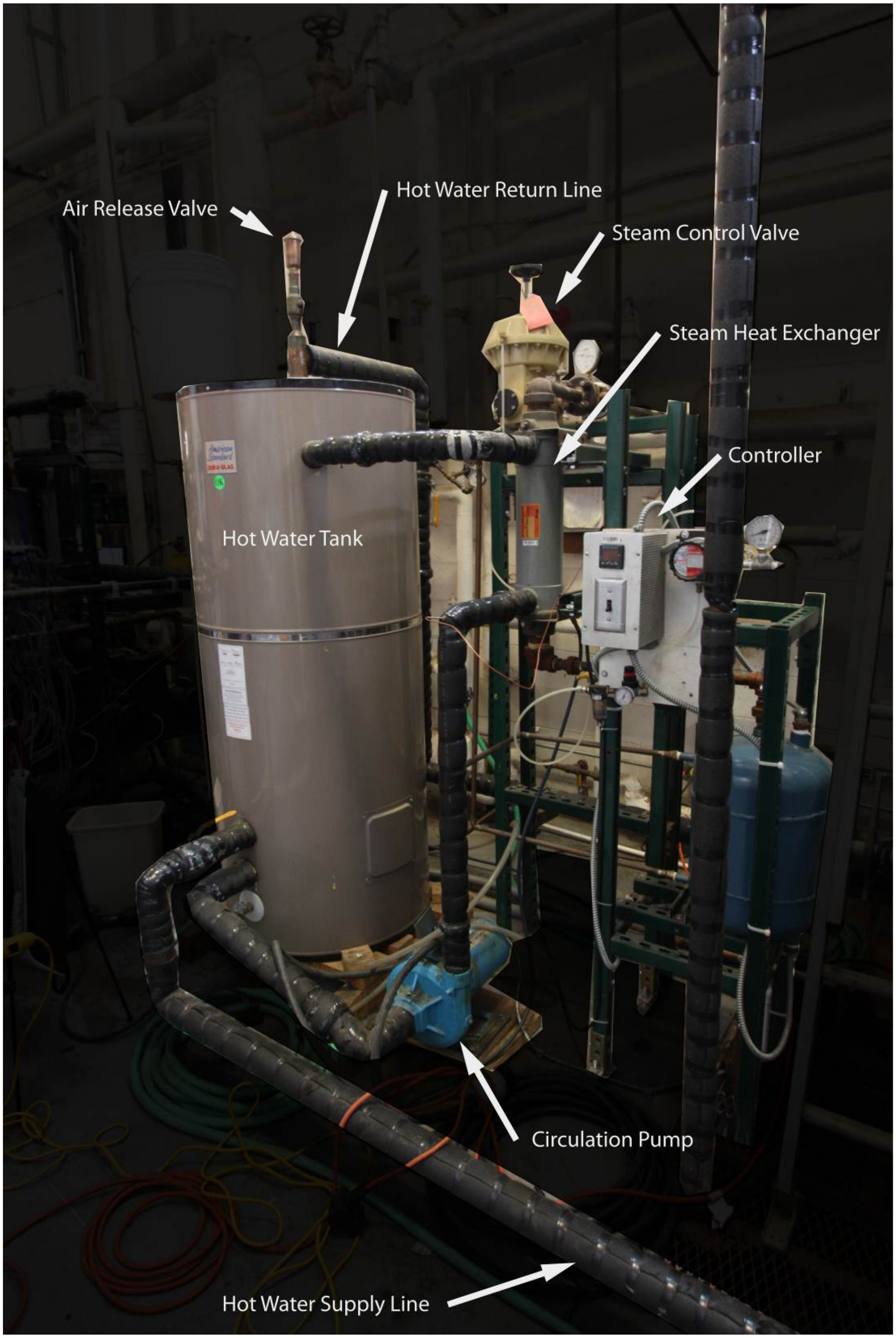
Appendix B Visuals of the Test Facility

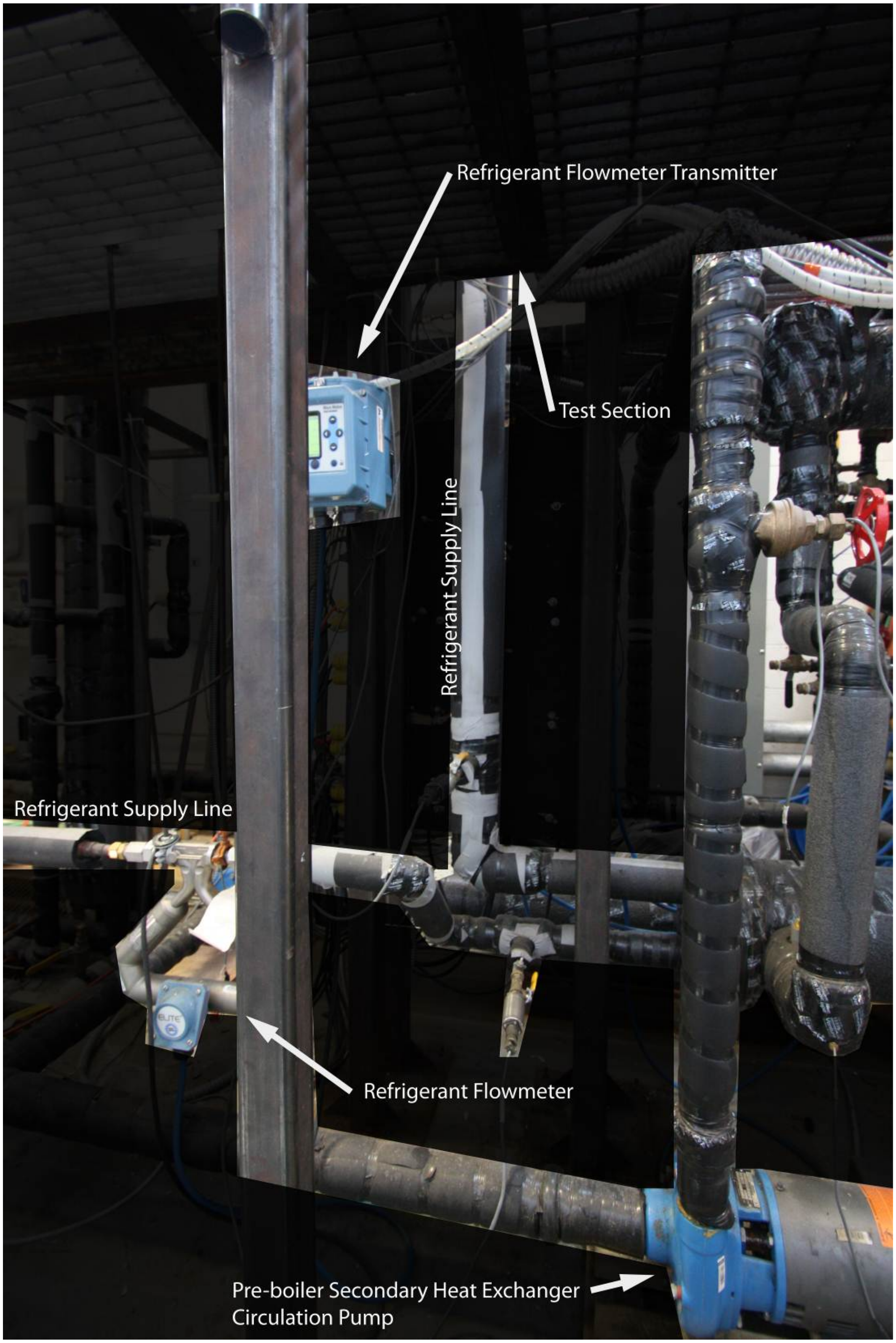

Air Release Valve
Water Inlet
Water Outlet
Booster Pump
Test Section
Refrigerant Outlet
Refrigerant Inlet

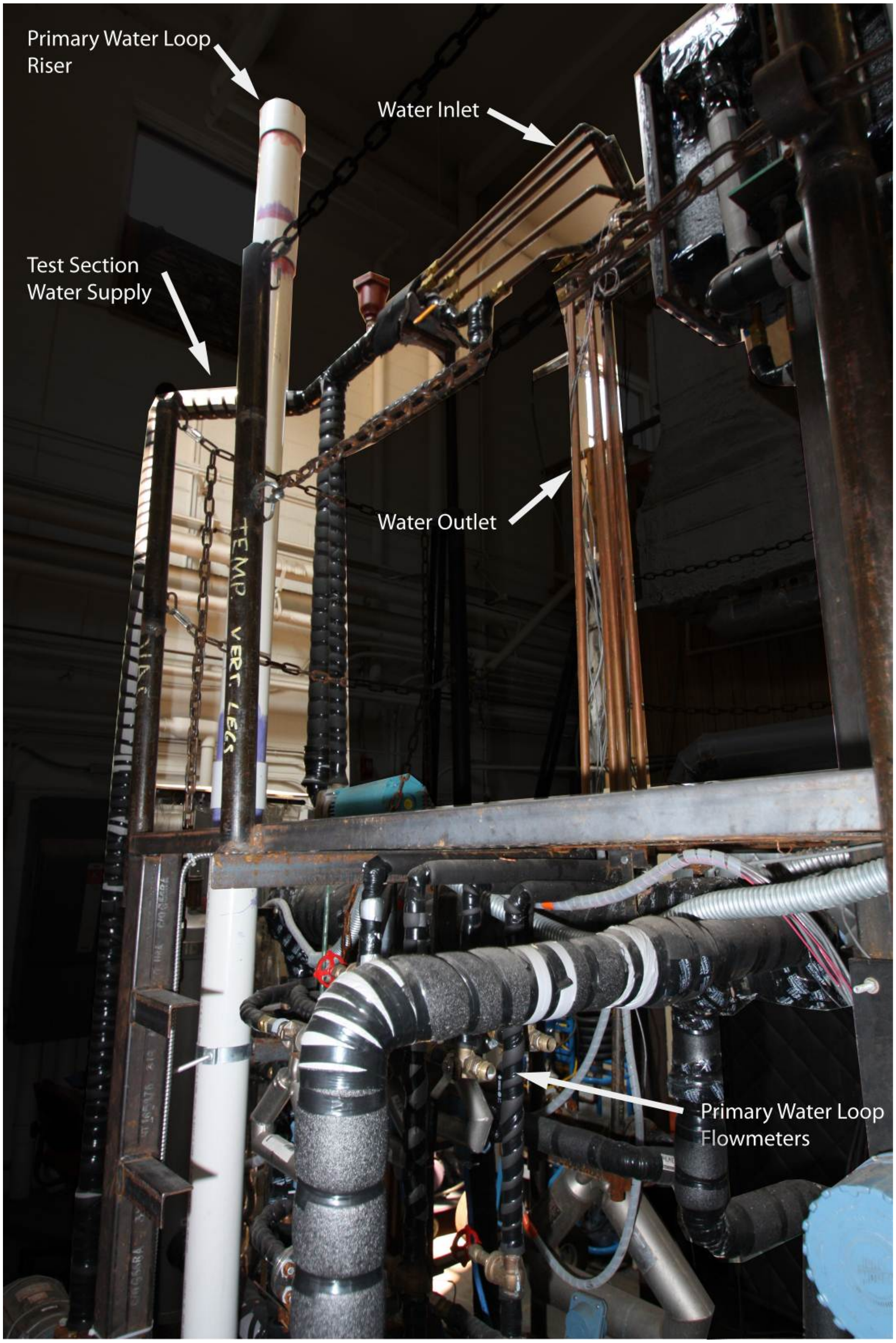

Test Section
Refrigerant Outlet
Refrigerant Inlet
HORIZ
Thermistors' Wires
Instrumented Tubes
Refrigerant
Purge Unit
Storage Tank

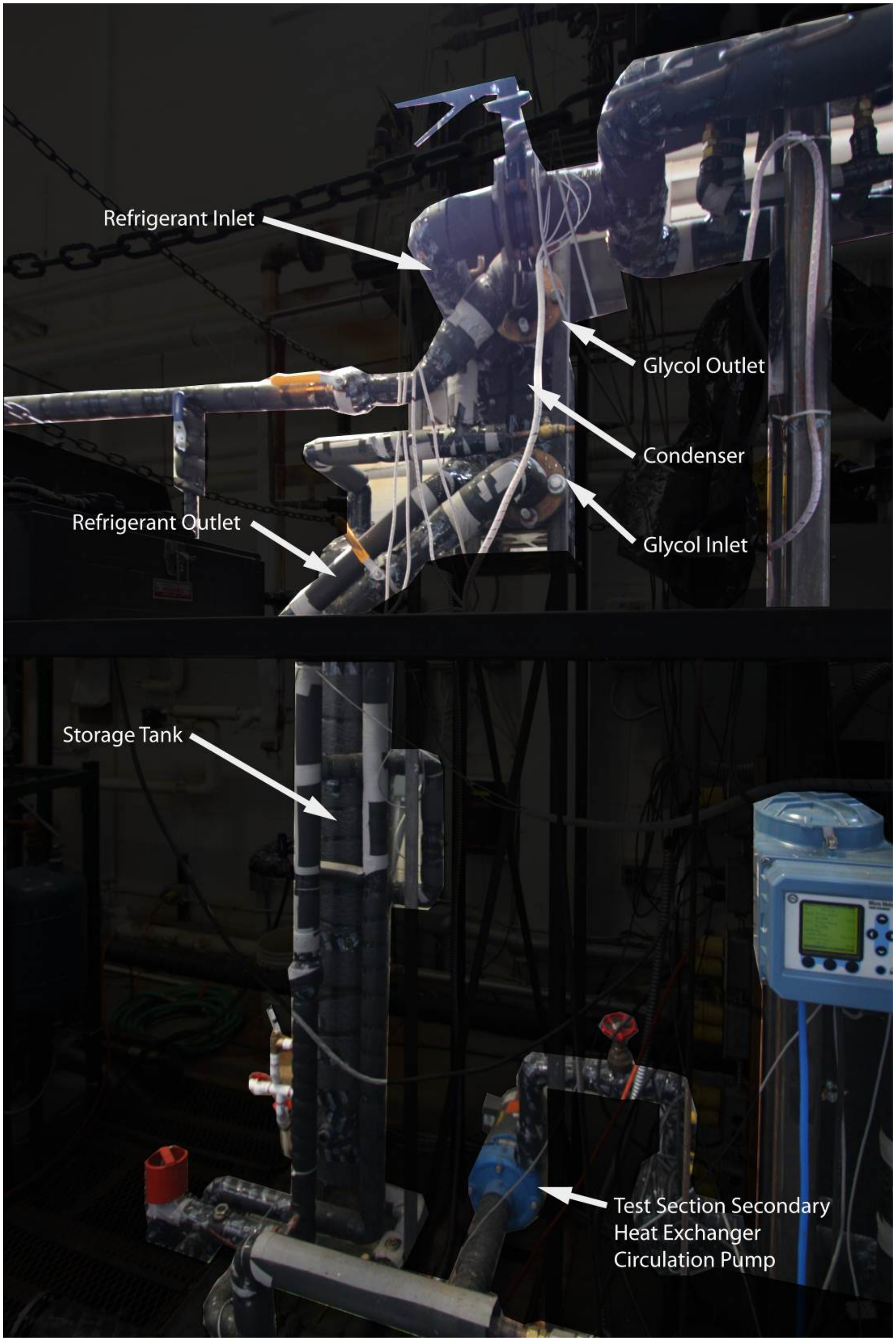

Refrigerant Purge Unit
Condenser
Test Section Refrigerant
Inlet Valve
Test Section


Pre-boiler Secondary Heat Exchanger
Pre-boiler Water Flowmeter
Pre-boiler

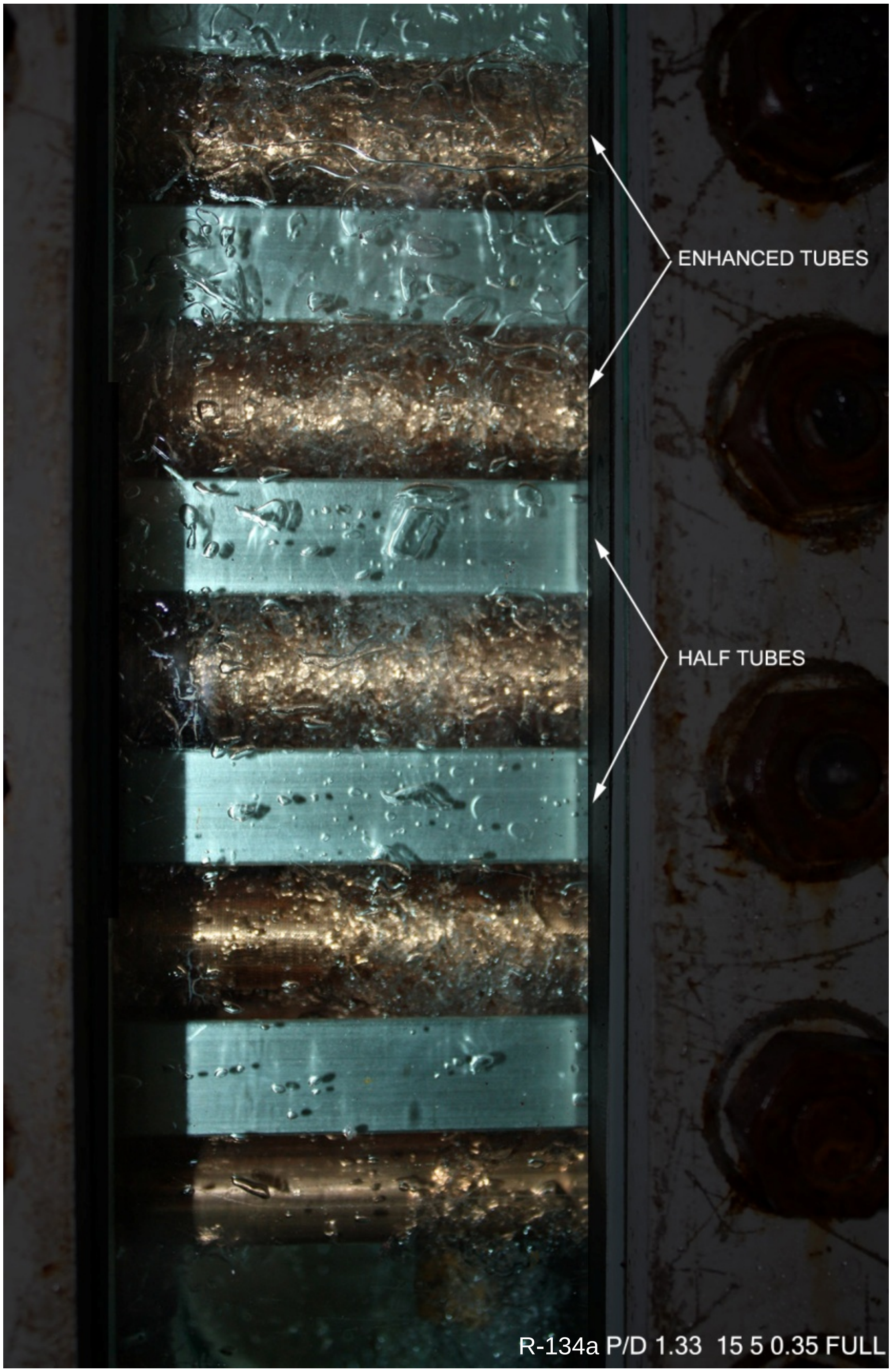

Air Release Valve
Hot Water Return Line
Steam Control Valve
Steam Heat Exchanger
Controller
Hot Water Tank
Circulation Pump
Hot Water Supply Line

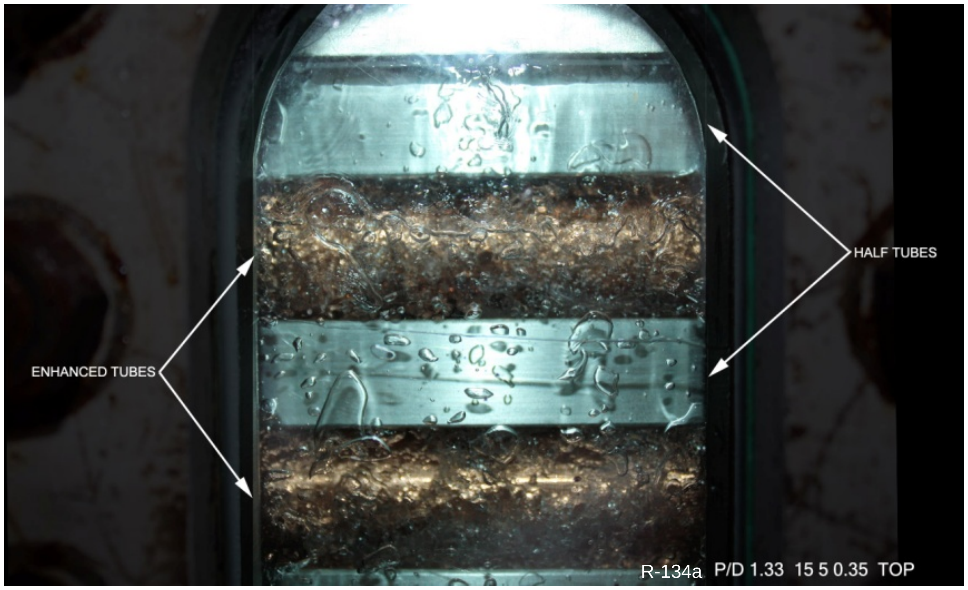

Refrigerant Flowmeter Transmitter
Test Section
Refrigerant Supply Line
Refrigerant Supply Line
Refrigerant Flowmeter
Pre-boiler Secondary Heat Exchanger
Circulation Pump

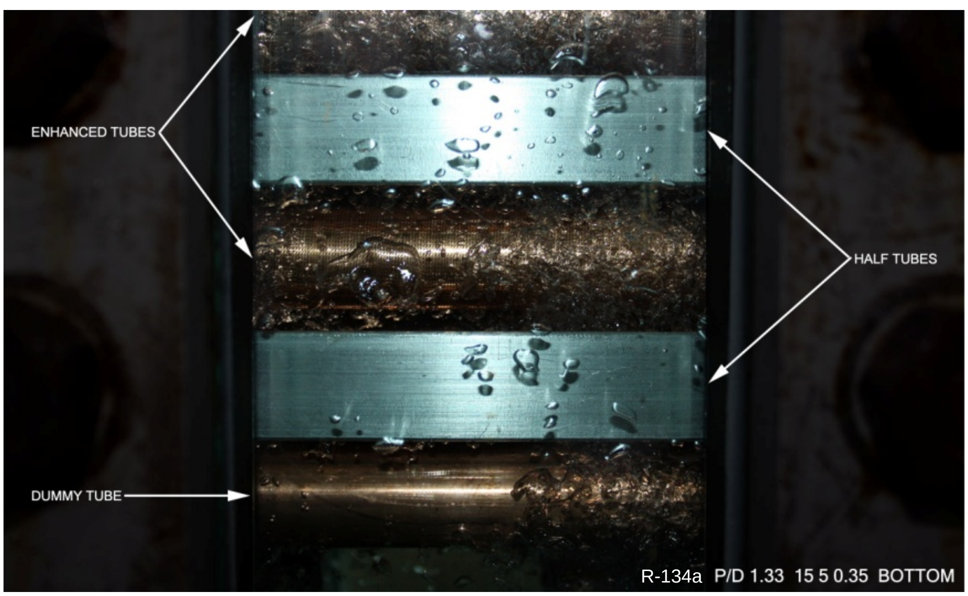

Primary Water Loop
Riser
Water Inlet
Test Section
Water Supply
Water Outlet
TEMP VERT LEGS
Primary Water Loop
Flowmeters

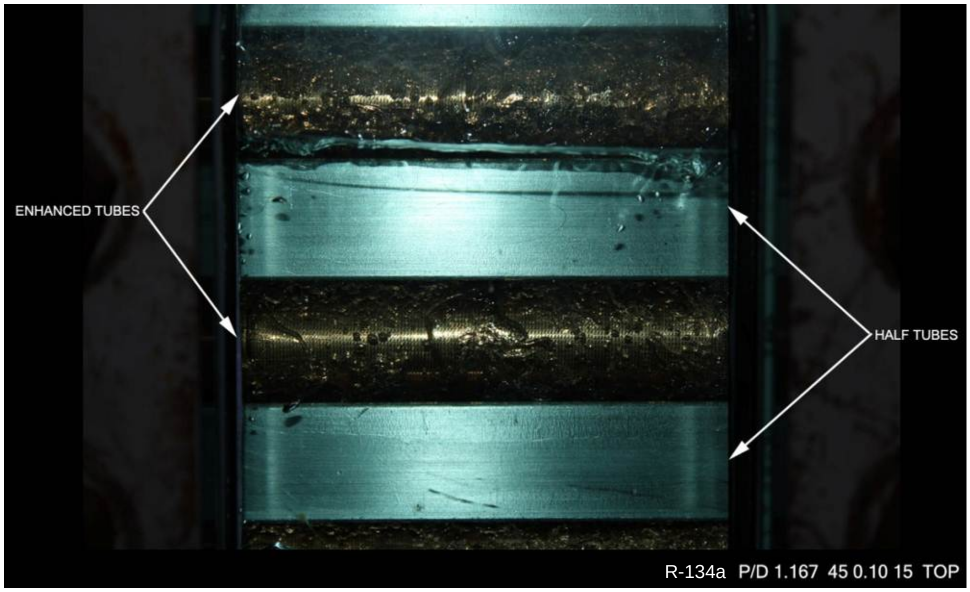

Refrigerant Inlet
Glycol Outlet
Condenser
Refrigerant Outlet
Glycol Inlet
Storage Tank
Test Section Secondary
Heat Exchanger
Circulation Pump

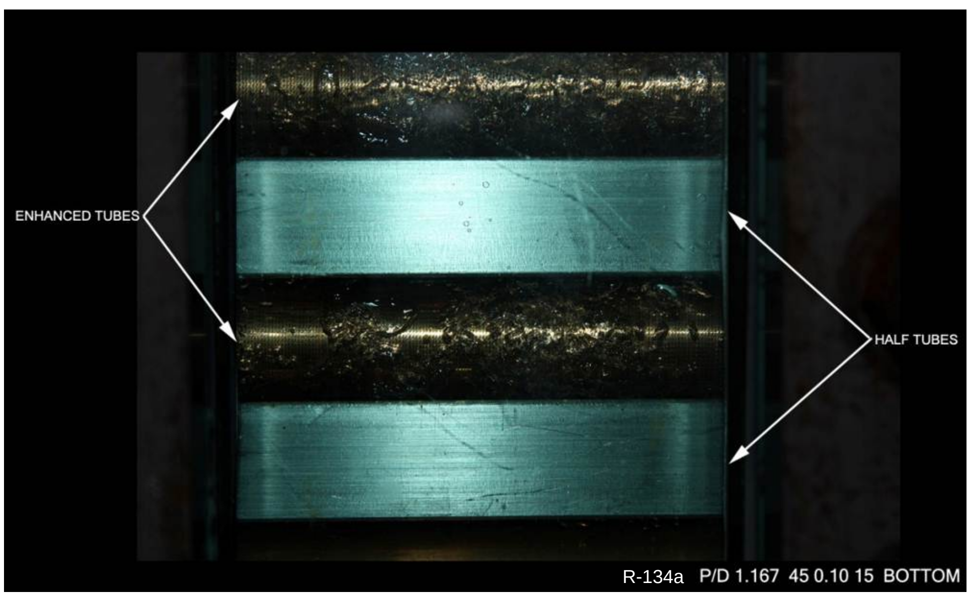
Appendix C Boiling Visuals

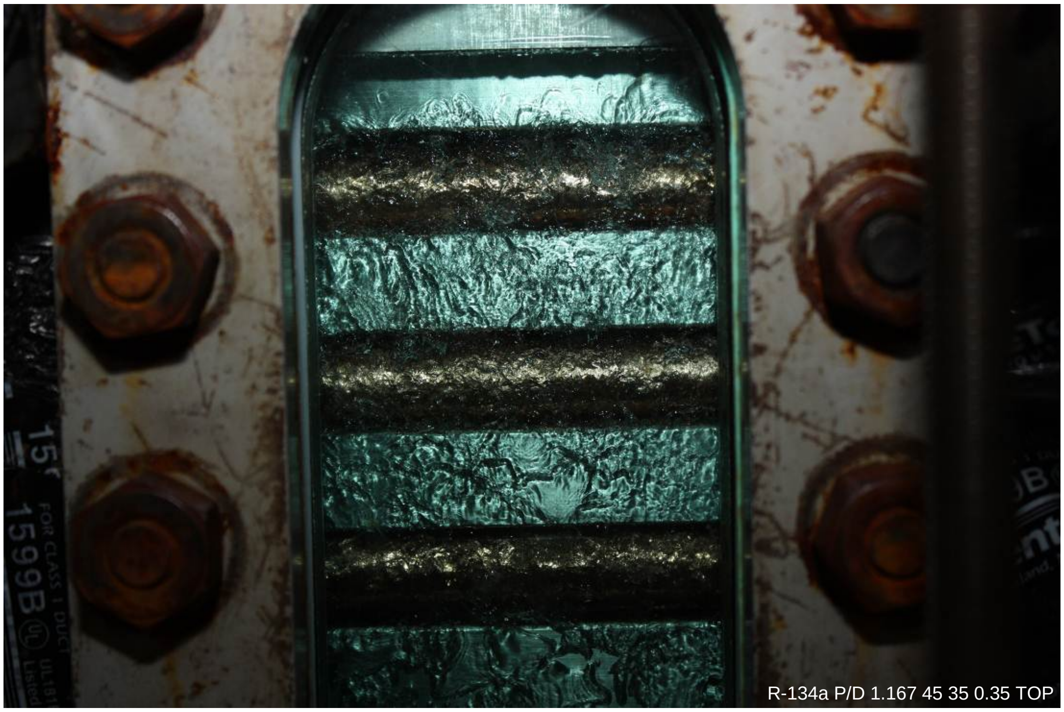



HALF TUBES
ENHANCED TUBES
R-134a P/D 1.33 15 5 0.35 TOP


ENHANCED TUBES
HALF TUBES
DUMMY TUBE
R-134a P/D 1.33 15 5 0.35 BOTTOM


ENHANCED TUBES
HALF TUBES
R-134a P/D 1.167 45 0.10 15 TOP


ENHANCED TUBES
HALF TUBES
R-134a P/D 1.167 45 0.10 15 BOTTOM


R-134a P/D 1.167 45 35 0.35 TOP

Appendix D Example of an Uncertainty Worksheet

The following pages show a screen shot of a MathCad worksheet (due to the difficulty of importing a MathCad worksheet directly into MS Word) of one test run. The table at the beginning of the worksheet lists all the variables needed for calculating the heat transfer coefficient uncertainty. This table was generated and copied from the MS Excel file of the same run. The uncertainty analysis was calculated for each tube. It starts with the average heat transfer coefficient then the five local heat transfer coefficient. The uncertainty analysis was discussed at length in the Section 4.10.

Data :=

	0	1	2	3	4	5	6	7
0	"Flow Rate (kg/s)"	""	"Pw,in (kPa)"	"Ti (ºC) "	"T1 (ºC) "	"T2 (ºC) "	"T3 (ºC) "	"T4 (ºC) "
1	0.281	""	752.765	14.631	13.817	13.092	12.415	11.787
2	0.281	""	621.755	10.683	10.295	9.839	9.333	8.927
3	0.281	""	521.755	8.211	7.903	7.558	7.222	6.912
4	0.281	""	365.386	6.523	6.369	6.19	6.017	...

$Ao := \pi \cdot 0.75 \cdot 0.0254 \cdot 1$

$mdot := Data_{1,0}$

Tube A1

Average Heat Transfer Coefficient Uncertainty Calculation

$umdot := \frac{0.1}{100} \cdot mdot$

$\rho 1 := Data_{1,15}$

$u\rho 1 := 7 \cdot 10^{-13} \cdot \rho 1$

$\Delta P1 := \left(Data_{1,10} - Data_{1,2}\right) \cdot \frac{1m}{59.5in} \cdot 1000$

$u\Delta P := \sqrt{2} \cdot 1034.21359$

$Tinlet1 := Data_{1,3}$

$Toutlet1 := Data_{1,9}$

$uT := 0.015$

$Cp1 := 1000 \cdot Data_{1,13}$

$uCp1 := 6 \cdot 10^{-14} \cdot Cp1$

$hw1 := Data_{1,29}$

$uhw1 := 0.04 \cdot hw1$

$Rw := Data_{1,30}$

$Tsat1 := Data_{1,19}$

$uTsat := 0.022$

$$ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1) := \left[\frac{1}{\dfrac{mdot \cdot Cp1 \cdot (Tinlet1 - Toutlet1) + mdot \cdot \frac{1}{\rho 1} \cdot (-\Delta P1)}{\dfrac{Tinlet1 - Toutlet1}{\ln\left(\frac{Tinlet1 - Tsat1}{Toutlet1 - Tsat1}\right)} \cdot \pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw1} \cdot \frac{0.75}{0.7} \right]^{-1}$$

$$\begin{aligned} uha_{A1} := \Bigg[& \left[\left(\frac{d}{dmdot} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot uCp1\right]^2 \ldots \\ & + \left[\left(\frac{d}{dTinlet1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot uT\right]^2 + \left[\left(\frac{d}{dToutlet1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot uT\right]^2 \ldots \\ & + \left[\left(\frac{d}{dTsat1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot uTsat\right]^2 + \left[\left(\frac{d}{d\rho 1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot u\rho 1\right]^2 \ldots \\ & + \left[\left(\frac{d}{d\Delta P1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot u\Delta P\right]^2 + \left[\left(\frac{d}{dhw1} ha_{A1}(mdot, Cp1, Tinlet1, Toutlet1, Tsat1, \rho 1, \Delta P1, hw1)\right) \cdot uhw1\right]^2 \Bigg]^{0.5} \end{aligned}$$

$uha_{A1} = 153.788$

$$\frac{uha_{A1}}{Data_{1,31}} \cdot 100 = 1.249$$

Local Heat Transfer Coefficient Uncertainty Calculations

$$\Delta P \Delta x_{A1} := \frac{-\left(Data_{1,10} - Data_{1,2}\right) \cdot 1000}{59.5 \cdot 0.0254}$$

Monte Carlo Simulation For Determining The Uncertainty in dT/dx

$Ti_{A1} := Data_{1,3}$

$T1_{A1} := Data_{1,32}$ $\quad$ $T1a_{A1} := Data_{1,4}$

$T2_{A1} := Data_{1,33}$ $\quad$ $T2a_{A1} := Data_{1,5}$

$T3_{A1} := Data_{1,34}$ $\quad$ $T3a_{A1} := Data_{1,6}$

$T4_{A1} := Data_{1,35}$ $\quad$ $T4a_{A1} := Data_{1,7}$

$T5_{A1} := Data_{1,36}$ $\quad$ $T5a_{A1} := Data_{1,8}$

$To_{A1} := Data_{1,9}$

$i := 0..12000$

$Z_i := rnorm(7, 0, 0.0075)$

$$TT_{A1_i} := \begin{pmatrix} Ti_{A1} \\ T1_{A1} \\ T2_{A1} \\ T3_{A1} \\ T4_{A1} \\ T5_{A1} \\ To_{A1} \end{pmatrix} + Z_i \qquad Dist_i := \begin{pmatrix} 0 \\ 0.17 \\ 0.33 \\ 0.5 \\ 0.67 \\ 0.83 \\ 1 \end{pmatrix}$$

$$REG_{A1_i} := regress\left(Dist_i, TT_{A1_i}, 2\right)$$

$$Un17_{A1_i} := \frac{\left[2 \cdot \left(REG_{A1_i}\right)_5 \cdot (0.17) + \left(REG_{A1_i}\right)_4 - Data_{1,37}\right]}{Data_{1,37}}$$

$$Un33_{A1_i} := \frac{\left[2 \cdot \left(REG_{A1_i}\right)_5 \cdot (0.33) + \left(REG_{A1_i}\right)_4 - Data_{1,38}\right]}{Data_{1,38}}$$

$$Un50_{A1_i} := \frac{\left[2 \cdot \left(REG_{A1_i}\right)_5 \cdot (0.5) + \left(REG_{A1_i}\right)_4 - Data_{1,39}\right]}{Data_{1,39}}$$

$$Un67_{A1_i} := \frac{\left[2 \cdot \left(REG_{A1_i}\right)_5 \cdot (0.67) + \left(REG_{A1_i}\right)_4 - Data_{1,40}\right]}{Data_{1,40}}$$

$$Un83_{A1_i} := \frac{\left[2 \cdot \left(REG_{A1_i}\right)_5 \cdot (0.83) + \left(REG_{A1_i}\right)_4 - Data_{1,41}\right]}{Data_{1,41}}$$

$$TT_{A1_i} := \begin{pmatrix} Ti_{A1} \\ T1_{A1} \\ T2_{A1} \\ T3_{A1} \\ T4_{A1} \\ T5_{A1} \\ To_{A1} \end{pmatrix} + Z_i \qquad Dist_i := \begin{pmatrix} 0 \\ 0.17 \\ 0.33 \\ 0.5 \\ 0.67 \\ 0.83 \\ 1 \end{pmatrix}$$

$$REG_{A1_i} := \text{regress}\left(Dist_i, TT_{A1_i}, 2\right)$$

$$Un17_{A1_i} := \frac{\left[2\cdot\left(REG_{A1_i}\right)_5\cdot(0.17) + \left(REG_{A1_i}\right)_4 - Data_{1,37}\right]}{Data_{1,37}}$$

$$Un33_{A1_i} := \frac{\left[2\cdot\left(REG_{A1_i}\right)_5\cdot(0.33) + \left(REG_{A1_i}\right)_4 - Data_{1,38}\right]}{Data_{1,38}}$$

$$Un50_{A1_i} := \frac{\left[2\cdot\left(REG_{A1_i}\right)_5\cdot(0.5) + \left(REG_{A1_i}\right)_4 - Data_{1,39}\right]}{Data_{1,39}}$$

$$Un67_{A1_i} := \frac{\left[2\cdot\left(REG_{A1_i}\right)_5\cdot(0.67) + \left(REG_{A1_i}\right)_4 - Data_{1,40}\right]}{Data_{1,40}}$$

$$Un83_{A1_i} := \frac{\left[2\cdot\left(REG_{A1_i}\right)_5\cdot(0.83) + \left(REG_{A1_i}\right)_4 - Data_{1,41}\right]}{Data_{1,41}}$$

$$udTdx_{A1} := \begin{pmatrix} \text{sort}\left(Un17_{A1}\right)_{11400} \\ \text{sort}\left(Un33_{A1}\right)_{11400} \\ \text{sort}\left(Un50_{A1}\right)_{11400} \\ \text{sort}\left(Un67_{A1}\right)_{11400} \\ \text{sort}\left(Un83_{A1}\right)_{11400} \end{pmatrix}$$

$$dTdx1_{A1} := Data_{1,42} \qquad uT1a_{A1} := \sqrt{uT^2 + \left[dTdx1_{A1}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx2_{A1} := Data_{1,43} \qquad uT2a_{A1} := \sqrt{uT^2 + \left[dTdx2_{A1}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx3_{A1} := Data_{1,44} \qquad uT3a_{A1} := \sqrt{uT^2 + \left[dTdx3_{A1}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx4_{A1} := Data_{1,45} \qquad uT4a_{A1} := \sqrt{uT^2 + \left[dTdx4_{A1}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx5_{A1} := Data_{1,46} \qquad uT5a_{A1} := \sqrt{uT^2 + \left[dTdx5_{A1}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

<u>1st Local HTC Uncertainty Calculation</u>

$$hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1\right) := \left[\frac{\left(T1a_{A1} - Tsat1\right)}{\frac{mdot\cdot Cp1\cdot dTdx1_{A1} + mdot\cdot\frac{1}{\rho1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot0.75\cdot0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$udTdx_{A1} := \begin{pmatrix} \mathrm{sort}\left(Un17_{A1}\right)_{11400} \\ \mathrm{sort}\left(Un33_{A1}\right)_{11400} \\ \mathrm{sort}\left(Un50_{A1}\right)_{11400} \\ \mathrm{sort}\left(Un67_{A1}\right)_{11400} \\ \mathrm{sort}\left(Un83_{A1}\right)_{11400} \end{pmatrix}$$

$$dTdx1_{A1} := Data_{1,42} \qquad uT1a_{A1} := \sqrt{uT^2 + \left[dTdx1_{A1}\cdot\left(1.5875\times 10^{-3}\right)\right]^2}$$

$$dTdx2_{A1} := Data_{1,43} \qquad uT2a_{A1} := \sqrt{uT^2 + \left[dTdx2_{A1}\cdot\left(1.5875\times 10^{-3}\right)\right]^2}$$

$$dTdx3_{A1} := Data_{1,44} \qquad uT3a_{A1} := \sqrt{uT^2 + \left[dTdx3_{A1}\cdot\left(1.5875\times 10^{-3}\right)\right]^2}$$

$$dTdx4_{A1} := Data_{1,45} \qquad uT4a_{A1} := \sqrt{uT^2 + \left[dTdx4_{A1}\cdot\left(1.5875\times 10^{-3}\right)\right]^2}$$

$$dTdx5_{A1} := Data_{1,46} \qquad uT5a_{A1} := \sqrt{uT^2 + \left[dTdx5_{A1}\cdot\left(1.5875\times 10^{-3}\right)\right]^2}$$

1st Local HTC Uncertainty Calculation

$$hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right) := \left[\frac{\left(T1a_{A1} - Tsat1\right)}{\dfrac{mdot\cdot Cp1\cdot dTdx1_{A1} + mdot\cdot\dfrac{1}{\rho 1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$\begin{aligned} uhl1_{A1} := \Bigg[& \left[\left(\frac{d}{dT1a_{A1}} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot uT1a_{A1}\right]^2 + \left[\left(\frac{d}{dTsat1} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot uTsat\right]^2 \ldots \\ & + \left[\left(\frac{d}{dmdot} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot uCp1\right]^2 \ldots \\ & + \left[\left(\frac{d}{ddTdx1_{A1}} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot dTdx1_{A1}\cdot {udTdx_{A1}}_{0}\right]^2 \ldots \\ & + \left[\left(\frac{d}{d\rho 1} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot u\rho 1\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A1}} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot u\Delta P\right]^2 \ldots \\ & + \left[\left(\frac{d}{dhw1} hl1_{A1}\left(T1a_{A1}, Tsat1, mdot, Cp1, dTdx1_{A1}, \rho 1, \Delta P\Delta x_{A1}, hw1\right)\right)\cdot uhw1\right]^2 \Bigg]^{0.5} \end{aligned}$$

$$\frac{uhl1_{A1}}{Data_{1,47}}\cdot 100 = 1.251$$

2nd Local HTC Uncertainty Calculation

$$hl2_{A1}\left(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1\right) := \left[\frac{(T2a_{A1} - Tsat1)}{\frac{mdot\cdot Cp1\cdot dTdx2_{A1} + mdot\cdot\frac{1}{\rho1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl2_{A1} := \left[\left[\left(\frac{d}{dT2a_{A1}}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uT2a_{A1}\right]^2 + \left[\left(\frac{d}{dTsat1}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uCp1\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx2_{A1}}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot dTdx2_{A1}\cdot udTdx_{A1_1}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho1}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\rho1\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A1}}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw1}hl2_{A1}(T2a_{A1}, Tsat1, mdot, Cp1, dTdx2_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uhw1\right]^2\right]^{0.5}$$

$$\frac{uhl2_{A1}}{Data_{1,48}}\cdot 100 = 1.843$$

3rd Local HTC Uncertainty Calculation

$$hl3_{A1}\left(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1\right) := \left[\frac{(T3a_{A1} - Tsat1)}{\frac{mdot\cdot Cp1\cdot dTdx3_{A1} + mdot\cdot\frac{1}{\rho1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl3_{A1} := \left[\left[\left(\frac{d}{dT3a_{A1}}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uT3a_{A1}\right]^2 + \left[\left(\frac{d}{dTsat1}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uCp1\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx3_{A1}}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot dTdx3_{A1}\cdot udTdx_{A1_2}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho1}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\rho1\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A1}}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw1}hl3_{A1}(T3a_{A1}, Tsat1, mdot, Cp1, dTdx3_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uhw1\right]^2\right]^{0.5}$$

$$\frac{uhl3_{A1}}{Data_{1,49}}\cdot 100 = 2.068$$

4th Local HTC Uncertainty Calculation

$$hl4_{A1}\left(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1\right) := \left[\frac{(T4a_{A1} - Tsat1)}{\frac{mdot\cdot Cp1\cdot dTdx4_{A1} + mdot\cdot\frac{1}{\rho1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl4_{A1} := \left[\left[\left(\frac{d}{dT4a_{A1}} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uT4a_{A1}\right]^2 + \left[\left(\frac{d}{dTsat1} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uCp1\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx4_{A1}} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot dTdx4_{A1}\cdot udTdx_{A1_3}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho1} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\rho1\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A1}} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw1} hl4_{A1}(T4a_{A1}, Tsat1, mdot, Cp1, dTdx4_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uhw1\right]^2\right]^{0.5}$$

$$\frac{uhl4_{A1}}{Data_{1,50}}\cdot 100 = 1.944$$

5th Local HTC Uncertainty Calculation

$$hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1) := \left[\frac{(T5a_{A1} - Tsat1)}{\dfrac{mdot\cdot Cp1\cdot dTdx5_{A1} + mdot\cdot\dfrac{1}{\rho1}\cdot\Delta P\Delta x_{A1}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw1}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl5_{A1} := \left[\left[\left(\frac{d}{dT5a_{A1}} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uT5a_{A1}\right]^2 + \left[\left(\frac{d}{dTsat1} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp1} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uCp1\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx5_{A1}} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot dTdx5_{A1}\cdot udTdx_{A1_4}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho1} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\rho1\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A1}} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw1} hl5_{A1}(T5a_{A1}, Tsat1, mdot, Cp1, dTdx5_{A1}, \rho1, \Delta P\Delta x_{A1}, hw1)\right)\cdot uhw1\right]^2\right]^{0.5}$$

$$\frac{uhl5_{A1}}{Data_{1,51}}\cdot 100 = 1.349$$

Tube A2

Average Heat Transfer Coefficient Uncertainty Calculation

$\rho2 := Data_{2,15}$

$u\rho2 := 7\cdot 10^{-13}\cdot\rho2$

$\Delta P2 := (Data_{2,10} - Data_{2,2})\cdot\frac{1m}{59.5in}\cdot 1000$

$Tinlet2 := Data_{2,3}$

$Toutlet2 := Data_{2,9}$

$Cp2 := 1000\cdot Data_{2,13}$

$uCp2 := 6\cdot 10^{-14}\cdot Cp2$

$hw2 := Data_{2,29}$

$uhw2 := 0.04\cdot hw2$

$Tsat2 := Data_{2,19}$

$$ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2) := \left[\frac{1}{\dfrac{mdot\cdot Cp2\cdot(Tinlet2-Toutlet2)+mdot\cdot\dfrac{1}{\rho 2}\cdot(-\Delta P2)}{\dfrac{Tinlet2-Toutlet2}{\ln\left(\dfrac{Tinlet2-Tsat2}{Toutlet2-Tsat2}\right)}\cdot\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uha_{A2} := \left[\begin{array}{l}\left[\left(\frac{d}{dmdot}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot uCp2\right]^2 \ldots \\ + \left[\left(\frac{d}{dTinlet2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot uT\right]^2 + \left[\left(\frac{d}{dToutlet2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot uT\right]^2 \ldots \\ + \left[\left(\frac{d}{dTsat2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot uTsat\right]^2 + \left[\left(\frac{d}{d\rho 2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot u\rho 2\right]^2 \ldots \\ + \left[\left(\frac{d}{d\Delta P2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot u\Delta P\right]^2 + \left[\left(\frac{d}{dhw2}ha_{A2}(mdot,Cp2,Tinlet2,Toutlet2,Tsat2,\rho 2,\Delta P2,hw2)\right)\cdot uhw2\right]^2\end{array}\right]^{0.5}$$

$uha_{A2} = 224.173$

$\dfrac{uha_{A2}}{Data_{2,31}}\cdot 100 = 1.712$

Local Heat Transfer Coefficient Uncertainty Calculations

$$\Delta P\Delta x_{A2} := \frac{-\left(Data_{2,10} - Data_{2,2}\right)\cdot 1000}{59.5\cdot 0.0254}$$

Monte Carlo Simulation For Determining The Uncertainty in dT/dx

$Ti_{A2} := Data_{2,3}$

$T1_{A2} := Data_{2,32}$ $\quad$ $T1a_{A2} := Data_{2,4}$

$T2_{A2} := Data_{2,33}$ $\quad$ $T2a_{A2} := Data_{2,5}$

$T3_{A2} := Data_{2,34}$ $\quad$ $T3a_{A2} := Data_{2,6}$

$T4_{A2} := Data_{2,35}$ $\quad$ $T4a_{A2} := Data_{2,7}$

$T5_{A2} := Data_{2,36}$ $\quad$ $T5a_{A2} := Data_{2,8}$

$To_{A2} := Data_{2,9}$

$i := 0..12000$

$Z_i := rnorm(7,0,0.0075)$

$$TT_{A2_i} := \begin{pmatrix} Ti_{A2} \\ T1_{A2} \\ T2_{A2} \\ T3_{A2} \\ T4_{A2} \\ T5_{A2} \\ To_{A2} \end{pmatrix} + Z_i$$

$$REG_{A2_i} := \mathrm{regress}\left(Dist_i, TT_{A2_i}, 2\right)$$

$$Un17_{A2_i} := \frac{\left[2\cdot\left(REG_{A2_i}\right)_5\cdot(0.17) + \left(REG_{A2_i}\right)_4 - Data_{2,37}\right]}{Data_{2,37}}$$

$$Un33_{A2_i} := \frac{\left[2\cdot\left(REG_{A2_i}\right)_5\cdot(0.33) + \left(REG_{A2_i}\right)_4 - Data_{2,38}\right]}{Data_{2,38}}$$

$$Un50_{A2_i} := \frac{\left[2\cdot\left(REG_{A2_i}\right)_5\cdot(0.5) + \left(REG_{A2_i}\right)_4 - Data_{2,39}\right]}{Data_{2,39}}$$

$$Un67_{A2_i} := \frac{\left[2\cdot\left(REG_{A2_i}\right)_5\cdot(0.67) + \left(REG_{A2_i}\right)_4 - Data_{2,40}\right]}{Data_{2,40}}$$

$$Un83_{A2_i} := \frac{\left[2\cdot\left(REG_{A2_i}\right)_5\cdot(0.83) + \left(REG_{A2_i}\right)_4 - Data_{2,41}\right]}{Data_{2,41}}$$

$$udTdx_{A2} := \begin{pmatrix} \mathrm{sort}\left(Un17_{A2}\right)_{11400} \\ \mathrm{sort}\left(Un33_{A2}\right)_{11400} \\ \mathrm{sort}\left(Un50_{A2}\right)_{11400} \\ \mathrm{sort}\left(Un67_{A2}\right)_{11400} \\ \mathrm{sort}\left(Un83_{A2}\right)_{11400} \end{pmatrix}$$

$$dTdx1_{A2} := Data_{2,42} \qquad uT1a_{A2} := \sqrt{uT^2 + \left[dTdx1_{A2}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx2_{A2} := Data_{2,43} \qquad uT2a_{A2} := \sqrt{uT^2 + \left[dTdx2_{A2}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx3_{A2} := Data_{2,44} \qquad uT3a_{A2} := \sqrt{uT^2 + \left[dTdx3_{A2}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx4_{A2} := Data_{2,45} \qquad uT4a_{A2} := \sqrt{uT^2 + \left[dTdx4_{A2}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx5_{A2} := Data_{2,46} \qquad uT5a_{A2} := \sqrt{uT^2 + \left[dTdx5_{A2}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

1st Local HTC Uncertainty Calculation

$$hl1_{A2}\left(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho2, \Delta P\Delta x_{A2}, hw2\right) := \left[\frac{\left(T1a_{A2} - Tsat2\right)}{\dfrac{mdot\cdot Cp2\cdot dTdx1_{A2} + mdot\cdot\dfrac{1}{\rho2}\cdot\Delta P\Delta x_{A2}}{\pi\cdot0.75\cdot0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$
\begin{aligned}
uhl1_{A2} := \Bigg[& \left[\left(\frac{d}{dT1a_{A2}} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uT1a_{A2}\right]^2 + \left[\left(\frac{d}{dTsat2} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uTsat\right]^2 \ldots \\
& + \left[\left(\frac{d}{dmdot} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uCp2\right]^2 \ldots \\
& + \left[\left(\frac{d}{ddTdx1_{A2}} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot dTdx1_{A2}\cdot udTdx_{A2_0}\right]^2 \ldots \\
& + \left[\left(\frac{d}{d\rho 2} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\rho 2\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A2}} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\Delta P\right]^2 \ldots \\
& + \left[\left(\frac{d}{dhw2} hl1_{A2}(T1a_{A2}, Tsat2, mdot, Cp2, dTdx1_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uhw2\right]^2 \Bigg]^{0.5}
\end{aligned}
$$

$$\frac{uhl1_{A2}}{Data_{2,47}}\cdot 100 = 1.579$$

2nd Local HTC Uncertainty Calculation

$$hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2) := \left[\frac{(T2a_{A2} - Tsat2)}{\dfrac{mdot\cdot Cp2\cdot dTdx2_{A2} + mdot\cdot \dfrac{1}{\rho 2}\cdot \Delta P\Delta x_{A2}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$
\begin{aligned}
uhl2_{A2} := \Bigg[& \left[\left(\frac{d}{dT2a_{A2}} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uT2a_{A2}\right]^2 + \left[\left(\frac{d}{dTsat2} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uTsat\right]^2 \ldots \\
& + \left[\left(\frac{d}{dmdot} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uCp2\right]^2 \ldots \\
& + \left[\left(\frac{d}{ddTdx2_{A2}} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot dTdx2_{A2}\cdot udTdx_{A2_1}\right]^2 \ldots \\
& + \left[\left(\frac{d}{d\rho 2} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\rho 2\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A2}} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\Delta P\right]^2 \ldots \\
& + \left[\left(\frac{d}{dhw2} hl2_{A2}(T2a_{A2}, Tsat2, mdot, Cp2, dTdx2_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uhw2\right]^2 \Bigg]^{0.5}
\end{aligned}
$$

$$\frac{uhl2_{A2}}{Data_{2,48}}\cdot 100 = 2.176$$

3rd Local HTC Uncertainty Calculation

$$hl3_{A2}(T3a_{A2}, Tsat2, mdot, Cp2, dTdx3_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2) := \left[\frac{(T3a_{A2} - Tsat2)}{\dfrac{mdot\cdot Cp2\cdot dTdx3_{A2} + mdot\cdot \dfrac{1}{\rho 2}\cdot \Delta P\Delta x_{A2}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl3_{A2} := \left[\left[\left(\frac{d}{dT3a_{A2}}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uT3a_{A2}\right]^2 + \left[\left(\frac{d}{dTsat2}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uCp2\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx3_{A2}}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot dTdx3_{A2}\cdot udTdx_{A2_2}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho2}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot u\rho2\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A2}}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw2}hl3_{A2}(T3a_{A2},Tsat2,mdot,Cp2,dTdx3_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uhw2\right]^2\right]^{0.5}$$

$$\frac{uhl3_{A2}}{Data_{2,49}}\cdot 100 = 2.414$$

4th Local HTC Uncertainty Calculation

$$hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2) := \left[\frac{(T4a_{A2} - Tsat2)}{\frac{mdot\cdot Cp2\cdot dTdx4_{A2}+mdot\cdot\frac{1}{\rho2}\cdot\Delta P\Delta x_{A2}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl4_{A2} := \left[\left[\left(\frac{d}{dT4a_{A2}}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uT4a_{A2}\right]^2 + \left[\left(\frac{d}{dTsat2}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uCp2\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx4_{A2}}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot dTdx4_{A2}\cdot udTdx_{A2_3}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho2}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot u\rho2\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A2}}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw2}hl4_{A2}(T4a_{A2},Tsat2,mdot,Cp2,dTdx4_{A2},\rho2,\Delta P\Delta x_{A2},hw2)\right)\cdot uhw2\right]^2\right]^{0.5}$$

$$\frac{uhl4_{A2}}{Data_{2,50}}\cdot 100 = 2.507$$

5th Local HTC Uncertainty Calculation

$$hl5_{A2}(T5a_{A2},Tsat2,mdot,Cp2,dTdx5_{A2},\rho2,\Delta P\Delta x_{A2},hw2) := \left[\frac{(T5a_{A2} - Tsat2)}{\frac{mdot\cdot Cp2\cdot dTdx5_{A2}+mdot\cdot\frac{1}{\rho2}\cdot\Delta P\Delta x_{A2}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw2}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uh15_{A2} := \left[\left[\left(\frac{d}{dT5a_{A2}} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uT5a_{A2}\right]^2 + \left[\left(\frac{d}{dTsat2} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp2} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uCp2\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx5_{A2}} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot dTdx5_{A2}\cdot udTdx_{A2_4}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho 2} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\rho 2\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A2}} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw2} h15_{A2}(T5a_{A2}, Tsat2, mdot, Cp2, dTdx5_{A2}, \rho 2, \Delta P\Delta x_{A2}, hw2)\right)\cdot uhw2\right]^2\right]^{0.5}$$

$$\frac{uh15_{A2}}{Data_{2,51}}\cdot 100 = 2.133$$

Tube A3

Average Heat Transfer Coefficient Uncertainty Calculation

$\rho 3 := Data_{3,15}$

$u\rho 3 := 7\cdot 10^{-13}\cdot \rho 3$

$\Delta P3 := \left(Data_{3,10} - Data_{3,2}\right)\cdot \frac{1m}{59.5in}\cdot 1000$

$Tinlet3 := Data_{3,3}$

$Toutlet3 := Data_{3,9}$

$Cp3 := 1000\cdot Data_{3,13}$

$uCp3 := 6\cdot 10^{-14}\cdot Cp3$

$hw3 := Data_{3,29}$

$uhw3 := 0.04\cdot hw3$

$Tsat3 := Data_{3,19}$

$$ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3) := \left[\frac{1}{\dfrac{mdot\cdot Cp3\cdot(Tinlet3 - Toutlet3) + mdot\cdot\dfrac{1}{\rho 3}\cdot(-\Delta P3)}{\dfrac{Tinlet3 - Toutlet3}{\ln\left(\dfrac{Tinlet3 - Tsat3}{Toutlet3 - Tsat3}\right)}\cdot\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw3}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uha_{A3} := \left[\left[\left(\frac{d}{dmdot} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot uCp3\right]^2 \ldots \\ + \left[\left(\frac{d}{dTinlet3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot uT\right]^2 + \left[\left(\frac{d}{dToutlet3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot uT\right]^2 \ldots \\ + \left[\left(\frac{d}{dTsat3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot uTsat\right]^2 + \left[\left(\frac{d}{d\rho 3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot u\rho 3\right]^2 \ldots \\ + \left[\left(\frac{d}{d\Delta P3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot u\Delta P\right]^2 + \left[\left(\frac{d}{dhw3} ha_{A3}(mdot, Cp3, Tinlet3, Toutlet3, Tsat3, \rho 3, \Delta P3, hw3)\right)\cdot uhw3\right]^2\right]^{0.5}$$

$uha_{A3} = 481.355$

$$\frac{uha_{A3}}{Data_{3,31}}\cdot 100 = 2.739$$

Local Heat Transfer Coefficient Uncertainty Calculations

$$\Delta P \Delta x_{A3} := \frac{-\left(Data_{3,10} - Data_{3,2}\right) \cdot 1000}{59.5 \cdot 0.0254}$$

Monte Carlo Simulation For Determining The Uncertainty in dT/dx

$Ti_{A3} := Data_{3,3}$

$T1_{A3} := Data_{3,32}$ $\qquad$ $T1a_{A3} := Data_{3,4}$

$T2_{A3} := Data_{3,33}$ $\qquad$ $T2a_{A3} := Data_{3,5}$

$T3_{A3} := Data_{3,34}$ $\qquad$ $T3a_{A3} := Data_{3,6}$

$T4_{A3} := Data_{3,35}$ $\qquad$ $T4a_{A3} := Data_{3,7}$

$T5_{A3} := Data_{3,36}$ $\qquad$ $T5a_{A3} := Data_{3,8}$

$To_{A3} := Data_{3,9}$

$i := 0..12000$

$Z_i := rnorm(7, 0, 0.0075)$

$$TT_{A3_i} := \begin{pmatrix} Ti_{A3} \\ T1_{A3} \\ T2_{A3} \\ T3_{A3} \\ T4_{A3} \\ T5_{A3} \\ To_{A3} \end{pmatrix} + Z_i$$

$REG_{A3_i} := regress\left(Dist_i, TT_{A3_i}, 2\right)$

$$Un17_{A3_i} := \frac{\left[2 \cdot \left(REG_{A3_i}\right)_5 \cdot (0.17) + \left(REG_{A3_i}\right)_4 - Data_{3,37}\right]}{Data_{3,37}}$$

$$Un33_{A3_i} := \frac{\left[2 \cdot \left(REG_{A3_i}\right)_5 \cdot (0.33) + \left(REG_{A3_i}\right)_4 - Data_{3,38}\right]}{Data_{3,38}}$$

$$Un50_{A3_i} := \frac{\left[2 \cdot \left(REG_{A3_i}\right)_5 \cdot (0.5) + \left(REG_{A3_i}\right)_4 - Data_{3,39}\right]}{Data_{3,39}}$$

$$Un67_{A3_i} := \frac{\left[2 \cdot \left(REG_{A3_i}\right)_5 \cdot (0.67) + \left(REG_{A3_i}\right)_4 - Data_{3,40}\right]}{Data_{3,40}}$$

$$Un83_{A3_i} := \frac{\left[2 \cdot \left(REG_{A3_i}\right)_5 \cdot (0.83) + \left(REG_{A3_i}\right)_4 - Data_{3,41}\right]}{Data_{3,41}}$$

$$udTdx_{A3} := \begin{pmatrix} sort(Un17_{A3})_{11400} \\ sort(Un33_{A3})_{11400} \\ sort(Un50_{A3})_{11400} \\ sort(Un67_{A3})_{11400} \\ sort(Un83_{A3})_{11400} \end{pmatrix}$$

$$dTdx1_{A3} := Data_{3,42} \qquad uT1a_{A3} := \sqrt{uT^2 + \left[dTdx1_{A3}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx2_{A3} := Data_{3,43} \qquad uT2a_{A3} := \sqrt{uT^2 + \left[dTdx2_{A3}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx3_{A3} := Data_{3,44} \qquad uT3a_{A3} := \sqrt{uT^2 + \left[dTdx3_{A3}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx4_{A3} := Data_{3,45} \qquad uT4a_{A3} := \sqrt{uT^2 + \left[dTdx4_{A3}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

$$dTdx5_{A3} := Data_{3,46} \qquad uT5a_{A3} := \sqrt{uT^2 + \left[dTdx5_{A3}\cdot\left(1.5875\times10^{-3}\right)\right]^2}$$

1st Local HTC Uncertainty Calculation

$$hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3) := \left[\frac{(T1a_{A3} - Tsat3)}{\dfrac{mdot\cdot Cp3\cdot dTdx1_{A3} + mdot\cdot\dfrac{1}{\rho3}\cdot\Delta P\Delta x_{A3}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw3}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$\begin{aligned} uhl1_{A3} := \Bigg[& \left[\left(\frac{d}{dT1a_{A3}} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uT1a_{A3}\right]^2 + \left[\left(\frac{d}{dTsat3} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uTsat\right]^2 \ldots \\ & + \left[\left(\frac{d}{dmdot} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uCp3\right]^2 \ldots \\ & + \left[\left(\frac{d}{ddTdx1_{A3}} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot dTdx1_{A3}\cdot udTdx_{A3_0}\right]^2 \ldots \\ & + \left[\left(\frac{d}{d\rho3} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\rho3\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A3}} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\Delta P\right]^2 \ldots \\ & + \left[\left(\frac{d}{dhw3} hl1_{A3}(T1a_{A3}, Tsat3, mdot, Cp3, dTdx1_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uhw3\right]^2 \Bigg]^{0.5} \end{aligned}$$

$$\frac{uhl1_{A3}}{Data_{3,47}}\cdot 100 = 2.59$$

2nd Local HTC Uncertainty Calculation

$$hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3) := \left[\frac{(T2a_{A3} - Tsat3)}{\dfrac{mdot\cdot Cp3\cdot dTdx2_{A3} + mdot\cdot\dfrac{1}{\rho3}\cdot\Delta P\Delta x_{A3}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw3}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl2_{A3} := \left[\left[\left(\frac{d}{dT2a_{A3}} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uT2a_{A3}\right]^2 + \left[\left(\frac{d}{dTsat3} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uCp3\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx2_{A3}} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot dTdx2_{A3} \cdot udTdx_{A3_1}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho3} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot u\rho3\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A3}} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw3} hl2_{A3}(T2a_{A3}, Tsat3, mdot, Cp3, dTdx2_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uhw3\right]^2\right]^{0.5}$$

$$\frac{uhl2_{A3}}{Data_{3,48}} \cdot 100 = 3.577$$

3rd Local HTC Uncertainty Calculation

$$hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3) := \left[\frac{(T3a_{A3} - Tsat3)}{\dfrac{mdot \cdot Cp3 \cdot dTdx3_{A3} + mdot \cdot \frac{1}{\rho3} \cdot \Delta P\Delta x_{A3}}{\pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw3} \cdot \frac{0.75}{0.7}\right]^{-1}$$

$$uhl3_{A3} := \left[\left[\left(\frac{d}{dT3a_{A3}} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uT3a_{A3}\right]^2 + \left[\left(\frac{d}{dTsat3} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uCp3\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx3_{A3}} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot dTdx3_{A3} \cdot udTdx_{A3_2}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho3} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot u\rho3\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A3}} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw3} hl3_{A3}(T3a_{A3}, Tsat3, mdot, Cp3, dTdx3_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right) \cdot uhw3\right]^2\right]^{0.5}$$

$$\frac{uhl3_{A3}}{Data_{3,49}} \cdot 100 = 3.949$$

4th Local HTC Uncertainty Calculation

$$hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3) := \left[\frac{(T4a_{A3} - Tsat3)}{\dfrac{mdot \cdot Cp3 \cdot dTdx4_{A3} + mdot \cdot \frac{1}{\rho3} \cdot \Delta P\Delta x_{A3}}{\pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw3} \cdot \frac{0.75}{0.7}\right]^{-1}$$

$$uhl4_{A3} := \left[\begin{aligned}&\left[\left(\frac{d}{dT4a_{A3}}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uT4a_{A3}\right]^2 + \left[\left(\frac{d}{dTsat3}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uTsat\right]^2 \ldots \\ &+\left[\left(\frac{d}{dmdot}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uCp3\right]^2 \ldots \\ &+\left[\left(\frac{d}{ddTdx4_{A3}}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot dTdx4_{A3}\cdot udTdx_{{A3}_{3}}\right]^2 \ldots \\ &+\left[\left(\frac{d}{d\rho3}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\rho3\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A3}}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\Delta P\right]^2 \ldots \\ &+\left[\left(\frac{d}{dhw3}hl4_{A3}(T4a_{A3}, Tsat3, mdot, Cp3, dTdx4_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uhw3\right]^2\end{aligned}\right]^{0.5}$$

$$\frac{uhl4_{A3}}{Data_{3,50}}\cdot 100 = 4.057$$

5th Local HTC Uncertainty Calculation

$$hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3) := \left[\frac{(T5a_{A3} - Tsat3)}{\dfrac{mdot\cdot Cp3\cdot dTdx5_{A3} + mdot\cdot\dfrac{1}{\rho3}\cdot\Delta P\Delta x_{A3}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw3}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl5_{A3} := \left[\begin{aligned}&\left[\left(\frac{d}{dT5a_{A3}}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uT5a_{A3}\right]^2 + \left[\left(\frac{d}{dTsat3}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uTsat\right]^2 \ldots \\ &+\left[\left(\frac{d}{dmdot}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot umdot\right]^2 + \left[\left(\frac{d}{dCp3}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uCp3\right]^2 \ldots \\ &+\left[\left(\frac{d}{ddTdx5_{A3}}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot dTdx5_{A3}\cdot udTdx_{{A3}_{4}}\right]^2 \ldots \\ &+\left[\left(\frac{d}{d\rho3}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\rho3\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A3}}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot u\Delta P\right]^2 \ldots \\ &+\left[\left(\frac{d}{dhw3}hl5_{A3}(T5a_{A3}, Tsat3, mdot, Cp3, dTdx5_{A3}, \rho3, \Delta P\Delta x_{A3}, hw3)\right)\cdot uhw3\right]^2\end{aligned}\right]^{0.5}$$

$$\frac{uhl5_{A3}}{Data_{3,51}}\cdot 100 = 3.301$$

Tube A4

Average Heat Transfer Coefficient Uncertainty Calculation

$\rho4 := Data_{4,15}$

$u\rho4 := 7\cdot 10^{-13}\cdot\rho4$

$\Delta P4 := (Data_{4,10} - Data_{4,2})\cdot\frac{1m}{59.5in}\cdot 1000$

$Tinlet4 := Data_{4,3}$

$Toutlet4 := Data_{4,9}$

$Cp4 := 1000\cdot Data_{4,13}$

$uCp4 := 6 \cdot 10^{-14} \cdot Cp4$

$hw4 := Data_{4,29}$

$uhw4 := 0.04 \cdot hw4$

$Tsat4 := Data_{4,19}$

$$ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4) := \left[\frac{1}{\dfrac{mdot \cdot Cp4 \cdot (Tinlet4 - Toutlet4) + mdot \cdot \dfrac{1}{\rho4} \cdot (-\Delta P3)}{\dfrac{Tinlet4 - Toutlet4}{\ln\left(\dfrac{Tinlet4 - Tsat4}{Toutlet4 - Tsat4}\right)} \cdot \pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw4} \cdot \frac{0.75}{0.7} \right]^{-1}$$

$$uha_{A4} := \left[\begin{aligned} &\left[\left(\frac{d}{dmdot} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot uCp4\right]^2 \ldots \\ &+ \left[\left(\frac{d}{dTinlet4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot uT\right]^2 + \left[\left(\frac{d}{dToutlet4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot uT\right]^2 \ldots \\ &+ \left[\left(\frac{d}{dTsat4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot uTsat\right]^2 + \left[\left(\frac{d}{d\rho4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot u\rho4\right]^2 \ldots \\ &+ \left[\left(\frac{d}{d\Delta P3} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot u\Delta P\right]^2 + \left[\left(\frac{d}{dhw4} ha_{A4}(mdot, Cp4, Tinlet4, Toutlet4, Tsat4, \rho4, \Delta P3, hw4)\right) \cdot uhw4\right]^2 \end{aligned} \right]^{0.5}$$

$uha_{A4} = 662.395$

$$\frac{uha_{A4}}{Data_{4,31}} \cdot 100 = 4.274$$

Local Heat Transfer Coefficient Uncertainty Calculations

$$\Delta P \Delta x_{A4} := \frac{-\left(Data_{4,10} - Data_{4,2}\right) \cdot 1000}{59.5 \cdot 0.0254}$$

Monte Carlo Simulation For Determining The Uncertainty in dT/dx

$Ti_{A4} := Data_{4,3}$

$T1_{A4} := Data_{4,32}$ $\quad$ $T1a_{A4} := Data_{4,4}$

$T2_{A4} := Data_{4,33}$ $\quad$ $T2a_{A4} := Data_{4,5}$

$T3_{A4} := Data_{4,34}$ $\quad$ $T3a_{A4} := Data_{4,6}$

$T4_{A4} := Data_{4,35}$ $\quad$ $T4a_{A4} := Data_{4,7}$

$T5_{A4} := Data_{4,36}$ $\quad$ $T5a_{A4} := Data_{4,8}$

$To_{A4} := Data_{4,9}$

$i := 0 .. 12000$

$Z_i := rnorm(7, 0, 0.0075)$

$$TT_{A4_i} := \begin{pmatrix} Ti_{A4} \\ T1_{A4} \\ T2_{A4} \\ T3_{A4} \\ T4_{A4} \\ T5_{A4} \\ To_{A4} \end{pmatrix} + Z_i$$

$$REG_{A4_i} := \text{regress}\left(Dist_i, TT_{A4_i}, 2\right)$$

$$Un17_{A4_i} := \frac{\left[2 \cdot \left(REG_{A4_i}\right)_5 \cdot (0.17) + \left(REG_{A4_i}\right)_4 - Data_{4,37}\right]}{Data_{4,37}}$$

$$Un33_{A4_i} := \frac{\left[2 \cdot \left(REG_{A4_i}\right)_5 \cdot (0.33) + \left(REG_{A4_i}\right)_4 - Data_{4,38}\right]}{Data_{4,38}}$$

$$Un50_{A4_i} := \frac{\left[2 \cdot \left(REG_{A4_i}\right)_5 \cdot (0.5) + \left(REG_{A4_i}\right)_4 - Data_{4,39}\right]}{Data_{4,39}}$$

$$Un67_{A4_i} := \frac{\left[2 \cdot \left(REG_{A4_i}\right)_5 \cdot (0.67) + \left(REG_{A4_i}\right)_4 - Data_{4,40}\right]}{Data_{4,40}}$$

$$Un83_{A4_i} := \frac{\left[2 \cdot \left(REG_{A4_i}\right)_5 \cdot (0.83) + \left(REG_{A4_i}\right)_4 - Data_{4,41}\right]}{Data_{4,41}}$$

$$udTdx_{A4} := \begin{pmatrix} \text{sort}\left(Un17_{A4}\right)_{11400} \\ \text{sort}\left(Un33_{A4}\right)_{11400} \\ \text{sort}\left(Un50_{A4}\right)_{11400} \\ \text{sort}\left(Un67_{A4}\right)_{11400} \\ \text{sort}\left(Un83_{A4}\right)_{11400} \end{pmatrix}$$

$$dTdx1_{A4} := Data_{4,42} \qquad uT1a_{A4} := \sqrt{uT^2 + \left[dTdx1_{A4} \cdot \left(1.5875 \times 10^{-3}\right)\right]^2}$$

$$dTdx2_{A4} := Data_{4,43} \qquad uT2a_{A4} := \sqrt{uT^2 + \left[dTdx2_{A4} \cdot \left(1.5875 \times 10^{-3}\right)\right]^2}$$

$$dTdx3_{A4} := Data_{4,44} \qquad uT3a_{A4} := \sqrt{uT^2 + \left[dTdx3_{A4} \cdot \left(1.5875 \times 10^{-3}\right)\right]^2}$$

$$dTdx4_{A4} := Data_{4,45} \qquad uT4a_{A4} := \sqrt{uT^2 + \left[dTdx4_{A4} \cdot \left(1.5875 \times 10^{-3}\right)\right]^2}$$

$$dTdx5_{A4} := Data_{4,46} \qquad uT5a_{A4} := \sqrt{uT^2 + \left[dTdx5_{A4} \cdot \left(1.5875 \times 10^{-3}\right)\right]^2}$$

1st Local HTC Uncertainty Calculation

$$hl1_{A4}\left(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4\right) := \left[\frac{\left(T1a_{A4} - Tsat4\right)}{\dfrac{mdot \cdot Cp4 \cdot dTdx1_{A4} + mdot \cdot \dfrac{1}{\rho 4} \cdot \Delta P\Delta x_{A4}}{\pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw4} \cdot \frac{0.75}{0.7}\right]^{-1}$$

$$uhl1_{A4} := \left[\left[\left(\frac{d}{dT1a_{A4}} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uT1a_{A4}\right]^2 + \left[\left(\frac{d}{dTsat4} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp4} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uCp4\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx1_{A4}} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot dTdx1_{A4} \cdot udTdx_{A4_0}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho4} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\rho4\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A4}} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw4} hl1_{A4}(T1a_{A4}, Tsat4, mdot, Cp4, dTdx1_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uhw4\right]^2\right]^{0.5}$$

$$\frac{uhl1_{A4}}{Data_{4,47}} \cdot 100 = 6.349$$

2nd Local HTC Uncertainty Calculation

$$hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4) := \left[\frac{(T2a_{A4} - Tsat4)}{\frac{mdot \cdot Cp4 \cdot dTdx2_{A4} + mdot \cdot \frac{1}{\rho4} \cdot \Delta P\Delta x_{A4}}{\pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw4} \cdot \frac{0.75}{0.7}\right]^{-1}$$

$$uhl2_{A4} := \left[\left[\left(\frac{d}{dT2a_{A4}} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uT2a_{A4}\right]^2 + \left[\left(\frac{d}{dTsat4} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uTsat\right]^2 \ldots \\ + \left[\left(\frac{d}{dmdot} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp4} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uCp4\right]^2 \ldots \\ + \left[\left(\frac{d}{ddTdx2_{A4}} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot dTdx2_{A4} \cdot udTdx_{A4_1}\right]^2 \ldots \\ + \left[\left(\frac{d}{d\rho4} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\rho4\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A4}} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\Delta P\right]^2 \ldots \\ + \left[\left(\frac{d}{dhw4} hl2_{A4}(T2a_{A4}, Tsat4, mdot, Cp4, dTdx2_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uhw4\right]^2\right]^{0.5}$$

$$\frac{uhl2_{A4}}{Data_{4,48}} \cdot 100 = 6.497$$

3rd Local HTC Uncertainty Calculation

$$hl3_{A4}(T3a_{A4}, Tsat4, mdot, Cp4, dTdx3_{A4}, \rho4, \Delta P\Delta x_{A4}, hw4) := \left[\frac{(T3a_{A4} - Tsat4)}{\frac{mdot \cdot Cp4 \cdot dTdx3_{A4} + mdot \cdot \frac{1}{\rho4} \cdot \Delta P\Delta x_{A4}}{\pi \cdot 0.75 \cdot 0.0254}} - Ao \cdot Rw - \frac{1}{hw4} \cdot \frac{0.75}{0.7}\right]^{-1}$$

$$uhl3_{A4} := \left[\begin{aligned}&\left[\left(\frac{d}{dT3a_{A4}}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uT3a_{A4}\right]^2+\left[\left(\frac{d}{dTsat4}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uTsat\right]^2 \ldots\\&+\left[\left(\frac{d}{dmdot}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot umdot\right]^2+\left[\left(\frac{d}{dCp4}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uCp4\right]^2 \ldots\\&+\left[\left(\frac{d}{ddTdx3_{A4}}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot dTdx3_{A4}\cdot udTdx_{A4_2}\right]^2 \ldots\\&+\left[\left(\frac{d}{d\rho4}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot u\rho4\right]^2+\left[\left(\frac{d}{d\Delta P\Delta x_{A4}}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot u\Delta P\right]^2 \ldots\\&+\left[\left(\frac{d}{dhw4}hl3_{A4}(T3a_{A4},Tsat4,mdot,Cp4,dTdx3_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uhw4\right]^2\end{aligned}\right]^{0.5}$$

$$\frac{uhl3_{A4}}{Data_{4,49}}\cdot 100 = 6.387$$

4th Local HTC Uncertainty Calculation

$$hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4) := \left[\frac{(T4a_{A4}-Tsat4)}{\dfrac{mdot\cdot Cp4\cdot dTdx4_{A4}+mdot\cdot\dfrac{1}{\rho4}\cdot\Delta P\Delta x_{A4}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw4}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl4_{A4} := \left[\begin{aligned}&\left[\left(\frac{d}{dT4a_{A4}}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uT4a_{A4}\right]^2+\left[\left(\frac{d}{dTsat4}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uTsat\right]^2 \ldots\\&+\left[\left(\frac{d}{dmdot}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot umdot\right]^2+\left[\left(\frac{d}{dCp4}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uCp4\right]^2 \ldots\\&+\left[\left(\frac{d}{ddTdx4_{A4}}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot dTdx4_{A4}\cdot udTdx_{A4_3}\right]^2 \ldots\\&+\left[\left(\frac{d}{d\rho4}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot u\rho4\right]^2+\left[\left(\frac{d}{d\Delta P\Delta x_{A4}}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot u\Delta P\right]^2 \ldots\\&+\left[\left(\frac{d}{dhw4}hl4_{A4}(T4a_{A4},Tsat4,mdot,Cp4,dTdx4_{A4},\rho4,\Delta P\Delta x_{A4},hw4)\right)\cdot uhw4\right]^2\end{aligned}\right]^{0.5}$$

$$\frac{uhl4_{A4}}{Data_{4,50}}\cdot 100 = 7.278$$

5th Local HTC Uncertainty Calculation

$$hl5_{A4}(T5a_{A4},Tsat4,mdot,Cp4,dTdx5_{A4},\rho4,\Delta P\Delta x_{A4},hw4) := \left[\frac{(T5a_{A4}-Tsat4)}{\dfrac{mdot\cdot Cp4\cdot dTdx5_{A4}+mdot\cdot\dfrac{1}{\rho4}\cdot\Delta P\Delta x_{A4}}{\pi\cdot 0.75\cdot 0.0254}} - Ao\cdot Rw - \frac{1}{hw4}\cdot\frac{0.75}{0.7}\right]^{-1}$$

$$uhl5_{A4} := \left[\left[\left(\frac{d}{dT5a_{A4}} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uT5a_{A4}\right]^2 + \left[\left(\frac{d}{dTsat4} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uTsat\right]^2 \ldots \right.$$

$$+ \left[\left(\frac{d}{dmdot} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot umdot\right]^2 + \left[\left(\frac{d}{dCp4} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uCp4\right]^2 \ldots$$

$$+ \left[\left(\frac{d}{ddTdx5_{A4}} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot dTdx5_{A4} \cdot udTdx_{A4_4}\right]^2 \ldots$$

$$+ \left[\left(\frac{d}{d\rho 4} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\rho 4\right]^2 + \left[\left(\frac{d}{d\Delta P\Delta x_{A4}} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot u\Delta P\right]^2 \ldots$$

$$\left. + \left[\left(\frac{d}{dhw4} hl5_{A4}(T5a_{A4}, Tsat4, mdot, Cp4, dTdx5_{A4}, \rho 4, \Delta P\Delta x_{A4}, hw4)\right) \cdot uhw4\right]^2 \right]^{0.5}$$

$$\frac{uhl5_{A4}}{Data_{4,51}} \cdot 100 = 8.014$$

$$uavrg := \begin{pmatrix} uha_{A1} \\ uha_{A2} \\ uha_{A3} \\ uha_{A4} \end{pmatrix}$$

uavrg =

	0
0	153.788
1	224.173
2	481.355
3	662.395

$$ulocals := \begin{pmatrix} uhl1_{A1} \\ uhl2_{A1} \\ uhl3_{A1} \\ uhl4_{A1} \\ uhl5_{A1} \\ uhl1_{A2} \\ uhl2_{A2} \\ uhl3_{A2} \\ uhl4_{A2} \\ uhl5_{A2} \\ uhl1_{A3} \\ uhl2_{A3} \\ uhl3_{A3} \\ uhl4_{A3} \\ uhl5_{A3} \\ uhl1_{A4} \\ uhl2_{A4} \\ uhl3_{A4} \\ uhl4_{A4} \\ uhl5_{A4} \end{pmatrix}$$

ulocals =

	0
0	155.446
1	231.509
2	259.277
3	241.108
4	165.529
5	189.54
6	275.23
7	327.435
8	358.39
9	323.642
10	469.597
11	666.228
12	749.218
13	775.546
14	607.786
15	1006.898
16	1054.862
17	1051.484
18	1198.395
19	1267.122

Appendix E Data Tables

The following tables present the temperatures, pressures, flow rates, heat fluxes, heat transfer coefficients, and qualities for each test run. All of which were used in the data analysis and data plots. The data tables are arranged R-134a-P/D 1.167, R-134a-P/D 1.33, R-134a-P/D 1.5, R-123-P/D 1.167, R-123-P/D 1.33, R-123-P/D 1.5, respectively. The Point ID on the top of each table is used to identify the test run's position within the test matrix starting with the refrigerant type and tube pitch. The Point ID is interpreted as follows "Mass-flux Heat-flux Inlet-quality". For example, the first table presents the data of a test run of 15 $kg/m^2.s$ mass flux, 5 kW/m^2 heat flux, and 10 % inlet quality.

Point ID	R-134a, P/D 1.167, 15 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.90	5.18	4.86	4.70	14961.69	0.25	0.2653	
T_1 (˚C)	5.75	5.14	4.83	4.69	15457.19	0.25	0.2778	
T_2 (˚C)	5.61	5.07	4.80	4.67	15586.68	0.25	0.2884	
T_3 (˚C)	5.48	5.00	4.76	4.66	15614.16	0.25	0.2962	
T_4 (˚C)	5.36	4.94	4.74	4.64	15575.58	0.25	0.3011	
T_5 (˚C)	5.25	4.89	4.71	4.63	9453.86	0.19	0.1959	
T_{out} (˚C)	5.18	4.85	4.70	4.62	9889.50	0.19	0.2020	
m_{water} (kg/s)	0.23				10489.48	0.19	0.2079	
$P_{water,in}$ (kPa)	568.66	N/A	N/A	291.67	10833.28	0.19	0.2131	
$P_{water,out}$ (kPa)	473.98	N/A	N/A	183.66	11287.86	0.19	0.2174	
P_{sat} (kPa)	340.92	341.83	340.67	341.71	9524.31	0.14	0.1484	15.15
$P_{bundle,in}$ (kPa)	341.70				9344.18	0.14	0.1514	
$P_{bundle,out}$ (kPa)	340.15				9201.74	0.14	0.1540	
m_{ref} (kg/s)	0.14				8747.41	0.14	0.1559	
	Path B	**Path C**	**Path D**	**Path E**	8254.14	0.14	0.1572	
$T_{water,in}$ (˚C)	5.84	5.83	5.84	5.90	4811.33	0.11	0.1124	
$T_{water,out}$ (˚C)	4.82	4.99	4.92	4.91	4838.82	0.11	0.1141	
m_{water} (kg/s)	0.31	0.34	0.32	0.31	4828.09	0.11	0.1157	
	Pre-boiler				4840.39	0.11	0.1172	
$T_{water,in}$ (˚C)	8.49				4789.79	0.11	0.1185	
$T_{water,out}$ (˚C)	6.37							
m_{water} (kg/s)	0.48							
$T_{ref,in}$ (˚C)	-1.43							
$P_{ref,in}$ (kPa)	362.75							
$P_{ref,out}$ (kPa)	357.31							

Point ID	R-134a, P/D 1.167, 15 5 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.98	5.26	4.93	4.77	14.67	15699.60	0.5267	
T_1 (˚C)	5.83	5.22	4.90	4.76	13.52	16222.16	0.5248	
T_2 (˚C)	5.70	5.14	4.87	4.75	12.30	16696.84	0.5229	
T_3 (˚C)	5.56	5.07	4.83	4.73	11.07	16993.98	0.5213	
T_4 (˚C)	5.44	5.01	4.81	4.72	9.92	17341.21	0.5200	
T_5 (˚C)	5.33	4.96	4.78	4.71	6.99	11115.08	0.4437	
T_{out} (˚C)	5.26	4.92	4.77	4.70	6.58	11563.86	0.4430	
m_{water} (kg/s)	0.23				6.14	12208.53	0.4423	
$P_{water,in}$ (kPa)	569.83	N/A	N/A	291.80	5.71	12312.15	0.4419	
$P_{water,out}$ (kPa)	474.80	N/A	N/A	183.32	5.30	12523.34	0.4415	
P_{sat} (kPa)	342.39	343.33	342.20	343.27	3.59	11346.39	0.3877	15.29
$P_{bundle,in}$ (kPa)	343.06				3.27	11067.77	0.3880	
$P_{bundle,out}$ (kPa)	341.74				2.93	10871.28	0.3883	
m_{ref} (kg/s)	0.15				2.59	10254.57	0.3888	
	Path B	**Path C**	**Path D**	**Path E**	2.28	9479.74	0.3892	
$T_{water,in}$ (˚C)	5.92	5.92	5.91	5.98	1.78	5693.06	0.3519	
$T_{water,out}$ (˚C)	4.90	5.06	4.98	4.99	1.67	5574.40	0.3516	
m_{water} (kg/s)	0.31	0.34	0.32	0.31	1.55	5395.78	0.3512	
	Pre-boiler				1.43	5209.14	0.3509	
$T_{water,in}$ (˚C)	14.60				1.32	4886.18	0.3505	
$T_{water,out}$ (˚C)	13.34							
m_{water} (kg/s)	2.12							
$T_{ref,in}$ (˚C)	-2.36							
$P_{ref,in}$ (kPa)	436.47							
$P_{ref,out}$ (kPa)	431.31							

Point ID	R-134a, P/D 1.167, 15 5 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	6.02	5.30	4.95	4.80	14.89	16690.15	0.7372	
T_1 (˚C)	5.86	5.25	4.92	4.79	13.65	16951.31	0.7349	
T_2 (˚C)	5.74	5.17	4.89	4.77	12.34	17637.22	0.7326	
T_3 (˚C)	5.59	5.09	4.86	4.76	11.03	17815.77	0.7305	
T_4 (˚C)	5.47	5.04	4.83	4.75	9.80	17964.80	0.7288	
T_5 (˚C)	5.36	4.99	4.81	4.74	7.06	11725.90	0.6533	
T_{out} (˚C)	5.29	4.94	4.80	4.73	6.66	12337.15	0.6527	
m_{water} (kg/s)	0.23				6.24	13184.73	0.6523	
$P_{water,in}$ (kPa)	566.74	N/A	N/A	290.00	5.82	13378.28	0.6518	
$P_{water,out}$ (kPa)	472.51	N/A	N/A	182.44	5.42	13919.32	0.6516	
P_{sat} (kPa)	342.88	343.92	342.78	343.94	3.63	12744.48	0.5973	15.28
$P_{bundle,in}$ (kPa)	343.58				3.27	12354.17	0.5974	
$P_{bundle,out}$ (kPa)	342.40				2.89	12000.84	0.5976	
m_{ref} (kg/s)	0.15				2.50	11089.48	0.5978	
	Path B	**Path C**	**Path D**	**Path E**	2.14	9947.48	0.5981	
$T_{water,in}$ (˚C)	5.95	5.96	5.93	6.01	1.75	5955.41	0.5601	
$T_{water,out}$ (˚C)	4.93	5.09	5.08	5.04	1.63	5820.97	0.5598	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.51	5604.48	0.5594	
	Pre-boiler				1.39	5363.53	0.5590	
$T_{water,in}$ (˚C)	12.28				1.28	5025.12	0.5587	
$T_{water,out}$ (˚C)	9.01							
m_{water} (kg/s)	1.24							
$T_{ref,in}$ (˚C)	-2.26							
$P_{ref,in}$ (kPa)	375.41							
$P_{ref,out}$ (kPa)	370.30							

Point ID	R-134a, P/D 1.167, 15 5 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.83	5.13	4.77	4.61	14.11	15145.29	0.8942	
T_1 (˚C)	5.68	5.08	4.74	4.60	13.06	15741.39	0.8925	
T_2 (˚C)	5.55	5.00	4.71	4.58	11.95	16290.29	0.8908	
T_3 (˚C)	5.42	4.92	4.67	4.57	10.83	16703.71	0.8894	
T_4 (˚C)	5.31	4.86	4.64	4.55	9.79	17184.91	0.8883	
T_5 (˚C)	5.20	4.81	4.62	4.54	7.42	12075.70	0.8116	
T_{out} (˚C)	5.12	4.76	4.61	4.53	6.98	12667.26	0.8109	
m_{water} (kg/s)	0.23				6.51	13501.42	0.8103	
$P_{water,in}$ (kPa)	566.62	N/A	N/A	289.73	6.04	13757.81	0.8099	
$P_{water,out}$ (kPa)	471.86	N/A	N/A	181.76	5.59	14107.14	0.8096	
P_{sat} (kPa)	340.56	341.61	340.53	341.69	3.90	13506.86	0.7534	15.31
$P_{bundle,in}$ (kPa)	341.18				3.49	13058.79	0.7534	
$P_{bundle,out}$ (kPa)	340.16				3.06	12636.02	0.7535	
m_{ref} (kg/s)	0.15				2.64	11599.20	0.7536	
	Path B	**Path C**	**Path D**	**Path E**	2.23	10256.81	0.7538	
$T_{water,in}$ (˚C)	5.78	5.78	5.75	5.83	1.86	6319.52	0.7152	
$T_{water,out}$ (˚C)	4.74	4.89	4.88	4.84	1.73	6148.31	0.7147	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.59	5875.97	0.7143	
	Pre-boiler				1.45	5589.36	0.7139	
$T_{water,in}$ (˚C)	15.02				1.32	5181.32	0.7135	
$T_{water,out}$ (˚C)	12.21							
m_{water} (kg/s)	1.82							
$T_{ref,in}$ (˚C)	-2.05							
$P_{ref,in}$ (kPa)	415.81							
$P_{ref,out}$ (kPa)	410.21							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	8.38	6.77	5.80	5.32	34.18	13245.22	0.5995	
T_1 (˚C)	8.05	6.63	5.71	5.28	31.79	13627.13	0.5961	
T_2 (˚C)	7.74	6.44	5.61	5.24	29.24	13726.51	0.5932	
T_3 (˚C)	7.47	6.22	5.51	5.21	26.70	13728.01	0.5911	
T_4 (˚C)	7.22	6.07	5.42	5.17	24.30	13977.50	0.5899	
T_5 (˚C)	6.96	5.91	5.36	5.14	20.57	12966.11	0.3764	
T_{out} (˚C)	6.77	5.79	5.31	5.11	19.59	13832.89	0.3759	
m_{water} (kg/s)	0.25				18.54	15038.62	0.3757	
$P_{water,in}$ (kPa)	647.56	N/A	N/A	322.81	17.50	15839.99	0.3760	
$P_{water,out}$ (kPa)	536.88	N/A	N/A	195.96	16.52	16976.79	0.3767	
P_{sat} (kPa)	343.82	344.77	343.68	344.82	11.56	14316.97	0.2173	15.04
$P_{bundle,in}$ (kPa)	344.57				10.50	14294.93	0.2175	
$P_{bundle,out}$ (kPa)	343.25				9.36	14157.80	0.2180	
m_{ref} (kg/s)	0.14				8.23	13523.39	0.2186	
	Path B	**Path C**	**Path D**	**Path E**	7.17	12591.99	0.2194	
$T_{water,in}$ (˚C)	8.33	8.33	8.31	8.38	4.35	6688.95	0.1115	
$T_{water,out}$ (˚C)	5.65	5.90	5.79	5.77	4.22	6870.55	0.1111	
m_{water} (kg/s)	0.33	0.36	0.34	0.34	4.07	7016.42	0.1106	
	Pre-boiler				3.93	7146.03	0.1102	
$T_{water,in}$ (˚C)	10.50				3.80	7244.88	0.1097	
$T_{water,out}$ (˚C)	7.16							
m_{water} (kg/s)	0.29							
$T_{ref,in}$ (˚C)	-2.16							
$P_{ref,in}$ (kPa)	377.40							
$P_{ref,out}$ (kPa)	371.70							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.51	6.18	5.25	4.76	29.11	12057.62	0.8102	
T_1 (˚C)	7.25	6.05	5.16	4.72	27.59	12470.95	0.8097	
T_2 (˚C)	7.01	5.86	5.06	4.67	25.98	12860.15	0.8098	
T_3 (˚C)	6.78	5.66	4.95	4.63	24.38	13276.76	0.8106	
T_4 (˚C)	6.56	5.50	4.87	4.59	22.86	13922.06	0.8119	
T_5 (˚C)	6.33	5.36	4.80	4.55	20.73	13768.21	0.6192	
T_{out} (˚C)	6.17	5.24	4.76	4.52	19.77	14681.92	0.6185	
m_{water} (kg/s)	0.27				18.76	16071.30	0.6182	
$P_{water,in}$ (kPa)	710.05	N/A	N/A	349.88	17.74	17092.08	0.6182	
$P_{water,out}$ (kPa)	587.08	N/A	N/A	208.95	16.78	18316.21	0.6186	
P_{sat} (kPa)	337.91	338.95	337.85	339.12	12.56	17183.63	0.4711	15.73
$P_{bundle,in}$ (kPa)	338.58				11.37	17242.75	0.4714	
$P_{bundle,out}$ (kPa)	338.71				10.12	17285.28	0.4718	
m_{ref} (kg/s)	0.15				8.86	16747.81	0.4723	
	Path B	**Path C**	**Path D**	**Path E**	7.68	15522.50	0.4730	
$T_{water,in}$ (˚C)	7.43	7.42	7.46	7.48	5.70	10321.81	0.3730	
$T_{water,out}$ (˚C)	5.09	5.22	5.10	5.23	5.35	10415.10	0.3719	
m_{water} (kg/s)	0.36	0.38	0.34	0.39	4.98	10461.79	0.3708	
	Pre-boiler				4.61	10354.44	0.3697	
$T_{water,in}$ (˚C)	8.88				4.26	10075.45	0.3686	
$T_{water,out}$ (˚C)	6.37							
m_{water} (kg/s)	1.23							
$T_{ref,in}$ (˚C)	-8.82							
$P_{ref,in}$ (kPa)	352.01							
$P_{ref,out}$ (kPa)	346.84							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	9.76	7.59	6.09	5.31	40.03	10406.80	0.7368	
T_1 (˚C)	9.35	7.36	5.94	5.26	38.36	10953.16	0.7391	
T_2 (˚C)	8.96	7.06	5.77	5.19	36.59	11455.60	0.7427	
T_3 (˚C)	8.61	6.72	5.61	5.13	34.82	12128.13	0.7477	
T_4 (˚C)	8.24	6.48	5.47	5.08	33.16	13023.61	0.7536	
T_5 (˚C)	7.87	6.26	5.37	5.05	30.13	13823.11	0.4645	
T_{out} (˚C)	7.59	6.08	5.31	5.01	28.25	14655.40	0.4619	
m_{water} (kg/s)		0.24			26.25	15947.03	0.4599	
$P_{water,in}$ (kPa)	578.24	N/A	N/A	294.96	24.25	16551.93	0.4586	
$P_{water,out}$ (kPa)	482.75	N/A	N/A	184.45	22.37	17265.04	0.4581	
P_{sat} (kPa)	341.84	342.84	341.75	342.93	17.40	17275.27	0.2498	14.74
$P_{bundle,in}$ (kPa)		342.53			15.62	17496.55	0.2500	
$P_{bundle,out}$ (kPa)		341.36			13.72	17492.78	0.2506	
m_{ref} (kg/s)		0.14			11.82	16855.95	0.2514	
	Path B	**Path C**	**Path D**	**Path E**	10.03	15482.01	0.2525	
$T_{water,in}$ (˚C)	9.69	9.71	9.76	9.77	6.58	9204.74	0.1155	
$T_{water,out}$ (˚C)	5.78	5.89	5.85	5.89	6.00	8996.89	0.1136	
m_{water} (kg/s)	0.30	0.30	0.29	0.30	5.38	8662.81	0.1116	
		Pre-boiler			4.76	8019.30	0.1096	
$T_{water,in}$ (˚C)		7.48			4.17	7244.11	0.1077	
$T_{water,out}$ (˚C)		6.67						
m_{water} (kg/s)		1.23						
$T_{ref,in}$ (˚C)		-4.26						
$P_{ref,in}$ (kPa)		368.08						
$P_{ref,out}$ (kPa)		362.79						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	6.08	5.37	5.05	4.89	14.71	14940.97	0.2241	
T_1 (˚C)	5.94	5.33	5.02	4.88	13.53	15502.91	0.2224	
T_2 (˚C)	5.80	5.26	4.99	4.86	12.27	15653.47	0.2208	
T_3 (˚C)	5.67	5.19	4.95	4.85	11.00	15738.31	0.2192	
T_4 (˚C)	5.55	5.13	4.93	4.83	9.82	15753.73	0.2179	
T_5 (˚C)	5.44	5.08	4.90	4.82	6.61	9575.51	0.1621	
T_{out} (˚C)	5.36	5.04	4.89	4.81	6.30	9980.43	0.1618	
m_{water} (kg/s)		0.23			5.98	10546.52	0.1616	
$P_{water,in}$ (kPa)	569.02	N/A	N/A	292.03	5.66	10851.04	0.1615	
$P_{water,out}$ (kPa)	473.95	N/A	N/A	183.75	5.35	11205.92	0.1614	
P_{sat} (kPa)	343.23	344.20	342.96	344.04	3.56	9674.21	0.1216	20.71
$P_{bundle,in}$ (kPa)		344.00			3.28	9507.49	0.1219	
$P_{bundle,out}$ (kPa)		342.47			2.98	9389.41	0.1223	
m_{ref} (kg/s)		0.20			2.69	8958.05	0.1226	
	Path B	**Path C**	**Path D**	**Path E**	2.41	8483.44	0.1230	
$T_{water,in}$ (˚C)	6.03	6.03	6.02	6.09	1.77	4913.88	0.0953	
$T_{water,out}$ (˚C)	5.02	5.18	5.11	5.10	1.70	4903.38	0.0951	
m_{water} (kg/s)	0.31	0.34	0.32	0.31	1.62	4846.79	0.0949	
		Pre-boiler			1.54	4795.59	0.0947	
$T_{water,in}$ (˚C)		8.18			1.47	4687.46	0.0945	
$T_{water,out}$ (˚C)		6.65						
m_{water} (kg/s)		0.78						
$T_{ref,in}$ (˚C)		-1.09						
$P_{ref,in}$ (kPa)		366.45						
$P_{ref,out}$ (kPa)		360.61						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.80	5.09	4.76	4.61	14.62	16198.25	0.4908	
T_1 (˚C)	5.65	5.04	4.73	4.60	13.43	16793.30	0.4893	
T_2 (˚C)	5.52	4.97	4.70	4.58	12.17	17248.25	0.4878	
T_3 (˚C)	5.39	4.89	4.67	4.57	10.91	17503.18	0.4864	
T_4 (˚C)	5.27	4.84	4.64	4.56	9.73	17750.42	0.4853	
T_5 (˚C)	5.16	4.79	4.62	4.55	6.95	11493.43	0.4286	
T_{out} (˚C)	5.08	4.75	4.61	4.54	6.53	11960.21	0.4282	
m_{water} (kg/s)	0.23				6.09	12644.26	0.4277	
$P_{water,in}$ (kPa)	568.01	N/A	N/A	290.93	5.64	12769.08	0.4274	
$P_{water,out}$ (kPa)	474.08	N/A	N/A	183.92	5.22	12954.26	0.4272	
P_{sat} (kPa)	340.62	341.60	340.45	341.55	3.51	11847.86	0.3875	20.10
$P_{bundle,in}$ (kPa)	341.25				3.18	11509.52	0.3877	
$P_{bundle,out}$ (kPa)	339.99				2.83	11199.74	0.3879	
m_{ref} (kg/s)	0.19				2.47	10431.72	0.3882	
	Path B	Path C	Path D	Path E	2.14	9454.61	0.3885	
$T_{water,in}$ (˚C)	5.74	5.75	5.73	5.80	1.65	5436.83	0.3617	
$T_{water,out}$ (˚C)	4.73	4.89	4.82	4.84	1.55	5316.68	0.3614	
m_{water} (kg/s)	0.30	0.34	0.32	0.31	1.44	5127.33	0.3612	
	Pre-boiler				1.33	4922.77	0.3609	
$T_{water,in}$ (˚C)	14.90				1.23	4628.63	0.3607	
$T_{water,out}$ (˚C)	12.55							
m_{water} (kg/s)	1.54							
$T_{ref,in}$ (˚C)	-2.55							
$P_{ref,in}$ (kPa)	429.67							
$P_{ref,out}$ (kPa)	423.73							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.73	5.02	4.67	4.52	14.52	16098.38	0.6897	
T_1 (˚C)	5.58	4.97	4.64	4.51	13.37	16631.88	0.6881	
T_2 (˚C)	5.45	4.90	4.61	4.49	12.15	17229.38	0.6866	
T_3 (˚C)	5.31	4.81	4.57	4.48	10.93	17560.00	0.6852	
T_4 (˚C)	5.20	4.76	4.55	4.46	9.78	17904.97	0.6841	
T_5 (˚C)	5.09	4.71	4.53	4.46	7.22	12069.60	0.6261	
T_{out} (˚C)	5.01	4.66	4.52	4.45	6.79	12664.88	0.6256	
m_{water} (kg/s)	0.23				6.34	13528.95	0.6252	
$P_{water,in}$ (kPa)	567.29	N/A	N/A	290.06	5.89	13768.81	0.6249	
$P_{water,out}$ (kPa)	472.77	N/A	N/A	182.69	5.46	14157.50	0.6248	
P_{sat} (kPa)	339.57	340.68	339.54	340.68	3.75	13632.32	0.5831	20.05
$P_{bundle,in}$ (kPa)	340.26				3.35	13110.23	0.5831	
$P_{bundle,out}$ (kPa)	339.16				2.93	12597.65	0.5831	
m_{ref} (kg/s)	0.19				2.50	11452.18	0.5833	
	Path B	Path C	Path D	Path E	2.10	10011.34	0.5835	
$T_{water,in}$ (˚C)	5.67	5.68	5.65	5.73	1.72	5830.54	0.5551	
$T_{water,out}$ (˚C)	4.65	4.80	4.79	4.75	1.60	5666.03	0.5548	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.48	5415.30	0.5545	
	Pre-boiler				1.35	5153.35	0.5542	
$T_{water,in}$ (˚C)	13.87				1.24	4783.75	0.5539	
$T_{water,out}$ (˚C)	10.02							
m_{water} (kg/s)	1.39							
$T_{ref,in}$ (˚C)	-2.47							
$P_{ref,in}$ (kPa)	391.20							
$P_{ref,out}$ (kPa)	384.43							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.91	5.24	4.88	4.72	13.43	14436.24	0.8374	
T_1 (˚C)	5.78	5.19	4.85	4.70	12.49	15110.91	0.8365	
T_2 (˚C)	5.65	5.12	4.82	4.69	11.48	15565.25	0.8356	
T_3 (˚C)	5.53	5.03	4.78	4.67	10.48	16053.27	0.8349	
T_4 (˚C)	5.42	4.97	4.75	4.66	9.53	16643.43	0.8344	
T_5 (˚C)	5.31	4.92	4.73	4.65	7.50	12306.01	0.7768	
T_{out} (˚C)	5.24	4.88	4.72	4.64	7.03	12854.07	0.7762	
m_{water} (kg/s)	0.23				6.53	13700.39	0.7757	
$P_{water,in}$ (kPa)	567.21	N/A	N/A	291.15	6.04	13908.71	0.7754	
$P_{water,out}$ (kPa)	471.98	N/A	N/A	182.93	5.57	14130.83	0.7751	
P_{sat} (kPa)	341.99	343.05	341.95	343.12	3.98	14313.75	0.7335	19.93
$P_{bundle,in}$ (kPa)	342.44				3.56	13854.53	0.7335	
$P_{bundle,out}$ (kPa)	341.61				3.11	13396.50	0.7336	
m_{ref} (kg/s)	0.19				2.66	12265.27	0.7338	
	Path B	**Path C**	**Path D**	**Path E**	2.23	10759.18	0.7340	
$T_{water,in}$ (˚C)	5.86	5.89	5.93	5.92	1.84	6433.57	0.7058	
$T_{water,out}$ (˚C)	4.84	4.99	5.03	4.94	1.71	6254.76	0.7055	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.57	5982.93	0.7052	
	Pre-boiler				1.43	5700.10	0.7048	
$T_{water,in}$ (˚C)	14.27				1.30	5276.55	0.7045	
$T_{water,out}$ (˚C)	11.49							
m_{water} (kg/s)	2.39							
$T_{ref,in}$ (˚C)	-2.59							
$P_{ref,in}$ (kPa)	413.55							
$P_{ref,out}$ (kPa)	406.61							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	8.27	6.62	5.64	5.16	35.05	13602.09	0.4895	
T_1 (˚C)	7.93	6.48	5.55	5.12	32.64	14032.11	0.4873	
T_2 (˚C)	7.62	6.28	5.45	5.08	30.08	14274.42	0.4855	
T_3 (˚C)	7.34	6.06	5.35	5.04	27.52	14417.18	0.4843	
T_4 (˚C)	7.07	5.90	5.26	5.00	25.11	14777.09	0.4837	
T_5 (˚C)	6.80	5.75	5.20	4.97	20.93	13423.16	0.3201	
T_{out} (˚C)	6.61	5.63	5.15	4.94	19.86	14278.98	0.3195	
m_{water} (kg/s)	0.25				18.72	15565.12	0.3191	
$P_{water,in}$ (kPa)	648.08	N/A	N/A	322.96	17.58	16394.82	0.3190	
$P_{water,out}$ (kPa)	536.73	N/A	N/A	195.86	16.51	17467.98	0.3193	
P_{sat} (kPa)	342.19	343.15	342.02	343.16	11.55	14765.85	0.1988	20.07
$P_{bundle,in}$ (kPa)	342.87				10.50	14788.76	0.1992	
$P_{bundle,out}$ (kPa)	341.60				9.39	14798.78	0.1997	
m_{ref} (kg/s)	0.19				8.28	14271.97	0.2004	
	Path B	**Path C**	**Path D**	**Path E**	7.23	13369.34	0.2012	
$T_{water,in}$ (˚C)	8.20	8.21	8.19	8.26	4.57	7395.93	0.1201	
$T_{water,out}$ (˚C)	5.49	5.74	5.64	5.61	4.40	7575.53	0.1197	
m_{water} (kg/s)	0.33	0.36	0.34	0.34	4.21	7705.84	0.1192	
	Pre-boiler				4.03	7845.44	0.1188	
$T_{water,in}$ (˚C)	10.40				3.86	7907.51	0.1184	
$T_{water,out}$ (˚C)	6.27							
m_{water} (kg/s)	0.34							
$T_{ref,in}$ (˚C)	-2.56							
$P_{ref,in}$ (kPa)	365.67							
$P_{ref,out}$ (kPa)	360.07							

Point ID	**R-134a, P/D 1.167, 20 15 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	7.60	6.25	5.39	4.94	29.80	13177.89	0.7127	
T_1 (°C)	7.33	6.13	5.31	4.91	28.07	13647.87	0.7117	
T_2 (°C)	7.08	5.96	5.22	4.86	26.22	14007.77	0.7111	
T_3 (°C)	6.85	5.77	5.12	4.82	24.37	14400.40	0.7111	
T_4 (°C)	6.63	5.62	5.04	4.78	22.63	15041.77	0.7116	
T_5 (°C)	6.40	5.49	4.98	4.75	19.16	13631.15	0.5603	
T_{out} (°C)	6.24	5.38	4.94	4.72	18.28	14531.01	0.5599	
m_{water} (kg/s)	0.27				17.35	15901.66	0.5597	
$P_{water,in}$ (kPa)	709.13	N/A	N/A	349.11	16.42	16908.42	0.5599	
$P_{water,out}$ (kPa)	586.91	N/A	N/A	209.20	15.55	18114.46	0.5604	
P_{sat} (kPa)	340.58	341.57	340.47	341.63	11.52	16810.20	0.4479	19.92
$P_{bundle,in}$ (kPa)	341.14				10.44	16836.51	0.4482	
$P_{bundle,out}$ (kPa)	340.11				9.29	16839.35	0.4487	
m_{ref} (kg/s)	0.19				8.14	16249.70	0.4492	
	Path B	**Path C**	**Path D**	**Path E**	7.05	15048.85	0.4499	
$T_{water,in}$ (°C)	7.53	7.51	7.54	7.57	5.32	10205.17	0.3738	
$T_{water,out}$ (°C)	5.21	5.40	5.35	5.36	5.00	10295.08	0.3730	
m_{water} (kg/s)	0.36	0.38	0.38	0.39	4.66	10348.09	0.3722	
	Pre-boiler				4.32	10244.47	0.3714	
$T_{water,in}$ (°C)	8.65				4.00	9983.53	0.3706	
$T_{water,out}$ (°C)	6.97							
m_{water} (kg/s)	2.36							
$T_{ref,in}$ (°C)	-9.13							
$P_{ref,in}$ (kPa)	356.12							
$P_{ref,out}$ (kPa)	349.96							

Point ID	**R-134a, P/D 1.167, 20 27 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	11.53	8.64	6.63	5.46	57.83	11355.71	0.7507	
T_1 (°C)	10.90	8.35	6.40	5.38	53.00	11323.63	0.7439	
T_2 (°C)	10.36	7.96	6.15	5.29	47.87	11120.53	0.7380	
T_3 (°C)	9.85	7.55	5.90	5.20	42.73	10670.23	0.7334	
T_4 (°C)	9.42	7.22	5.70	5.12	37.90	10241.97	0.7303	
T_5 (°C)	8.99	6.89	5.55	5.06	37.45	12045.43	0.4570	
T_{out} (°C)	8.65	6.62	5.46	5.00	36.19	13146.74	0.4586	
m_{water} (kg/s)	0.24				34.86	14646.31	0.4610	
$P_{water,in}$ (kPa)	578.29	N/A	N/A	295.16	33.53	16059.90	0.4641	
$P_{water,out}$ (kPa)	482.29	N/A	N/A	184.75	32.28	18015.91	0.4677	
P_{sat} (kPa)	340.21	341.23	340.26	341.45	26.42	19490.04	0.2592	20.24
$P_{bundle,in}$ (kPa)	341.04				23.52	19852.33	0.2582	
$P_{bundle,out}$ (kPa)	339.95				20.45	19953.22	0.2574	
m_{ref} (kg/s)	0.19				17.37	19068.98	0.2570	
	Path B	**Path C**	**Path D**	**Path E**	14.48	17148.74	0.2569	
$T_{water,in}$ (°C)	11.46	11.48	11.50	11.53	9.52	10687.85	0.1206	
$T_{water,out}$ (°C)	6.13	6.21	6.14	6.26	8.85	10860.55	0.1190	
m_{water} (kg/s)	0.29	0.30	0.29	0.30	8.14	10879.69	0.1173	
	Pre-boiler				7.43	10735.84	0.1156	
$T_{water,in}$ (°C)	7.18				6.76	10418.75	0.1140	
$T_{water,out}$ (°C)	6.61							
m_{water} (kg/s)	2.53							
$T_{ref,in}$ (°C)	-4.54							
$P_{ref,in}$ (kPa)	364.44							
$P_{ref,out}$ (kPa)	358.71							

Point ID	R-134a, P/D 1.167, 25 5 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.75	5.04	4.71	4.55	14.50	14714.58	0.2032	
T_1 (˚C)	5.60	4.99	4.68	4.54	13.39	15313.28	0.2021	
T_2 (˚C)	5.46	4.92	4.65	4.52	12.21	15547.27	0.2010	
T_3 (˚C)	5.34	4.84	4.62	4.51	11.03	15814.03	0.2001	
T_4 (˚C)	5.22	4.79	4.59	4.49	9.92	16035.22	0.1992	
T_5 (˚C)	5.10	4.74	4.56	4.49	6.75	9915.08	0.1526	
T_{out} (˚C)	5.03	4.70	4.55	4.47	6.39	10259.93	0.1522	
m_{water} (kg/s)	0.23				6.00	10761.47	0.1518	
$P_{water,in}$ (kPa)	569.20	N/A	N/A	292.24	5.61	10880.02	0.1515	
$P_{water,out}$ (kPa)	473.76	N/A	N/A	183.76	5.25	11047.30	0.1512	
P_{sat} (kPa)	339.30	340.22	339.01	340.05	3.49	9526.31	0.1182	24.74
$P_{bundle,in}$ (kPa)	340.01				3.24	9418.04	0.1186	
$P_{bundle,out}$ (kPa)	338.49				2.97	9363.77	0.1189	
m_{ref} (kg/s)	0.24				2.70	9085.05	0.1193	
	Path B	**Path C**	**Path D**	**Path E**	2.45	8756.18	0.1197	
$T_{water,in}$ (˚C)	5.69	5.68	5.69	5.75	1.80	5098.00	0.0965	
$T_{water,out}$ (˚C)	4.68	4.84	4.78	4.77	1.70	5005.10	0.0963	
m_{water} (kg/s)	0.31	0.34	0.32	0.31	1.59	4865.88	0.0961	
	Pre-boiler				1.48	4691.59	0.0958	
$T_{water,in}$ (˚C)	9.90				1.38	4445.94	0.0956	
$T_{water,out}$ (˚C)	9.36							
m_{water} (kg/s)	2.55							
$T_{ref,in}$ (˚C)	-0.80							
$P_{ref,in}$ (kPa)	399.57							
$P_{ref,out}$ (kPa)	393.49							

Point ID	R-134a, P/D 1.167, 25 5 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.62	4.91	4.57	4.42	14.78	16405.21	0.4574	
T_1 (˚C)	5.48	4.86	4.54	4.41	13.58	17055.61	0.4562	
T_2 (˚C)	5.34	4.79	4.51	4.39	12.30	17527.35	0.4550	
T_3 (˚C)	5.21	4.71	4.47	4.38	11.02	17813.47	0.4540	
T_4 (˚C)	5.09	4.65	4.45	4.36	9.82	18083.89	0.4532	
T_5 (˚C)	4.97	4.60	4.43	4.36	7.10	11914.03	0.4069	
T_{out} (˚C)	4.90	4.56	4.42	4.35	6.66	12410.76	0.4064	
m_{water} (kg/s)	0.23				6.20	13163.46	0.4060	
$P_{water,in}$ (kPa)	568.11	N/A	N/A	291.07	5.73	13301.02	0.4057	
$P_{water,out}$ (kPa)	472.53	N/A	N/A	183.73	5.29	13477.85	0.4054	
P_{sat} (kPa)	338.42	339.40	338.30	339.39	3.60	12469.11	0.3728	25.09
$P_{bundle,in}$ (kPa)	339.05				3.24	12101.57	0.3730	
$P_{bundle,out}$ (kPa)	337.86				2.87	11754.16	0.3732	
m_{ref} (kg/s)	0.24				2.50	10897.06	0.3734	
	Path B	**Path C**	**Path D**	**Path E**	2.14	9794.62	0.3737	
$T_{water,in}$ (˚C)	5.56	5.57	5.55	5.62	1.70	5774.81	0.3515	
$T_{water,out}$ (˚C)	4.54	4.69	4.62	4.65	1.59	5611.52	0.3513	
m_{water} (kg/s)	0.30	0.34	0.32	0.31	1.47	5371.09	0.3510	
	Pre-boiler				1.34	5143.69	0.3508	
$T_{water,in}$ (˚C)	18.09				1.23	4761.93	0.3506	
$T_{water,out}$ (˚C)	16.39							
m_{water} (kg/s)	2.58							
$T_{ref,in}$ (˚C)	-2.43							
$P_{ref,in}$ (kPa)	486.98							
$P_{ref,out}$ (kPa)	480.31							

Point ID	R-134a, P/D 1.167, 25 5 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.87	5.18	4.83	4.68	14.10	15814.88	0.6606	
T_1 (˚C)	5.73	5.13	4.80	4.67	13.01	16545.36	0.6596	
T_2 (˚C)	5.60	5.06	4.77	4.65	11.85	17041.26	0.6587	
T_3 (˚C)	5.47	4.97	4.74	4.64	10.69	17455.12	0.6580	
T_4 (˚C)	5.36	4.92	4.71	4.63	9.60	17882.62	0.6573	
T_5 (˚C)	5.25	4.87	4.69	4.62	7.30	12516.79	0.6100	
T_{out} (˚C)	5.17	4.83	4.68	4.61	6.82	13050.12	0.6095	
m_{water} (kg/s)		0.23			6.31	13844.93	0.6091	
$P_{water,in}$ (kPa)	567.32	N/A	N/A	290.65	5.80	13943.49	0.6087	
$P_{water,out}$ (kPa)	472.62	N/A	N/A	182.62	5.32	14048.69	0.6084	
P_{sat} (kPa)	341.70	342.73	341.64	342.82	3.71	13781.92	0.5747	24.72
$P_{bundle,in}$ (kPa)		342.24			3.32	13328.99	0.5748	
$P_{bundle,out}$ (kPa)		341.27			2.91	12874.12	0.5750	
m_{ref} (kg/s)		0.24			2.49	11782.99	0.5752	
	Path B	**Path C**	**Path D**	**Path E**	2.10	10354.27	0.5755	
$T_{water,in}$ (˚C)	5.82	5.86	5.88	5.88	1.69	5990.38	0.5527	
$T_{water,out}$ (˚C)	4.80	4.95	4.97	4.90	1.57	5834.10	0.5524	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.45	5587.64	0.5522	
		Pre-boiler			1.33	5340.45	0.5520	
$T_{water,in}$ (˚C)		20.52			1.22	4964.01	0.5518	
$T_{water,out}$ (˚C)		17.98						
m_{water} (kg/s)		2.59						
$T_{ref,in}$ (˚C)		-2.52						
$P_{ref,in}$ (kPa)		512.09						
$P_{ref,out}$ (kPa)		504.59						

Point ID	R-134a, P/D 1.167, 25 5 0.70							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.90	5.25	4.89	4.73	13.29	14509.65	0.8014	
T_1 (˚C)	5.77	5.19	4.85	4.71	12.34	15160.86	0.8005	
T_2 (˚C)	5.65	5.12	4.82	4.70	11.33	15599.97	0.7998	
T_3 (˚C)	5.53	5.03	4.78	4.68	10.33	16066.35	0.7992	
T_4 (˚C)	5.42	4.98	4.75	4.67	9.38	16616.32	0.7988	
T_5 (˚C)	5.31	4.92	4.73	4.66	7.44	12409.01	0.7535	
T_{out} (˚C)	5.24	4.88	4.72	4.65	6.98	12969.03	0.7531	
m_{water} (kg/s)		0.23			6.48	13841.48	0.7528	
$P_{water,in}$ (kPa)	567.17	N/A	N/A	290.69	5.98	14050.37	0.7525	
$P_{water,out}$ (kPa)	472.18	N/A	N/A	181.92	5.52	14281.12	0.7523	
P_{sat} (kPa)	342.15	343.21	342.15	343.31	3.98	14615.52	0.7195	25.04
$P_{bundle,in}$ (kPa)		342.62			3.54	14104.46	0.7195	
$P_{bundle,out}$ (kPa)		341.81			3.08	13580.52	0.7195	
m_{ref} (kg/s)		0.24			2.63	12368.68	0.7195	
	Path B	**Path C**	**Path D**	**Path E**	2.19	10762.24	0.7196	
$T_{water,in}$ (˚C)	5.85	5.88	5.92	5.91	1.78	6280.19	0.6973	
$T_{water,out}$ (˚C)	4.85	4.99	5.02	4.94	1.67	6164.83	0.6971	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.55	5960.57	0.6969	
		Pre-boiler			1.43	5772.03	0.6967	
$T_{water,in}$ (˚C)		17.45			1.32	5429.41	0.6964	
$T_{water,out}$ (˚C)		14.25						
m_{water} (kg/s)		2.57						
$T_{ref,in}$ (˚C)		-2.52						
$P_{ref,in}$ (kPa)		451.90						
$P_{ref,out}$ (kPa)		443.30						

Point ID	R-134a, P/D 1.167, 25 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	8.31	6.69	5.74	5.28	33.77	13340.91	0.4023	
T_1 (˚C)	8.00	6.56	5.66	5.24	31.77	13961.56	0.4016	
T_2 (˚C)	7.69	6.36	5.56	5.20	29.64	14418.57	0.4014	
T_3 (˚C)	7.41	6.14	5.46	5.16	27.52	14947.64	0.4016	
T_4 (˚C)	7.15	5.99	5.38	5.12	25.51	15773.06	0.4023	
T_5 (˚C)	6.87	5.84	5.31	5.09	20.68	13763.83	0.2730	
T_{out} (˚C)	6.69	5.73	5.27	5.06	19.50	14545.15	0.2721	
m_{water} (kg/s)	0.25				18.24	15793.49	0.2713	
$P_{water,in}$ (kPa)	648.08	N/A	N/A	322.91	16.99	16455.55	0.2708	
$P_{water,out}$ (kPa)	537.54	N/A	N/A	195.94	15.81	17226.69	0.2705	
P_{sat} (kPa)	343.87	344.85	343.72	344.85	11.05	14523.81	0.1774	25.17
$P_{bundle,in}$ (kPa)	344.54				10.09	14597.99	0.1780	
$P_{bundle,out}$ (kPa)	343.26				9.07	14711.44	0.1786	
m_{ref} (kg/s)	0.24				8.05	14334.78	0.1794	
	Path B	Path C	Path D	Path E	7.08	13587.80	0.1803	
$T_{water,in}$ (˚C)	8.26	8.26	8.24	8.31	4.81	8120.09	0.1175	
$T_{water,out}$ (˚C)	5.60	5.85	5.75	5.71	4.54	8174.46	0.1170	
m_{water} (kg/s)	0.33	0.36	0.34	0.34	4.26	8202.97	0.1165	
	Pre-boiler				3.98	8113.25	0.1159	
$T_{water,in}$ (˚C)	10.24				3.71	7911.72	0.1154	
$T_{water,out}$ (˚C)	6.47							
m_{water} (kg/s)	0.45							
$T_{ref,in}$ (˚C)	-2.59							
$P_{ref,in}$ (kPa)	368.73							
$P_{ref,out}$ (kPa)	362.73							

Point ID	R-134a, P/D 1.167, 25 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.65	6.25	5.36	4.88	30.75	13091.43	0.6368	
T_1 (˚C)	7.38	6.13	5.27	4.84	29.02	13605.29	0.6362	
T_2 (˚C)	7.12	5.95	5.17	4.80	27.18	13997.40	0.6360	
T_3 (˚C)	6.88	5.75	5.07	4.75	25.34	14449.15	0.6363	
T_4 (˚C)	6.65	5.60	4.98	4.71	23.61	15177.66	0.6371	
T_5 (˚C)	6.41	5.46	4.92	4.68	20.09	13899.09	0.5099	
T_{out} (˚C)	6.25	5.35	4.88	4.65	19.16	14836.56	0.5095	
m_{water} (kg/s)	0.27				18.18	16272.29	0.5094	
$P_{water,in}$ (kPa)	710.44	N/A	N/A	350.01	17.19	17342.39	0.5096	
$P_{water,out}$ (kPa)	587.66	N/A	N/A	209.10	16.26	18596.74	0.5101	
P_{sat} (kPa)	339.79	340.83	339.73	340.92	12.22	17700.88	0.4162	24.82
$P_{bundle,in}$ (kPa)	340.31				11.05	17776.08	0.4165	
$P_{bundle,out}$ (kPa)	339.38				9.81	17826.51	0.4169	
m_{ref} (kg/s)	0.24				8.56	17238.23	0.4174	
	Path B	Path C	Path D	Path E	7.39	15938.32	0.4180	
$T_{water,in}$ (˚C)	7.58	7.57	7.61	7.63	5.65	10905.51	0.3550	
$T_{water,out}$ (˚C)	5.16	5.35	5.30	5.31	5.27	10942.16	0.3543	
m_{water} (kg/s)	0.35	0.38	0.38	0.39	4.87	10927.55	0.3535	
	Pre-boiler				4.47	10756.31	0.3527	
$T_{water,in}$ (˚C)	9.04				4.09	10339.11	0.3520	
$T_{water,out}$ (˚C)	7.12							
m_{water} (kg/s)	2.53							
$T_{ref,in}$ (˚C)	-9.27							
$P_{ref,in}$ (kPa)	358.21							
$P_{ref,out}$ (kPa)	350.68							

Point ID	R-134a, P/D 1.167, 25 15 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.61	6.56	5.77	5.28	24.88	10964.95	0.8409	
T_1 (˚C)	7.42	6.45	5.68	5.23	24.08	11467.98	0.8413	
T_2 (˚C)	7.23	6.30	5.58	5.18	23.22	11901.12	0.8420	
T_3 (˚C)	7.06	6.14	5.48	5.13	22.36	12507.87	0.8432	
T_4 (˚C)	6.88	6.00	5.38	5.09	21.55	13257.73	0.8446	
T_5 (˚C)	6.70	5.87	5.32	5.05	19.53	12894.14	0.7232	
T_{out} (˚C)	6.56	5.77	5.27	5.02	18.93	13803.40	0.7235	
m_{water} (kg/s)	0.31				18.29	14904.25	0.7240	
$P_{water,in}$ (kPa)	874.98	N/A	N/A	413.48	17.66	16060.77	0.7248	
$P_{water,out}$ (kPa)	716.59	N/A	N/A	232.41	17.06	17236.67	0.7257	
P_{sat} (kPa)	343.66	344.76	343.71	344.94	14.43	18852.45	0.6305	24.76
$P_{bundle,in}$ (kPa)	344.22				13.11	19019.77	0.6304	
$P_{bundle,out}$ (kPa)	343.42				11.72	18979.51	0.6305	
m_{ref} (kg/s)	0.24				10.32	18536.60	0.6306	
	Path B	Path C	Path D	Path E	9.00	17273.35	0.6308	
$T_{water,in}$ (˚C)	7.60	7.58	7.67	7.68	7.05	12387.05	0.5627	
$T_{water,out}$ (˚C)	5.63	5.71	5.70	5.65	6.63	12542.87	0.5619	
m_{water} (kg/s)	0.45	0.45	0.44	0.41	6.19	12648.93	0.5611	
	Pre-boiler				5.76	12757.88	0.5602	
$T_{water,in}$ (˚C)	15.06				5.34	12473.46	0.5594	
$T_{water,out}$ (˚C)	7.13							
m_{water} (kg/s)	0.85							
$T_{ref,in}$ (˚C)	-4.74							
$P_{ref,in}$ (kPa)	363.90							
$P_{ref,out}$ (kPa)	355.36							

Point ID	R-134a, P/D 1.167, 25 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.43	8.88	7.07	5.91	56.76	11285.14	0.6831	
T_1 (˚C)	10.89	8.60	6.86	5.82	53.20	11396.78	0.6808	
T_2 (˚C)	10.45	8.27	6.61	5.71	49.42	11457.62	0.6793	
T_3 (˚C)	10.01	7.89	6.37	5.60	45.65	11427.00	0.6788	
T_4 (˚C)	9.61	7.60	6.16	5.51	42.09	11483.85	0.6793	
T_5 (˚C)	9.20	7.30	6.01	5.44	39.27	12307.76	0.4373	
T_{out} (˚C)	8.88	7.06	5.90	5.38	37.92	13122.95	0.4378	
m_{water} (kg/s)	0.28				36.48	14323.61	0.4389	
$P_{water,in}$ (kPa)	728.11	N/A	N/A	355.45	35.04	15289.63	0.4405	
$P_{water,out}$ (kPa)	601.50	N/A	N/A	209.50	33.68	16644.83	0.4425	
P_{sat} (kPa)	343.47	344.51	343.43	344.71	29.42	18786.80	0.2588	24.86
$P_{bundle,in}$ (kPa)	344.18				26.65	19201.06	0.2588	
$P_{bundle,out}$ (kPa)	343.13				23.71	19457.21	0.2591	
m_{ref} (kg/s)	0.24				20.77	19207.88	0.2596	
	Path B	Path C	Path D	Path E	18.00	18068.59	0.2602	
$T_{water,in}$ (˚C)	11.39	11.36	11.35	11.41	12.84	12716.57	0.1321	
$T_{water,out}$ (˚C)	6.44	6.64	6.73	6.58	11.87	12842.86	0.1302	
m_{water} (kg/s)	0.34	0.35	0.37	0.36	10.84	12815.15	0.1282	
	Pre-boiler				9.81	12562.72	0.1262	
$T_{water,in}$ (˚C)	7.61				8.83	11983.35	0.1244	
$T_{water,out}$ (˚C)	6.78							
m_{water} (kg/s)	2.53							
$T_{ref,in}$ (˚C)	-9.05							
$P_{ref,in}$ (kPa)	363.68							
$P_{ref,out}$ (kPa)	357.67							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	13.01	9.46	7.13	5.74	69.41	11352.23	0.7285	
T_1 (˚C)	12.26	9.10	6.87	5.64	64.39	11484.17	0.7250	
T_2 (˚C)	11.63	8.65	6.57	5.51	59.05	11541.40	0.7226	
T_3 (˚C)	11.00	8.16	6.28	5.39	53.71	11455.03	0.7216	
T_4 (˚C)	10.44	7.78	6.03	5.30	48.69	11411.81	0.7219	
T_5 (˚C)	9.89	7.42	5.85	5.22	44.76	12475.76	0.4504	
T_{out} (˚C)	9.48	7.12	5.74	5.15	42.64	13313.14	0.4501	
m_{water} (kg/s)	0.24				40.39	14586.67	0.4505	
$P_{water,in}$ (kPa)	577.37	N/A	N/A	295.95	38.13	15549.69	0.4517	
$P_{water,out}$ (kPa)	481.34	N/A	N/A	184.59	36.01	16787.02	0.4535	
P_{sat} (kPa)	341.29	342.33	341.27	342.48	30.94	19311.61	0.2571	25.23
$P_{bundle,in}$ (kPa)	341.94				27.74	19859.65	0.2570	
$P_{bundle,out}$ (kPa)	340.95				24.33	20268.33	0.2572	
m_{ref} (kg/s)	0.24				20.92	19941.90	0.2577	
	Path B	**Path C**	**Path D**	**Path E**	17.72	18449.40	0.2585	
$T_{water,in}$ (˚C)	12.94	12.95	12.98	13.02	12.47	12865.16	0.1277	
$T_{water,out}$ (˚C)	6.50	6.59	6.51	6.62	11.39	12984.69	0.1256	
m_{water} (kg/s)	0.29	0.30	0.29	0.30	10.24	12945.41	0.1234	
	Pre-boiler				9.10	12494.66	0.1212	
$T_{water,in}$ (˚C)	7.94				8.02	11693.08	0.1192	
$T_{water,out}$ (˚C)	6.72							
m_{water} (kg/s)	1.52							
$T_{ref,in}$ (˚C)	-4.71							
$P_{ref,in}$ (kPa)	366.02							
$P_{ref,out}$ (kPa)	360.59							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.93	5.21	4.89	4.74	14.83	15989.40	0.1884	
T_1 (˚C)	5.78	5.17	4.87	4.73	13.61	16566.92	0.1875	
T_2 (˚C)	5.64	5.10	4.84	4.72	12.32	16920.17	0.1866	
T_3 (˚C)	5.51	5.03	4.80	4.70	11.03	17119.05	0.1857	
T_4 (˚C)	5.39	4.97	4.78	4.69	9.81	17250.18	0.1850	
T_5 (˚C)	5.28	4.92	4.75	4.68	6.63	10489.67	0.1522	
T_{out} (˚C)	5.21	4.89	4.74	4.67	6.26	10860.42	0.1519	
m_{water} (kg/s)	0.23				5.86	11445.75	0.1517	
$P_{water,in}$ (kPa)	568.82	N/A	N/A	291.95	5.47	11568.67	0.1515	
$P_{water,out}$ (kPa)	474.30	N/A	N/A	183.83	5.09	11749.43	0.1513	
P_{sat} (kPa)	341.91	342.75	341.69	342.71	3.44	10272.52	0.1282	35.23
$P_{bundle,in}$ (kPa)	342.64				3.17	10130.65	0.1284	
$P_{bundle,out}$ (kPa)	341.14				2.88	10046.39	0.1286	
m_{ref} (kg/s)	0.34				2.59	9659.65	0.1288	
	Path B	**Path C**	**Path D**	**Path E**	2.32	9158.42	0.1290	
$T_{water,in}$ (˚C)	5.87	5.90	5.86	5.93	1.73	5391.21	0.1127	
$T_{water,out}$ (˚C)	4.86	5.02	4.97	4.97	1.64	5334.79	0.1125	
m_{water} (kg/s)	0.30	0.34	0.32	0.31	1.54	5229.95	0.1124	
	Pre-boiler				1.45	5130.08	0.1123	
$T_{water,in}$ (˚C)	11.86				1.36	4916.76	0.1122	
$T_{water,out}$ (˚C)	7.66							
m_{water} (kg/s)	0.57							
$T_{ref,in}$ (˚C)	-1.70							
$P_{ref,in}$ (kPa)	385.16							
$P_{ref,out}$ (kPa)	378.06							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.91	5.22	4.88	4.74	14.23	16446.25	0.4261	
T_1 (˚C)	5.77	5.17	4.86	4.73	13.09	17202.81	0.4252	
T_2 (˚C)	5.63	5.10	4.83	4.71	11.88	17718.90	0.4245	
T_3 (˚C)	5.51	5.02	4.79	4.70	10.67	18129.65	0.4238	
T_4 (˚C)	5.39	4.97	4.77	4.69	9.53	18498.46	0.4232	
T_5 (˚C)	5.29	4.92	4.75	4.68	7.08	12567.07	0.3912	
T_{out} (˚C)	5.21	4.88	4.74	4.67	6.62	13110.30	0.3909	
m_{water} (kg/s)		0.23			6.13	13977.23	0.3906	
$P_{water,in}$ (kPa)	566.93	N/A	N/A	289.93	5.64	14119.58	0.3904	
$P_{water,out}$ (kPa)	472.32	N/A	N/A	181.55	5.18	14245.71	0.3903	
P_{sat} (kPa)	342.50	343.52	342.46	343.56	3.53	13571.12	0.3676	35.32
$P_{bundle,in}$ (kPa)		343.12			3.17	13134.52	0.3676	
$P_{bundle,out}$ (kPa)		342.01			2.79	12758.04	0.3677	
m_{ref} (kg/s)		0.34			2.40	11743.69	0.3678	
	Path B	Path C	Path D	Path E	2.04	10428.59	0.3679	
$T_{water,in}$ (˚C)	5.85	5.87	5.92	5.93	1.58	5719.95	0.3525	
$T_{water,out}$ (˚C)	4.86	5.03	5.04	4.96	1.47	5561.46	0.3523	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.36	5317.38	0.3522	
		Pre-boiler			1.24	5067.50	0.3520	
$T_{water,in}$ (˚C)		15.33			1.14	4705.55	0.3519	
$T_{water,out}$ (˚C)		7.43						
m_{water} (kg/s)		0.80						
$T_{ref,in}$ (˚C)		-3.12						
$P_{ref,in}$ (kPa)		368.80						
$P_{ref,out}$ (kPa)		358.08						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.83	5.17	4.82	4.66	13.43	15208.39	0.6311	
T_1 (˚C)	5.70	5.12	4.79	4.65	12.47	16054.92	0.6305	
T_2 (˚C)	5.57	5.04	4.75	4.63	11.45	16624.24	0.6299	
T_3 (˚C)	5.45	4.96	4.72	4.62	10.43	17242.10	0.6295	
T_4 (˚C)	5.34	4.90	4.69	4.61	9.47	17969.53	0.6292	
T_5 (˚C)	5.23	4.85	4.67	4.60	7.36	12839.87	0.5969	
T_{out} (˚C)	5.16	4.81	4.66	4.59	6.88	13447.27	0.5966	
m_{water} (kg/s)		0.23			6.37	14357.02	0.5963	
$P_{water,in}$ (kPa)	566.29	N/A	N/A	288.53	5.86	14576.81	0.5961	
$P_{water,out}$ (kPa)	470.69	N/A	N/A	181.81	5.38	14706.67	0.5960	
P_{sat} (kPa)	341.55	342.63	341.58	342.79	3.84	15063.82	0.5729	35.08
$P_{bundle,in}$ (kPa)		342.09			3.42	14566.21	0.5729	
$P_{bundle,out}$ (kPa)		341.26			2.97	14046.65	0.5729	
m_{ref} (kg/s)		0.33			2.53	12824.94	0.5730	
	Path B	Path C	Path D	Path E	2.11	11132.89	0.5731	
$T_{water,in}$ (˚C)	5.77	5.80	5.85	5.85	1.68	6161.08	0.5576	
$T_{water,out}$ (˚C)	4.79	4.92	4.96	4.88	1.57	5994.31	0.5574	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.44	5718.60	0.5573	
		Pre-boiler			1.32	5453.85	0.5571	
$T_{water,in}$ (˚C)		15.34			1.20	5048.34	0.5569	
$T_{water,out}$ (˚C)		10.88						
m_{water} (kg/s)		2.12						
$T_{ref,in}$ (˚C)		-2.84						
$P_{ref,in}$ (kPa)		401.52						
$P_{ref,out}$ (kPa)		388.36						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	5.86	5.22	4.85	4.68	12.91	13851.74	0.7771	
T_1 (°C)	5.74	5.17	4.82	4.67	12.07	14591.68	0.7766	
T_2 (°C)	5.61	5.09	4.78	4.65	11.18	15145.36	0.7762	
T_3 (°C)	5.50	5.00	4.74	4.63	10.29	15760.37	0.7760	
T_4 (°C)	5.39	4.95	4.71	4.62	9.45	16530.52	0.7758	
T_5 (°C)	5.28	4.89	4.69	4.61	7.54	12374.34	0.7430	
T_{out} (°C)	5.21	4.85	4.68	4.60	7.10	13011.26	0.7428	
m_{water} (kg/s)	0.23				6.62	13948.73	0.7426	
$P_{water,in}$ (kPa)	567.70	N/A	N/A	290.00	6.14	14312.14	0.7424	
$P_{water,out}$ (kPa)	472.28	N/A	N/A	182.46	5.69	14656.35	0.7423	
P_{sat} (kPa)	341.57	342.71	341.65	342.86	4.22	15696.22	0.7186	34.92
$P_{bundle,in}$ (kPa)	342.11				3.76	15264.09	0.7186	
$P_{bundle,out}$ (kPa)	341.38				3.27	14762.71	0.7186	
m_{ref} (kg/s)	0.33				2.78	13580.36	0.7186	
	Path B	**Path C**	**Path D**	**Path E**	2.32	11843.51	0.7187	
$T_{water,in}$ (°C)	5.82	5.84	5.88	5.88	1.94	6945.48	0.7027	
$T_{water,out}$ (°C)	4.80	4.94	4.99	4.90	1.79	6752.05	0.7025	
m_{water} (kg/s)	0.30	0.34	0.34	0.31	1.64	6423.05	0.7023	
	Pre-boiler				1.49	6103.12	0.7020	
$T_{water,in}$ (°C)	17.19				1.34	5613.52	0.7018	
$T_{water,out}$ (°C)	9.04							
m_{water} (kg/s)	1.43							
$T_{ref,in}$ (°C)	-2.80							
$P_{ref,in}$ (kPa)	379.88							
$P_{ref,out}$ (kPa)	363.90							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	7.96	6.36	5.48	5.06	33.76	14478.45	0.2944	
T_1 (°C)	7.64	6.24	5.41	5.03	31.61	15091.07	0.2937	
T_2 (°C)	7.35	6.06	5.32	4.99	29.32	15708.39	0.2931	
T_3 (°C)	7.06	5.86	5.23	4.95	27.03	16264.86	0.2930	
T_4 (°C)	6.80	5.71	5.15	4.91	24.87	17119.69	0.2931	
T_5 (°C)	6.54	5.57	5.09	4.89	19.17	13895.11	0.2050	
T_{out} (°C)	6.36	5.47	5.06	4.86	18.08	14739.76	0.2044	
m_{water} (kg/s)	0.25				16.92	16005.10	0.2039	
$P_{water,in}$ (kPa)	646.43	N/A	N/A	322.28	15.76	16728.64	0.2036	
$P_{water,out}$ (kPa)	534.94	N/A	N/A	195.47	14.68	17588.52	0.2034	
P_{sat} (kPa)	341.99	342.96	341.84	342.95	10.14	14640.58	0.1411	35.67
$P_{bundle,in}$ (kPa)	342.69				9.25	14697.23	0.1415	
$P_{bundle,out}$ (kPa)	341.41				8.30	14800.28	0.1420	
m_{ref} (kg/s)	0.34				7.35	14397.93	0.1426	
	Path B	**Path C**	**Path D**	**Path E**	6.46	13593.66	0.1432	
$T_{water,in}$ (°C)	7.91	7.92	7.88	7.96	4.52	8291.70	0.1013	
$T_{water,out}$ (°C)	5.36	5.61	5.61	5.48	4.27	8365.37	0.1010	
m_{water} (kg/s)	0.32	0.36	0.37	0.33	4.01	8420.92	0.1006	
	Pre-boiler				3.75	8345.89	0.1003	
$T_{water,in}$ (°C)	10.66				3.50	8160.61	0.0999	
$T_{water,out}$ (°C)	8.09							
m_{water} (kg/s)	0.62							
$T_{ref,in}$ (°C)	3.62							
$P_{ref,in}$ (kPa)	387.00							
$P_{ref,out}$ (kPa)	380.21							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.63	6.24	5.35	4.87	30.50	13024.65	0.5545	
T_1 (˚C)	7.37	6.11	5.26	4.83	28.88	13600.16	0.5542	
T_2 (˚C)	7.11	5.94	5.16	4.78	27.15	14088.29	0.5542	
T_3 (˚C)	6.87	5.74	5.06	4.74	25.43	14645.82	0.5546	
T_4 (˚C)	6.64	5.59	4.97	4.69	23.80	15502.71	0.5552	
T_5 (˚C)	6.39	5.45	4.91	4.66	20.02	13998.63	0.4672	
T_{out} (˚C)	6.23	5.34	4.87	4.63	19.09	14963.19	0.4669	
m_{water} (kg/s)	0.27				18.09	16408.02	0.4669	
$P_{water,in}$ (kPa)	709.23	N/A	N/A	349.00	17.10	17508.73	0.4670	
$P_{water,out}$ (kPa)	588.27	N/A	N/A	208.82	16.16	18749.99	0.4673	
P_{sat} (kPa)	339.80	340.83	339.77	340.92	12.39	18406.17	0.4028	35.87
$P_{bundle,in}$ (kPa)	340.36				11.16	18462.40	0.4029	
$P_{bundle,out}$ (kPa)	339.40				9.85	18418.05	0.4032	
m_{ref} (kg/s)	0.34				8.55	17737.88	0.4036	
	Path B	Path C	Path D	Path E	7.32	16211.43	0.4040	
$T_{water,in}$ (˚C)	7.56	7.55	7.58	7.60	5.72	11425.83	0.3612	
$T_{water,out}$ (˚C)	5.14	5.32	5.25	5.26	5.33	11487.40	0.3607	
m_{water} (kg/s)	0.35	0.38	0.36	0.37	4.92	11498.82	0.3601	
	Pre-boiler				4.52	11392.48	0.3596	
$T_{water,in}$ (˚C)	11.76				4.13	10957.04	0.3590	
$T_{water,out}$ (˚C)	9.02							
m_{water} (kg/s)	2.54							
$T_{ref,in}$ (˚C)	-10.65							
$P_{ref,in}$ (kPa)	380.98							
$P_{ref,out}$ (kPa)	370.51							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.42	6.34	5.56	5.07	26.38	11952.37	0.7542	
T_1 (˚C)	7.21	6.23	5.47	5.03	25.19	12397.41	0.7540	
T_2 (˚C)	7.01	6.08	5.37	4.98	23.92	12684.52	0.7541	
T_3 (˚C)	6.84	5.92	5.27	4.93	22.65	13104.06	0.7544	
T_4 (˚C)	6.65	5.78	5.18	4.88	21.46	13618.33	0.7550	
T_5 (˚C)	6.48	5.66	5.11	4.85	19.28	13123.78	0.6681	
T_{out} (˚C)	6.33	5.55	5.07	4.82	18.66	14030.13	0.6683	
m_{water} (kg/s)	0.31				18.00	15191.77	0.6686	
$P_{water,in}$ (kPa)	874.98	N/A	N/A	413.24	17.34	16307.89	0.6691	
$P_{water,out}$ (kPa)	717.04	N/A	N/A	232.54	16.72	17499.84	0.6698	
P_{sat} (kPa)	341.52	342.66	341.60	342.81	14.22	19472.04	0.6022	34.96
$P_{bundle,in}$ (kPa)	342.11				12.91	19675.00	0.6021	
$P_{bundle,out}$ (kPa)	341.34				11.51	19620.10	0.6022	
m_{ref} (kg/s)	0.33				10.12	19186.58	0.6023	
	Path B	Path C	Path D	Path E	8.80	17833.92	0.6025	
$T_{water,in}$ (˚C)	7.41	7.41	7.47	7.49	6.98	12815.00	0.5541	
$T_{water,out}$ (˚C)	5.42	5.52	5.51	5.44	6.56	12996.69	0.5535	
m_{water} (kg/s)	0.45	0.45	0.44	0.41	6.12	13097.00	0.5529	
	Pre-boiler				5.67	13216.56	0.5523	
$T_{water,in}$ (˚C)	13.97				5.25	12911.28	0.5517	
$T_{water,out}$ (˚C)	8.28							
m_{water} (kg/s)	1.51							
$T_{ref,in}$ (˚C)	3.39							
$P_{ref,in}$ (kPa)	374.90							
$P_{ref,out}$ (kPa)	361.00							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	8.45	6.81	5.65	5.01	29.55	10488.20	0.8935	
T_1 (˚C)	8.13	6.63	5.53	4.96	27.59	10777.34	0.8927	
T_2 (˚C)	7.82	6.41	5.39	4.90	25.50	10904.03	0.8923	
T_3 (˚C)	7.53	6.15	5.25	4.84	23.42	11062.25	0.8924	
T_4 (˚C)	7.25	5.97	5.14	4.79	21.45	11163.20	0.8928	
T_5 (˚C)	7.00	5.79	5.06	4.75	20.70	12408.53	0.8077	
T_{out} (˚C)	6.81	5.64	5.01	4.72	19.65	13312.26	0.8075	
m_{water} (kg/s)	0.22				18.54	14759.84	0.8075	
$P_{water,in}$ (kPa)	508.88	N/A	N/A	268.34	17.43	15816.70	0.8077	
$P_{water,out}$ (kPa)	427.32	N/A	N/A	174.12	16.38	17145.65	0.8082	34.98
P_{sat} (kPa)	341.46	342.61	341.59	342.89	13.53	19735.84	0.7454	
$P_{bundle,in}$ (kPa)	342.02				12.02	20221.29	0.7453	
$P_{bundle,out}$ (kPa)	341.37				10.41	20393.66	0.7452	
m_{ref} (kg/s)	0.33				8.80	19687.26	0.7453	
	Path B	**Path C**	**Path D**	**Path E**	7.28	17661.79	0.7454	
$T_{water,in}$ (˚C)	8.38	8.39	8.44	8.46	5.81	12806.18	0.7050	
$T_{water,out}$ (˚C)	5.38	5.43	5.42	5.48	5.28	12895.50	0.7043	
m_{water} (kg/s)	0.28	0.28	0.27	0.28	4.73	12774.73	0.7036	
	Pre-boiler				4.17	12416.37	0.7028	
$T_{water,in}$ (˚C)	23.13				3.65	11445.56	0.7021	
$T_{water,out}$ (˚C)	8.44							
m_{water} (kg/s)	0.79							
$T_{ref,in}$ (˚C)	-2.76							
$P_{ref,in}$ (kPa)	381.98							
$P_{ref,out}$ (kPa)	366.15							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.01	8.40	6.58	5.46	57.87	11557.81	0.5239	
T_1 (˚C)	10.49	8.12	6.37	5.37	54.41	11834.04	0.5226	
T_2 (˚C)	10.00	7.79	6.13	5.26	50.74	11940.58	0.5220	
T_3 (˚C)	9.57	7.40	5.90	5.16	47.06	12026.04	0.5222	
T_4 (˚C)	9.15	7.10	5.70	5.07	43.60	12175.79	0.5231	
T_5 (˚C)	8.74	6.81	5.55	5.00	39.92	12944.72	0.3470	
T_{out} (˚C)	8.40	6.57	5.45	4.94	38.42	13803.75	0.3472	
m_{water} (kg/s)	0.28				36.83	15116.93	0.3479	
$P_{water,in}$ (kPa)	729.58	N/A	N/A	356.02	35.24	16209.97	0.3490	
$P_{water,out}$ (kPa)	602.91	N/A	N/A	210.51	33.74	17576.94	0.3504	35.27
P_{sat} (kPa)	338.62	339.69	338.68	339.71	28.76	19341.59	0.2186	
$P_{bundle,in}$ (kPa)	339.19				25.97	19654.18	0.2186	
$P_{bundle,out}$ (kPa)	338.30				23.00	19819.66	0.2188	
m_{ref} (kg/s)	0.34				20.03	19432.67	0.2192	
	Path B	**Path C**	**Path D**	**Path E**	17.24	18064.51	0.2197	
$T_{water,in}$ (˚C)	10.98	10.95	10.99	11.00	12.50	12870.38	0.1294	
$T_{water,out}$ (˚C)	5.97	6.09	6.21	6.06	11.58	13049.44	0.1281	
m_{water} (kg/s)	0.34	0.35	0.37	0.35	10.61	13124.64	0.1268	
	Pre-boiler				9.64	12924.12	0.1255	
$T_{water,in}$ (˚C)	8.12				8.73	12442.29	0.1242	
$T_{water,out}$ (˚C)	6.34							
m_{water} (kg/s)	1.65							
$T_{ref,in}$ (˚C)	-7.44							
$P_{ref,in}$ (kPa)	361.19							
$P_{ref,out}$ (kPa)	354.00							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.15	8.69	6.98	5.80	54.74	11102.57	0.7543	
T_1 (˚C)	10.65	8.43	6.76	5.70	51.35	11247.32	0.7530	
T_2 (˚C)	10.21	8.12	6.52	5.58	47.74	11274.93	0.7522	
T_3 (˚C)	9.80	7.76	6.28	5.46	44.13	11259.27	0.7523	
T_4 (˚C)	9.40	7.49	6.07	5.35	40.73	11270.64	0.7530	
T_5 (˚C)	9.02	7.20	5.91	5.27	37.15	11770.38	0.5828	
T_{out} (˚C)	8.70	6.97	5.80	5.20	35.96	12524.62	0.5831	
m_{water} (kg/s)	0.28				34.69	13627.44	0.5840	
$P_{water,in}$ (kPa)	728.90	N/A	N/A	356.44	33.43	14540.04	0.5852	
$P_{water,out}$ (kPa)	602.31	N/A	N/A	210.63	32.24	15766.97	0.5867	
P_{sat} (kPa)	342.34	343.37	342.38	343.46	29.39	18782.15	0.4595	35.03
$P_{bundle,in}$ (kPa)	342.76				26.74	19281.17	0.4598	
$P_{bundle,out}$ (kPa)	342.11				23.92	19639.99	0.4602	
m_{ref} (kg/s)	0.33				21.10	19660.08	0.4608	
	Path B	**Path C**	**Path D**	**Path E**	18.44	18753.50	0.4616	
$T_{water,in}$ (˚C)	11.11	11.09	11.12	11.13	14.63	15539.18	0.3723	
$T_{water,out}$ (˚C)	6.30	6.34	6.49	6.37	13.57	16023.28	0.3708	
m_{water} (kg/s)	0.34	0.35	0.37	0.35	12.44	16456.46	0.3693	
	Pre-boiler				11.32	16794.22	0.3677	
$T_{water,in}$ (˚C)	11.72				10.26	16456.84	0.3663	
$T_{water,out}$ (˚C)	7.79							
m_{water} (kg/s)	1.66							
$T_{ref,in}$ (˚C)	-5.41							
$P_{ref,in}$ (kPa)	368.22							
$P_{ref,out}$ (kPa)	357.38							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	14.68	10.81	8.25	6.51	88.49	11710.73	0.7298	
T_1 (˚C)	13.88	10.41	7.93	6.35	82.69	11817.97	0.7280	
T_2 (˚C)	13.20	9.93	7.58	6.17	76.52	11859.68	0.7272	
T_3 (˚C)	12.53	9.39	7.24	5.99	70.35	11836.36	0.7275	
T_4 (˚C)	11.89	8.98	6.92	5.82	64.55	11779.40	0.7288	
T_5 (˚C)	11.31	8.58	6.69	5.71	57.83	12225.76	0.4668	
T_{out} (˚C)	10.83	8.24	6.51	5.60	55.23	12805.68	0.4658	
m_{water} (kg/s)	0.28				52.46	13675.29	0.4653	
$P_{water,in}$ (kPa)	753.52	N/A	N/A	365.72	49.70	14275.60	0.4655	
$P_{water,out}$ (kPa)	621.32	N/A	N/A	212.86	47.10	14970.73	0.4661	
P_{sat} (kPa)	342.28	343.37	342.36	343.60	43.33	17735.14	0.2735	35.16
$P_{bundle,in}$ (kPa)	342.89				39.66	18210.50	0.2745	
$P_{bundle,out}$ (kPa)	342.15				35.75	18546.19	0.2758	
m_{ref} (kg/s)	0.34				31.85	18725.92	0.2774	
	Path B	**Path C**	**Path D**	**Path E**	28.18	18107.53	0.2791	
$T_{water,in}$ (˚C)	14.69	14.67	14.67	14.72	22.66	15891.16	0.1415	
$T_{water,out}$ (˚C)	7.39	7.45	7.53	7.55	20.85	16280.25	0.1390	
m_{water} (kg/s)	0.35	0.35	0.36	0.36	18.93	16495.44	0.1363	
	Pre-boiler				17.01	16471.26	0.1337	
$T_{water,in}$ (˚C)	12.90				15.20	15810.04	0.1312	
$T_{water,out}$ (˚C)	5.77							
m_{water} (kg/s)	0.39							
$T_{ref,in}$ (˚C)	-6.00							
$P_{ref,in}$ (kPa)	363.55							
$P_{ref,out}$ (kPa)	356.32							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	6.12	5.40	5.09	4.94	14.79	16038.97	0.1560	
T_1 (˚C)	5.97	5.36	5.06	4.93	13.56	16570.28	0.1553	
T_2 (˚C)	5.83	5.29	5.03	4.91	12.26	16918.25	0.1545	
T_3 (˚C)	5.70	5.22	5.00	4.90	10.95	17058.88	0.1539	
T_4 (˚C)	5.58	5.17	4.97	4.88	9.72	17121.09	0.1533	
T_5 (˚C)	5.47	5.12	4.95	4.87	6.60	10742.50	0.1281	
T_{out} (˚C)	5.40	5.08	4.93	4.86	6.23	11155.90	0.1279	
m_{water} (kg/s)	0.23				5.84	11804.84	0.1278	
$P_{water,in}$ (kPa)	569.11	N/A	N/A	291.48	5.45	11968.79	0.1276	
$P_{water,out}$ (kPa)	473.73	N/A	N/A	184.34	5.08	12207.55	0.1275	
P_{sat} (kPa)	344.30	345.17	344.27	345.11	3.43	10300.66	0.1100	45.26
$P_{bundle,in}$ (kPa)	345.02				3.16	10156.47	0.1101	
$P_{bundle,out}$ (kPa)	343.52				2.87	10067.14	0.1103	
m_{ref} (kg/s)	0.43				2.58	9675.05	0.1105	
	Path B	Path C	Path D	Path E	2.31	9164.81	0.1107	
$T_{water,in}$ (˚C)	6.06	6.07	6.04	6.12	1.71	5326.90	0.0984	
$T_{water,out}$ (˚C)	5.06	5.22	5.16	5.16	1.62	5260.54	0.0983	
m_{water} (kg/s)	0.30	0.34	0.32	0.31	1.52	5145.75	0.0982	
	Pre-boiler				1.43	5028.93	0.0981	
$T_{water,in}$ (˚C)	11.81				1.34	4809.31	0.0981	
$T_{water,out}$ (˚C)	8.72							
m_{water} (kg/s)	0.87							
$T_{ref,in}$ (˚C)	-0.92							
$P_{ref,in}$ (kPa)	399.11							
$P_{ref,out}$ (kPa)	390.99							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.81	5.12	4.78	4.63	14.24	16497.78	0.4087	
T_1 (˚C)	5.67	5.07	4.75	4.62	13.11	17281.19	0.4081	
T_2 (˚C)	5.54	5.00	4.72	4.61	11.91	17832.89	0.4075	
T_3 (˚C)	5.41	4.92	4.69	4.59	10.70	18273.97	0.4070	
T_4 (˚C)	5.29	4.86	4.66	4.58	9.57	18723.88	0.4066	
T_5 (˚C)	5.19	4.81	4.64	4.57	7.20	12951.63	0.3811	
T_{out} (˚C)	5.11	4.77	4.63	4.57	6.72	13541.43	0.3809	
m_{water} (kg/s)	0.23				6.21	14470.86	0.3806	
$P_{water,in}$ (kPa)	566.58	N/A	N/A	289.48	5.70	14591.44	0.3805	
$P_{water,out}$ (kPa)	471.47	N/A	N/A	182.50	5.21	14689.65	0.3803	
P_{sat} (kPa)	341.23	342.26	341.28	342.38	3.60	13986.75	0.3623	45.11
$P_{bundle,in}$ (kPa)	341.88				3.23	13532.89	0.3624	
$P_{bundle,out}$ (kPa)	340.84				2.83	13137.46	0.3625	
m_{ref} (kg/s)	0.43				2.43	12091.66	0.3626	
	Path B	Path C	Path D	Path E	2.05	10671.29	0.3627	
$T_{water,in}$ (˚C)	5.75	5.77	5.83	5.82	1.59	5821.93	0.3506	
$T_{water,out}$ (˚C)	4.76	4.88	4.93	4.86	1.48	5650.90	0.3505	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.37	5384.47	0.3503	
	Pre-boiler				1.25	5126.61	0.3502	
$T_{water,in}$ (˚C)	14.90				1.14	4744.09	0.3501	
$T_{water,out}$ (˚C)	8.51							
m_{water} (kg/s)	1.26							
$T_{ref,in}$ (˚C)	-3.11							
$P_{ref,in}$ (kPa)	377.72							
$P_{ref,out}$ (kPa)	363.30							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	5.86	5.20	4.85	4.69	13.36	15100.59	0.6091	
T_1 (°C)	5.74	5.15	4.82	4.68	12.43	16011.38	0.6087	
T_2 (°C)	5.60	5.07	4.78	4.66	11.44	16625.07	0.6084	
T_3 (°C)	5.48	4.99	4.75	4.65	10.45	17331.56	0.6081	
T_4 (°C)	5.37	4.93	4.72	4.63	9.51	18172.56	0.6079	
T_5 (°C)	5.26	4.88	4.70	4.62	7.37	12970.15	0.5824	
T_{out} (°C)	5.19	4.84	4.69	4.62	6.89	13606.38	0.5821	
m_{water} (kg/s)	0.23				6.38	14552.72	0.5819	
$P_{water,in}$ (kPa)	565.89	N/A	N/A	290.15	5.88	14829.48	0.5817	
$P_{water,out}$ (kPa)	472.36	N/A	N/A	181.67	5.40	15012.01	0.5816	
P_{sat} (kPa)	341.92	343.06	342.01	343.20	3.88	15642.37	0.5634	44.88
$P_{bundle,in}$ (kPa)	342.46				3.45	15161.04	0.5634	
$P_{bundle,out}$ (kPa)	341.68				3.00	14654.90	0.5634	
m_{ref} (kg/s)	0.43				2.55	13419.79	0.5635	
	Path B	**Path C**	**Path D**	**Path E**	2.12	11647.11	0.5635	
$T_{water,in}$ (°C)	5.80	5.83	5.88	5.88	1.78	6688.35	0.5512	
$T_{water,out}$ (°C)	4.81	4.95	4.98	4.91	1.64	6465.50	0.5511	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.50	6109.18	0.5509	
	Pre-boiler				1.35	5759.01	0.5508	
$T_{water,in}$ (°C)	17.97				1.21	5247.92	0.5506	
$T_{water,out}$ (°C)	13.34							
m_{water} (kg/s)	2.57							
$T_{ref,in}$ (°C)	-2.32							
$P_{ref,in}$ (kPa)	433.32							
$P_{ref,out}$ (kPa)	415.58							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	5.88	5.23	4.87	4.69	12.81	13948.19	0.7638	
T_1 (°C)	5.76	5.18	4.83	4.68	12.01	14791.06	0.7634	
T_2 (°C)	5.63	5.10	4.79	4.66	11.15	15424.17	0.7632	
T_3 (°C)	5.51	5.02	4.75	4.65	10.30	16205.91	0.7630	
T_4 (°C)	5.40	4.96	4.72	4.63	9.50	17171.75	0.7629	
T_5 (°C)	5.29	4.90	4.70	4.62	7.58	12851.38	0.7373	
T_{out} (°C)	5.22	4.86	4.69	4.61	7.10	13503.79	0.7371	
m_{water} (kg/s)	0.23				6.60	14454.84	0.7369	
$P_{water,in}$ (kPa)	565.08	N/A	N/A	288.88	6.09	14781.87	0.7368	
$P_{water,out}$ (kPa)	471.43	N/A	N/A	182.18	5.61	15050.51	0.7367	
P_{sat} (kPa)	341.83	342.99	341.97	343.17	4.22	16530.93	0.7182	44.83
$P_{bundle,in}$ (kPa)	342.36				3.75	16125.64	0.7181	
$P_{bundle,out}$ (kPa)	341.69				3.26	15631.42	0.7181	
m_{ref} (kg/s)	0.43				2.76	14372.95	0.7181	
	Path B	**Path C**	**Path D**	**Path E**	2.30	12480.45	0.7181	
$T_{water,in}$ (°C)	5.81	5.84	5.89	5.90	1.93	7196.18	0.7055	
$T_{water,out}$ (°C)	4.81	4.95	4.98	4.91	1.78	7012.19	0.7053	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.63	6678.52	0.7052	
	Pre-boiler				1.48	6354.21	0.7050	
$T_{water,in}$ (°C)	21.23				1.33	5847.23	0.7048	
$T_{water,out}$ (°C)	15.55							
m_{water} (kg/s)	2.58							
$T_{ref,in}$ (°C)	0.01							
$P_{ref,in}$ (kPa)	463.87							
$P_{ref,out}$ (kPa)	443.89							

Point ID	R-134a, P/D 1.167, 45 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.83	6.20	5.31	4.87	34.42	14579.10	0.2661	
T_1 (˚C)	7.51	6.08	5.23	4.84	32.21	15190.01	0.2654	
T_2 (˚C)	7.21	5.89	5.14	4.80	29.86	15819.75	0.2650	
T_3 (˚C)	6.92	5.68	5.04	4.75	27.51	16376.18	0.2649	
T_4 (˚C)	6.65	5.54	4.97	4.72	25.30	17239.48	0.2650	
T_5 (˚C)	6.38	5.40	4.91	4.69	19.64	14178.18	0.1928	
T_{out} (˚C)	6.20	5.30	4.87	4.66	18.50	15045.28	0.1922	
m_{water} (kg/s)	0.25				17.29	16375.40	0.1918	
$P_{water,in}$ (kPa)	646.92	N/A	N/A	322.19	16.07	17085.47	0.1915	
$P_{water,out}$ (kPa)	535.60	N/A	N/A	195.23	14.93	17953.50	0.1914	
P_{sat} (kPa)	339.80	340.77	339.68	340.77	10.41	15167.91	0.1402	44.54
$P_{bundle,in}$ (kPa)	340.48				9.47	15238.21	0.1406	
$P_{bundle,out}$ (kPa)	339.22				8.48	15325.87	0.1410	
m_{ref} (kg/s)	0.43				7.48	14882.25	0.1414	
	Path B	**Path C**	**Path D**	**Path E**	6.55	13985.74	0.1420	
$T_{water,in}$ (˚C)	7.77	7.78	7.75	7.83	4.72	8870.93	0.1077	
$T_{water,out}$ (˚C)	5.18	5.43	5.41	5.30	4.44	8924.48	0.1074	
m_{water} (kg/s)	0.32	0.36	0.37	0.33	4.14	8956.27	0.1070	
	Pre-boiler				3.84	8835.38	0.1067	
$T_{water,in}$ (˚C)	10.58				3.56	8571.77	0.1064	
$T_{water,out}$ (˚C)	8.60							
m_{water} (kg/s)	1.10							
$T_{ref,in}$ (˚C)	3.22							
$P_{ref,in}$ (kPa)	391.03							
$P_{ref,out}$ (kPa)	383.22							

Point ID	R-134a, P/D 1.167, 45 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.48	6.11	5.24	4.77	30.14	13288.32	0.5046	
T_1 (˚C)	7.22	5.99	5.15	4.73	28.44	13866.97	0.5042	
T_2 (˚C)	6.96	5.82	5.06	4.69	26.63	14301.84	0.5041	
T_3 (˚C)	6.72	5.62	4.95	4.64	24.82	14790.35	0.5042	
T_4 (˚C)	6.50	5.48	4.87	4.60	23.12	15545.60	0.5046	
T_5 (˚C)	6.26	5.34	4.81	4.57	19.51	14029.45	0.4359	
T_{out} (˚C)	6.11	5.23	4.77	4.54	18.60	15010.98	0.4358	
m_{water} (kg/s)	0.27				17.64	16470.28	0.4358	
$P_{water,in}$ (kPa)	710.59	N/A	N/A	348.83	16.68	17613.08	0.4359	
$P_{water,out}$ (kPa)	587.18	N/A	N/A	208.72	15.78	18865.93	0.4363	
P_{sat} (kPa)	338.90	340.03	338.91	340.10	12.25	19165.45	0.3863	44.66
$P_{bundle,in}$ (kPa)	339.43				11.02	19251.60	0.3864	
$P_{bundle,out}$ (kPa)	338.62				9.71	19233.57	0.3865	
m_{ref} (kg/s)	0.43				8.40	18530.73	0.3867	
	Path B	**Path C**	**Path D**	**Path E**	7.16	16881.40	0.3870	
$T_{water,in}$ (˚C)	7.42	7.40	7.43	7.46	5.61	11624.16	0.3539	
$T_{water,out}$ (˚C)	5.04	5.21	5.14	5.16	5.23	11717.94	0.3535	
m_{water} (kg/s)	0.35	0.38	0.36	0.37	4.83	11718.91	0.3530	
	Pre-boiler				4.42	11621.34	0.3526	
$T_{water,in}$ (˚C)	14.14				4.05	11182.83	0.3522	
$T_{water,out}$ (˚C)	10.64							
m_{water} (kg/s)	2.55							
$T_{ref,in}$ (˚C)	-10.45							
$P_{ref,in}$ (kPa)	400.17							
$P_{ref,out}$ (kPa)	386.12							

Point ID	R-134a, P/D 1.167, 45 15 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.63	6.51	5.71	5.19	27.52	11934.47	0.7223	
T_1 (˚C)	7.42	6.39	5.62	5.14	26.21	12354.19	0.7221	
T_2 (˚C)	7.20	6.24	5.51	5.09	24.82	12597.29	0.7221	
T_3 (˚C)	7.02	6.07	5.40	5.04	23.44	12950.34	0.7224	
T_4 (˚C)	6.83	5.94	5.30	4.98	22.13	13384.98	0.7228	
T_5 (˚C)	6.65	5.81	5.23	4.95	19.76	12817.34	0.6525	
T_{out} (˚C)	6.50	5.70	5.19	4.91	19.13	13671.58	0.6526	
m_{water} (kg/s)	0.31				18.46	14757.54	0.6529	
$P_{water,in}$ (kPa)	876.20	N/A	N/A	412.90	17.79	15786.23	0.6533	
$P_{water,out}$ (kPa)	717.29	N/A	N/A	232.62	17.16	16916.53	0.6537	
P_{sat} (kPa)	342.49	343.68	342.62	343.82	14.94	19235.28	0.5994	44.83
$P_{bundle,in}$ (kPa)	343.04				13.61	19546.78	0.5994	
$P_{bundle,out}$ (kPa)	342.37				12.19	19574.19	0.5995	
m_{ref} (kg/s)	0.43				10.78	19334.36	0.5997	
	Path B	**Path C**	**Path D**	**Path E**	9.45	18198.99	0.5999	
$T_{water,in}$ (˚C)	7.63	7.63	7.69	7.71	7.60	13468.93	0.5607	
$T_{water,out}$ (˚C)	5.53	5.65	5.64	5.56	7.12	13666.30	0.5602	
m_{water} (kg/s)	0.43	0.45	0.44	0.41	6.61	13738.65	0.5597	
	Pre-boiler				6.09	13817.85	0.5591	
$T_{water,in}$ (˚C)	15.38				5.61	13438.06	0.5586	
$T_{water,out}$ (˚C)	9.94							
m_{water} (kg/s)	2.08							
$T_{ref,in}$ (˚C)	2.21							
$P_{ref,in}$ (kPa)	391.88							
$P_{ref,out}$ (kPa)	371.99							

Point ID	R-134a, P/D 1.167, 45 15 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	8.62	6.96	5.86	5.23	29.80	10752.22	0.8445	
T_1 (˚C)	8.31	6.80	5.73	5.18	27.89	11148.54	0.8441	
T_2 (˚C)	7.99	6.58	5.60	5.11	25.87	11350.83	0.8440	
T_3 (˚C)	7.71	6.33	5.47	5.06	23.85	11628.71	0.8442	
T_4 (˚C)	7.42	6.15	5.36	5.01	21.95	11878.60	0.8447	
T_5 (˚C)	7.16	5.98	5.27	4.97	20.17	12424.09	0.7780	
T_{out} (˚C)	6.97	5.85	5.23	4.94	19.06	13236.08	0.7778	
m_{water} (kg/s)	0.22				17.88	14539.86	0.7776	
$P_{water,in}$ (kPa)	509.42	N/A	N/A	268.32	16.70	15366.06	0.7777	
$P_{water,out}$ (kPa)	426.95	N/A	N/A	173.33	15.59	16413.16	0.7779	
P_{sat} (kPa)	344.21	345.36	344.36	345.64	13.15	19299.08	0.7301	44.83
$P_{bundle,in}$ (kPa)	344.76				11.71	19837.47	0.7301	
$P_{bundle,out}$ (kPa)	344.16				10.18	20054.46	0.7301	
m_{ref} (kg/s)	0.43				8.65	19481.76	0.7303	
	Path B	**Path C**	**Path D**	**Path E**	7.21	17699.24	0.7305	
$T_{water,in}$ (˚C)	8.57	8.57	8.63	8.65	5.80	13011.23	0.6994	
$T_{water,out}$ (˚C)	5.59	5.65	5.64	5.68	5.27	13118.71	0.6989	
m_{water} (kg/s)	0.28	0.28	0.27	0.28	4.71	12964.16	0.6982	
	Pre-boiler				4.14	12542.50	0.6976	
$T_{water,in}$ (˚C)	22.16				3.61	11523.29	0.6971	
$T_{water,out}$ (˚C)	10.27							
m_{water} (kg/s)	1.20							
$T_{ref,in}$ (˚C)	1.15							
$P_{ref,in}$ (kPa)	402.57							
$P_{ref,out}$ (kPa)	380.14							

Point ID	R-134a, P/D 1.167, 45 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m²·s)
T_{in} (˚C)	11.36	8.72	6.89	5.76	58.88	11700.06	0.4132	
T_1 (˚C)	10.83	8.45	6.69	5.68	55.23	11929.23	0.4120	
T_2 (˚C)	10.35	8.11	6.45	5.57	51.35	12017.39	0.4114	
T_3 (˚C)	9.90	7.72	6.22	5.46	47.48	12046.94	0.4114	
T_4 (˚C)	9.48	7.42	6.01	5.38	43.83	12145.75	0.4120	
T_5 (˚C)	9.07	7.13	5.86	5.31	40.12	12899.02	0.2765	
T_{out} (˚C)	8.73	6.89	5.76	5.24	38.65	13786.55	0.2768	
m_{water} (kg/s)		0.28			37.09	15119.84	0.2774	
$P_{water,in}$ (kPa)	729.84	N/A	N/A	355.10	35.53	16218.64	0.2783	
$P_{water,out}$ (kPa)	602.57	N/A	N/A	208.92	34.06	17603.56	0.2796	
P_{sat} (kPa)	342.41	343.39	342.35	343.36	29.00	19350.11	0.1796	44.88
$P_{bundle,in}$ (kPa)		342.93			26.19	19738.39	0.1796	
$P_{bundle,out}$ (kPa)		341.96			23.21	19862.43	0.1797	
m_{ref} (kg/s)		0.43			20.22	19599.96	0.1800	
	Path B	Path C	Path D	Path E	17.42	18204.74	0.1803	
$T_{water,in}$ (˚C)	11.31	11.29	11.32	11.33	12.65	13150.23	0.1132	
$T_{water,out}$ (˚C)	6.19	6.31	6.32	6.24	11.71	13335.19	0.1122	
m_{water} (kg/s)	0.33	0.34	0.33	0.33	10.72	13428.28	0.1111	
		Pre-boiler			9.73	13235.97	0.1100	
$T_{water,in}$ (˚C)		9.35			8.79	12709.97	0.1090	
$T_{water,out}$ (˚C)		7.63						
m_{water} (kg/s)		2.10						
$T_{ref,in}$ (˚C)		-7.57						
$P_{ref,in}$ (kPa)		377.27						
$P_{ref,out}$ (kPa)		368.95						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m²·s)
T_{in} (˚C)	11.55	8.96	7.17	5.94	58.09	11198.83	0.6653	
T_1 (˚C)	11.02	8.69	6.95	5.82	54.38	11324.41	0.6641	
T_2 (˚C)	10.56	8.36	6.69	5.69	50.44	11331.95	0.6634	
T_3 (˚C)	10.12	8.00	6.45	5.57	46.50	11283.51	0.6633	
T_4 (˚C)	9.70	7.71	6.22	5.45	42.79	11248.39	0.6638	
T_5 (˚C)	9.30	7.41	6.05	5.36	38.46	11522.54	0.5267	
T_{out} (˚C)	8.97	7.16	5.94	5.29	37.31	12271.67	0.5271	
m_{water} (kg/s)		0.28			36.09	13345.38	0.5278	
$P_{water,in}$ (kPa)	730.08	N/A	N/A	355.87	34.88	14271.17	0.5289	
$P_{water,out}$ (kPa)	602.21	N/A	N/A	209.69	33.73	15512.76	0.5302	
P_{sat} (kPa)	342.91	344.01	343.01	344.13	30.83	18459.98	0.4293	44.59
$P_{bundle,in}$ (kPa)		343.38			28.12	18979.12	0.4297	
$P_{bundle,out}$ (kPa)		342.67			25.24	19384.60	0.4301	
m_{ref} (kg/s)		0.43			22.36	19512.36	0.4307	
	Path B	Path C	Path D	Path E	19.65	18754.02	0.4314	
$T_{water,in}$ (˚C)	11.51	11.48	11.52	11.53	15.74	15819.42	0.3615	
$T_{water,out}$ (˚C)	6.44	6.41	6.48	6.37	14.59	16339.67	0.3603	
m_{water} (kg/s)	0.34	0.34	0.33	0.33	13.36	16766.97	0.3589	
		Pre-boiler			12.13	17089.51	0.3576	
$T_{water,in}$ (˚C)		13.17			10.97	16741.85	0.3564	
$T_{water,out}$ (˚C)		9.95						
m_{water} (kg/s)		2.55						
$T_{ref,in}$ (˚C)		-5.86						
$P_{ref,in}$ (kPa)		391.05						
$P_{ref,out}$ (kPa)		377.45						

Point ID	**R-134a, P/D 1.167, 45 45 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
$\mathbf{T_{in}}$ **(°C)**	14.61	10.64	8.15	6.43	92.16	12397.94	0.5941	
$\mathbf{T_{1}}$ **(°C)**	13.79	10.25	7.83	6.28	85.45	12488.45	0.5916	
$\mathbf{T_{2}}$ **(°C)**	13.06	9.79	7.48	6.09	78.33	12422.39	0.5897	
$\mathbf{T_{3}}$ **(°C)**	12.37	9.28	7.15	5.91	71.20	12231.91	0.5887	
$\mathbf{T_{4}}$ **(°C)**	11.74	8.87	6.83	5.75	64.50	12027.30	0.5886	
$\mathbf{T_{5}}$ **(°C)**	11.14	8.48	6.60	5.64	55.51	11880.96	0.3809	
$\mathbf{T_{out}}$ **(°C)**	10.66	8.14	6.43	5.53	53.29	12497.86	0.3806	
$\mathbf{m_{water}}$ **(kg/s)**		0.28			50.92	13378.25	0.3807	
$\mathbf{P_{water,in}}$ **(kPa)**	752.09	N/A	N/A	366.15	48.56	14074.51	0.3813	
$\mathbf{P_{water,out}}$ **(kPa)**	621.33	N/A	N/A	213.06	46.33	14896.72	0.3823	
$\mathbf{P_{sat}}$ **(kPa)**	341.59	342.65	341.60	342.80	43.01	17890.63	0.2316	44.67
$\mathbf{P_{bundle,in}}$ **(kPa)**		342.16			39.34	18378.23	0.2324	
$\mathbf{P_{bundle,out}}$ **(kPa)**		341.30			35.44	18719.01	0.2335	
$\mathbf{m_{ref}}$ **(kg/s)**		0.43			31.53	18889.04	0.2348	
	Path B	**Path C**	**Path D**	**Path E**	27.86	18233.64	0.2362	
$\mathbf{T_{water,in}}$ **(°C)**	14.61	14.60	14.58	14.64	22.26	15846.32	0.1287	
$\mathbf{T_{water,out}}$ **(°C)**	7.27	7.38	7.45	7.38	20.50	16236.46	0.1268	
$\mathbf{m_{water}}$ **(kg/s)**	0.35	0.35	0.36	0.36	18.62	16466.97	0.1247	
		Pre-boiler			16.75	16468.36	0.1227	
$\mathbf{T_{water,in}}$ **(°C)**		12.56			14.98	15824.06	0.1208	
$\mathbf{T_{water,out}}$ **(°C)**		6.07						
$\mathbf{m_{water}}$ **(kg/s)**		0.53						
$\mathbf{T_{ref,in}}$ **(°C)**		-5.52						
$\mathbf{P_{ref,in}}$ **(kPa)**		365.27						
$\mathbf{P_{ref,out}}$ **(kPa)**		356.70						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
$\mathbf{T_{in}}$ **(°C)**	19.46	13.04	9.42	7.16	127.56	12327.60	0.7016	
$\mathbf{T_{1}}$ **(°C)**	18.13	12.44	8.99	6.95	117.91	12549.63	0.6986	
$\mathbf{T_{2}}$ **(°C)**	16.97	11.76	8.52	6.71	107.66	12686.18	0.6967	
$\mathbf{T_{3}}$ **(°C)**	15.83	10.99	8.07	6.49	97.41	12713.79	0.6962	
$\mathbf{T_{4}}$ **(°C)**	14.77	10.40	7.67	6.29	87.77	12694.32	0.6970	
$\mathbf{T_{5}}$ **(°C)**	13.81	9.88	7.37	6.16	70.93	12122.45	0.4282	
$\mathbf{T_{out}}$ **(°C)**	13.08	9.41	7.15	6.03	66.85	12683.11	0.4265	
$\mathbf{m_{water}}$ **(kg/s)**		0.24			62.51	13567.13	0.4254	
$\mathbf{P_{water,in}}$ **(kPa)**	579.94	N/A	N/A	298.06	58.17	14075.11	0.4251	
$\mathbf{P_{water,out}}$ **(kPa)**	483.51	N/A	N/A	185.32	54.09	14585.52	0.4255	
$\mathbf{P_{sat}}$ **(kPa)**	347.33	348.45	347.42	348.72	48.65	17460.44	0.2438	45.17
$\mathbf{P_{bundle,in}}$ **(kPa)**		347.99			44.11	18079.46	0.2451	
$\mathbf{P_{bundle,out}}$ **(kPa)**		347.19			39.29	18529.79	0.2468	
$\mathbf{m_{ref}}$ **(kg/s)**		0.43			34.47	18664.10	0.2488	
	Path B	**Path C**	**Path D**	**Path E**	29.93	17945.77	0.2510	
$\mathbf{T_{water,in}}$ **(°C)**	19.40	19.45	19.50	19.52	24.29	16584.19	0.1281	
$\mathbf{T_{water,out}}$ **(°C)**	8.52	8.43	8.35	8.65	22.04	17079.56	0.1257	
$\mathbf{m_{water}}$ **(kg/s)**	0.30	0.30	0.29	0.30	19.65	17385.14	0.1231	
		Pre-boiler			17.25	17189.32	0.1206	
$\mathbf{T_{water,in}}$ **(°C)**		24.04			15.00	16147.16	0.1182	
$\mathbf{T_{water,out}}$ **(°C)**		8.57						
$\mathbf{m_{water}}$ **(kg/s)**		0.13						
$\mathbf{T_{ref,in}}$ **(°C)**		4.79						
$\mathbf{P_{ref,in}}$ **(kPa)**		405.26						
$\mathbf{P_{ref,out}}$ **(kPa)**		397.53						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.90	5.18	4.86	4.71	14.79	16097.45	0.1392	
T_1 (˚C)	5.75	5.14	4.84	4.70	13.55	16608.91	0.1386	
T_2 (˚C)	5.61	5.07	4.81	4.69	12.24	16947.84	0.1380	
T_3 (˚C)	5.48	4.99	4.77	4.67	10.93	17060.30	0.1374	
T_4 (˚C)	5.36	4.94	4.75	4.66	9.69	17083.12	0.1370	
T_5 (˚C)	5.25	4.89	4.72	4.65	6.66	10615.01	0.1163	
T_{out} (˚C)	5.18	4.86	4.71	4.64	6.27	10974.89	0.1161	
m_{water} (kg/s)		0.23			5.86	11548.33	0.1160	
$P_{water,in}$ (kPa)	568.69	N/A	N/A	291.72	5.45	11619.72	0.1158	
$P_{water,out}$ (kPa)	473.92	N/A	N/A	183.43	5.06	11759.81	0.1157	
P_{sat} (kPa)	341.63	342.53	341.41	342.43	3.43	10475.98	0.1013	55.10
$P_{bundle,in}$ (kPa)		342.39			3.16	10335.62	0.1014	
$P_{bundle,out}$ (kPa)		340.86			2.87	10250.57	0.1015	
m_{ref} (kg/s)		0.53			2.58	9858.19	0.1017	
	Path B	**Path C**	**Path D**	**Path E**	2.31	9331.31	0.1018	
$T_{water,in}$ (˚C)	5.84	5.85	5.82	5.90	1.72	5426.11	0.0917	
$T_{water,out}$ (˚C)	4.84	5.00	4.93	4.94	1.62	5319.97	0.0916	
m_{water} (kg/s)	0.30	0.34	0.32	0.31	1.52	5161.97	0.0915	
		Pre-boiler			1.41	4997.45	0.0914	
$T_{water,in}$ (˚C)		11.64			1.31	4723.47	0.0914	
$T_{water,out}$ (˚C)		10.12						
m_{water} (kg/s)		1.96						
$T_{ref,in}$ (˚C)		-0.22						
$P_{ref,in}$ (kPa)		412.89						
$P_{ref,out}$ (kPa)		403.73						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.86	5.18	4.83	4.69	14.09	16324.24	0.3968	
T_1 (˚C)	5.73	5.13	4.80	4.67	12.99	17147.92	0.3963	
T_2 (˚C)	5.59	5.05	4.77	4.66	11.82	17739.02	0.3959	
T_3 (˚C)	5.46	4.97	4.74	4.65	10.66	18238.47	0.3955	
T_4 (˚C)	5.35	4.92	4.71	4.63	9.56	18776.02	0.3952	
T_5 (˚C)	5.24	4.87	4.69	4.63	7.23	13052.93	0.3744	
T_{out} (˚C)	5.17	4.83	4.68	4.62	6.75	13676.32	0.3742	
m_{water} (kg/s)		0.23			6.24	14632.58	0.3740	
$P_{water,in}$ (kPa)	567.48	N/A	N/A	290.30	5.72	14791.09	0.3739	
$P_{water,out}$ (kPa)	472.19	N/A	N/A	182.03	5.24	14913.35	0.3738	
P_{sat} (kPa)	341.93	342.97	341.97	343.08	3.67	14688.16	0.3590	54.97
$P_{bundle,in}$ (kPa)		342.54			3.27	14208.63	0.3591	
$P_{bundle,out}$ (kPa)		341.55			2.85	13712.68	0.3591	
m_{ref} (kg/s)		0.52			2.43	12527.31	0.3592	
	Path B	**Path C**	**Path D**	**Path E**	2.04	10929.29	0.3592	
$T_{water,in}$ (˚C)	5.80	5.82	5.88	5.88	1.62	6065.61	0.3492	
$T_{water,out}$ (˚C)	4.81	4.96	4.98	4.91	1.50	5866.67	0.3491	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.37	5558.83	0.3490	
		Pre-boiler			1.25	5264.20	0.3489	
$T_{water,in}$ (˚C)		14.23			1.13	4834.71	0.3488	
$T_{water,out}$ (˚C)		9.97						
m_{water} (kg/s)		2.28						
$T_{ref,in}$ (˚C)		-2.88						
$P_{ref,in}$ (kPa)		390.41						
$P_{ref,out}$ (kPa)		371.82						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.83	5.17	4.81	4.65	13.31	14902.44	0.5918	
T_1 (˚C)	5.70	5.12	4.78	4.63	12.41	15831.94	0.5915	
T_2 (˚C)	5.57	5.04	4.74	4.62	11.45	16486.18	0.5913	
T_3 (˚C)	5.45	4.96	4.71	4.60	10.49	17264.86	0.5910	
T_4 (˚C)	5.34	4.90	4.68	4.59	9.59	18207.18	0.5909	
T_5 (˚C)	5.23	4.85	4.66	4.58	7.45	13091.97	0.5701	
T_{out} (˚C)	5.16	4.80	4.64	4.57	6.97	13746.79	0.5699	
m_{water} (kg/s)	0.23				6.46	14712.95	0.5697	
$P_{water,in}$ (kPa)	567.20	N/A	N/A	289.38	5.94	15006.68	0.5696	
$P_{water,out}$ (kPa)	471.73	N/A	N/A	182.08	5.46	15208.16	0.5695	
P_{sat} (kPa)	341.40	342.51	341.53	342.71	4.01	16054.31	0.5546	55.25
$P_{bundle,in}$ (kPa)	341.92				3.56	15578.00	0.5546	
$P_{bundle,out}$ (kPa)	341.22				3.09	15040.51	0.5546	
m_{ref} (kg/s)	0.53				2.62	13743.60	0.5547	
	Path B	**Path C**	**Path D**	**Path E**	2.17	11880.87	0.5547	
$T_{water,in}$ (˚C)	5.76	5.79	5.85	5.84	1.82	6845.13	0.5447	
$T_{water,out}$ (˚C)	4.77	4.90	4.94	4.87	1.69	6663.59	0.5446	
m_{water} (kg/s)	0.29	0.34	0.34	0.31	1.54	6342.29	0.5445	
	Pre-boiler				1.40	6038.41	0.5444	
$T_{water,in}$ (˚C)	21.34				1.27	5567.30	0.5443	
$T_{water,out}$ (˚C)	15.90							
m_{water} (kg/s)	2.58							
$T_{ref,in}$ (˚C)	0.30							
$P_{ref,in}$ (kPa)	471.57							
$P_{ref,out}$ (kPa)	448.76							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.94	6.36	5.50	5.08	33.43	14700.78	0.2367	
T_1 (˚C)	7.63	6.24	5.43	5.05	31.30	15392.63	0.2362	
T_2 (˚C)	7.34	6.06	5.34	5.01	29.04	16053.06	0.2360	
T_3 (˚C)	7.06	5.86	5.25	4.97	26.77	16670.63	0.2359	
T_4 (˚C)	6.80	5.72	5.17	4.93	24.64	17619.05	0.2361	
T_5 (˚C)	6.53	5.59	5.11	4.91	18.95	14225.17	0.1796	
T_{out} (˚C)	6.36	5.49	5.08	4.88	17.82	15060.31	0.1791	
m_{water} (kg/s)	0.25				16.62	16361.72	0.1787	
$P_{water,in}$ (kPa)	646.75	N/A	N/A	321.64	15.42	17019.46	0.1785	
$P_{water,out}$ (kPa)	535.08	N/A	N/A	195.76	14.29	17768.45	0.1783	
P_{sat} (kPa)	342.63	343.59	342.49	343.63	10.05	15288.19	0.1386	55.38
$P_{bundle,in}$ (kPa)	343.22				9.15	15362.63	0.1389	
$P_{bundle,out}$ (kPa)	342.04				8.18	15454.30	0.1392	
m_{ref} (kg/s)	0.53				7.22	15016.12	0.1396	
	Path B	**Path C**	**Path D**	**Path E**	6.31	14099.36	0.1400	
$T_{water,in}$ (˚C)	7.89	7.90	7.87	7.95	4.68	9250.57	0.1133	
$T_{water,out}$ (˚C)	5.38	5.62	5.60	5.50	4.37	9238.36	0.1130	
m_{water} (kg/s)	0.32	0.36	0.37	0.33	4.04	9173.78	0.1127	
	Pre-boiler				3.71	8943.97	0.1124	
$T_{water,in}$ (˚C)	12.22				3.40	8551.70	0.1121	
$T_{water,out}$ (˚C)	10.53							
m_{water} (kg/s)	1.67							
$T_{ref,in}$ (˚C)	3.74							
$P_{ref,in}$ (kPa)	416.57							
$P_{ref,out}$ (kPa)	406.98							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.77	6.39	5.52	5.04	30.33	13204.92	0.4961	
T_1 (˚C)	7.51	6.27	5.43	4.99	28.66	13818.49	0.4958	
T_2 (˚C)	7.24	6.09	5.33	4.95	26.89	14268.77	0.4958	
T_3 (˚C)	7.01	5.90	5.22	4.90	25.11	14796.21	0.4959	
T_4 (˚C)	6.78	5.75	5.14	4.86	23.44	15615.61	0.4963	
T_5 (˚C)	6.54	5.62	5.07	4.83	19.62	13944.28	0.4399	
T_{out} (˚C)	6.38	5.51	5.03	4.80	18.69	14892.31	0.4398	
m_{water} (kg/s)	0.27				17.70	16276.08	0.4397	
$P_{water,in}$ (kPa)	710.16	N/A	N/A	348.26	16.71	17327.16	0.4398	
$P_{water,out}$ (kPa)	587.06	N/A	N/A	208.39	15.78	18494.37	0.4400	
P_{sat} (kPa)	341.98	343.14	342.01	343.24	12.47	19237.36	0.3991	54.99
$P_{bundle,in}$ (kPa)	342.50				11.22	19369.87	0.3991	
$P_{bundle,out}$ (kPa)	341.77				9.90	19405.12	0.3993	
m_{ref} (kg/s)	0.52				8.57	18771.93	0.3994	
	Path B	Path C	Path D	Path E	7.33	17171.37	0.3997	
$T_{water,in}$ (˚C)	7.71	7.69	7.72	7.75	5.81	12069.10	0.3723	
$T_{water,out}$ (˚C)	5.31	5.48	5.41	5.39	5.41	12153.61	0.3719	
m_{water} (kg/s)	0.35	0.38	0.36	0.36	4.97	12122.50	0.3715	
	Pre-boiler				4.54	12019.64	0.3712	
$T_{water,in}$ (˚C)	17.33				4.13	11507.03	0.3708	
$T_{water,out}$ (˚C)	13.07							
m_{water} (kg/s)	2.56							
$T_{ref,in}$ (˚C)	-9.91							
$P_{ref,in}$ (kPa)	433.50							
$P_{ref,out}$ (kPa)	416.06							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	8.31	6.72	5.70	5.11	30.77	11654.66	0.6743	
T_1 (˚C)	8.01	6.57	5.58	5.06	28.99	12192.02	0.6740	
T_2 (˚C)	7.70	6.36	5.46	5.00	27.09	12512.00	0.6739	
T_3 (˚C)	7.44	6.15	5.34	4.95	25.20	12923.83	0.6741	
T_4 (˚C)	7.17	5.97	5.23	4.90	23.42	13481.74	0.6745	
T_5 (˚C)	6.91	5.81	5.16	4.87	20.10	12803.94	0.6183	
T_{out} (˚C)	6.71	5.69	5.11	4.83	19.11	13758.41	0.6181	
m_{water} (kg/s)	0.24				18.05	14983.77	0.6181	
$P_{water,in}$ (kPa)	580.36	N/A	N/A	295.88	17.00	16009.29	0.6182	
$P_{water,out}$ (kPa)	483.37	N/A	N/A	184.18	16.00	17229.20	0.6185	
P_{sat} (kPa)	342.70	343.83	342.80	343.99	13.32	19500.19	0.5784	54.70
$P_{bundle,in}$ (kPa)	343.19				11.92	19928.96	0.5784	
$P_{bundle,out}$ (kPa)	342.54				10.42	20114.30	0.5785	
m_{ref} (kg/s)	0.52				8.93	19571.60	0.5786	
	Path B	Path C	Path D	Path E	7.53	17903.31	0.5787	
$T_{water,in}$ (˚C)	8.24	8.24	8.30	8.32	6.07	13180.86	0.5524	
$T_{water,out}$ (˚C)	5.46	5.54	5.52	5.47	5.56	13309.66	0.5520	
m_{water} (kg/s)	0.31	0.30	0.29	0.29	5.03	13244.79	0.5515	
	Pre-boiler				4.49	13043.05	0.5510	
$T_{water,in}$ (˚C)	17.09				3.99	12259.77	0.5506	
$T_{water,out}$ (˚C)	11.40							
m_{water} (kg/s)	2.32							
$T_{ref,in}$ (˚C)	4.88							
$P_{ref,in}$ (kPa)	410.15							
$P_{ref,out}$ (kPa)	383.84							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.40	8.68	6.84	5.74	60.16	11967.06	0.3625	
T_1 (˚C)	10.86	8.41	6.64	5.66	56.63	12312.78	0.3617	
T_2 (˚C)	10.36	8.06	6.41	5.55	52.88	12493.65	0.3615	
T_3 (˚C)	9.90	7.67	6.18	5.45	49.13	12652.31	0.3618	
T_4 (˚C)	9.47	7.37	5.98	5.36	45.61	12965.00	0.3625	
T_5 (˚C)	9.03	7.08	5.84	5.30	40.70	13363.01	0.2458	
T_{out} (˚C)	8.69	6.83	5.74	5.23	39.06	14245.63	0.2458	
m_{water} (kg/s)	0.28				37.32	15614.65	0.2461	
$P_{water,in}$ (kPa)	729.83	N/A	N/A	356.30	35.57	16721.80	0.2467	
$P_{water,out}$ (kPa)	602.79	N/A	N/A	210.16	33.93	18098.19	0.2476	54.81
P_{sat} (kPa)	342.34	343.33	342.37	343.41	28.28	19263.81	0.1614	
$P_{bundle,in}$ (kPa)	342.96				25.51	19545.39	0.1615	
$P_{bundle,out}$ (kPa)	341.95				22.57	19664.47	0.1617	
m_{ref} (kg/s)	0.52				19.62	19205.91	0.1620	
	Path B	**Path C**	**Path D**	**Path E**	16.85	17798.54	0.1624	
$T_{water,in}$ (˚C)	11.36	11.34	11.38	11.40	12.42	13038.84	0.1041	
$T_{water,out}$ (˚C)	6.27	6.39	6.51	6.36	11.50	13216.08	0.1033	
m_{water} (kg/s)	0.34	0.35	0.37	0.35	10.53	13297.67	0.1024	
	Pre-boiler				9.55	13104.90	0.1016	
$T_{water,in}$ (˚C)	9.00				8.64	12586.79	0.1008	
$T_{water,out}$ (˚C)	6.96							
m_{water} (kg/s)	2.09							
$T_{ref,in}$ (˚C)	-7.65							
$P_{ref,in}$ (kPa)	369.10							
$P_{ref,out}$ (kPa)	359.09							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.40	8.86	7.13	5.95	56.53	11325.52	0.6028	
T_1 (˚C)	10.90	8.59	6.92	5.84	53.15	11545.35	0.6020	
T_2 (˚C)	10.43	8.28	6.68	5.72	49.57	11655.03	0.6016	
T_3 (˚C)	10.00	7.93	6.44	5.60	45.98	11738.69	0.6017	
T_4 (˚C)	9.58	7.64	6.22	5.49	42.61	11897.88	0.6022	
T_5 (˚C)	9.17	7.36	6.07	5.41	37.01	11595.58	0.4910	
T_{out} (˚C)	8.87	7.13	5.95	5.33	35.89	12359.28	0.4913	
m_{water} (kg/s)	0.28				34.70	13433.30	0.4918	
$P_{water,in}$ (kPa)	729.48	N/A	N/A	356.23	33.52	14407.64	0.4926	
$P_{water,out}$ (kPa)	601.31	N/A	N/A	209.70	32.40	15662.47	0.4936	54.82
P_{sat} (kPa)	343.93	345.05	343.98	345.27	29.38	18533.39	0.4118	
$P_{bundle,in}$ (kPa)	344.49				26.79	19077.49	0.4121	
$P_{bundle,out}$ (kPa)	343.77				24.04	19500.13	0.4125	
m_{ref} (kg/s)	0.52				21.29	19627.10	0.4130	
	Path B	**Path C**	**Path D**	**Path E**	18.70	18869.81	0.4136	
$T_{water,in}$ (˚C)	11.38	11.36	11.36	11.41	14.98	15841.08	0.3562	
$T_{water,out}$ (˚C)	6.42	6.59	6.72	6.58	13.87	16348.45	0.3552	
m_{water} (kg/s)	0.34	0.35	0.37	0.36	12.69	16742.56	0.3542	
	Pre-boiler				11.52	17086.67	0.3531	
$T_{water,in}$ (˚C)	15.21				10.41	16673.57	0.3521	
$T_{water,out}$ (˚C)	10.43							
m_{water} (kg/s)	2.11							
$T_{ref,in}$ (˚C)	-6.33							
$P_{ref,in}$ (kPa)	396.39							
$P_{ref,out}$ (kPa)	378.06							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	14.63	10.68	8.21	6.52	91.26	12429.39	0.4915	
T_1 (˚C)	13.82	10.29	7.90	6.37	84.80	12560.07	0.4896	
T_2 (˚C)	13.09	9.84	7.56	6.19	77.94	12536.02	0.4883	
T_3 (˚C)	12.41	9.33	7.22	6.02	71.08	12399.79	0.4877	
T_4 (˚C)	11.79	8.93	6.91	5.86	64.62	12274.39	0.4878	
T_5 (˚C)	11.18	8.54	6.69	5.75	55.06	12001.35	0.3210	
T_{out} (˚C)	10.70	8.20	6.52	5.65	52.87	12647.17	0.3208	
m_{water} (kg/s)	0.28				50.55	13562.70	0.3209	
$P_{water,in}$ (kPa)	752.76	N/A	N/A	365.39	48.23	14297.13	0.3215	
$P_{water,out}$ (kPa)	621.75	N/A	N/A	212.72	46.04	15173.09	0.3224	
P_{sat} (kPa)	343.31	344.38	343.34	344.53	42.49	18131.42	0.2018	55.44
$P_{bundle,in}$ (kPa)	343.88				38.81	18622.86	0.2024	
$P_{bundle,out}$ (kPa)	343.03				34.91	18970.78	0.2033	
m_{ref} (kg/s)	0.53				31.00	19115.28	0.2043	
	Path B	**Path C**	**Path D**	**Path E**	27.32	18410.17	0.2054	
$T_{water,in}$ (˚C)	14.64	14.62	14.61	14.67	21.72	15860.16	0.1199	
$T_{water,out}$ (˚C)	7.36	7.47	7.55	7.46	20.00	16236.39	0.1184	
m_{water} (kg/s)	0.35	0.36	0.36	0.36	18.16	16463.80	0.1168	
	Pre-boiler				16.33	16465.41	0.1152	
$T_{water,in}$ (˚C)	9.95				14.61	15812.22	0.1137	
$T_{water,out}$ (˚C)	8.01							
m_{water} (kg/s)	2.10							
$T_{ref,in}$ (˚C)	-5.51							
$P_{ref,in}$ (kPa)	380.37							
$P_{ref,out}$ (kPa)	370.10							

Point ID	R-134a, P/D 1.33, 15 5 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.93	5.30	5.02	4.90	14.64	19298.00	0.1971	
T_1 (˚C)	5.80	5.25	5.00	4.89	13.37	19894.26	0.1959	
T_2 (˚C)	5.68	5.19	4.97	4.88	12.01	20730.71	0.1948	
T_3 (˚C)	5.55	5.14	4.94	4.87	10.65	21240.14	0.1937	
T_4 (˚C)	5.43	5.08	4.93	4.86	9.38	20420.85	0.1928	
T_5 (˚C)	5.36	5.04	4.91	4.85	6.54	12908.67	0.1566	
T_{out} (˚C)	5.28	5.01	4.89	4.85	6.06	13236.30	0.1561	
m_{water} (kg/s)	0.25				5.55	13149.08	0.1556	
$P_{water,in}$ (kPa)	644.64	N/A	N/A	311.77	5.05	13240.25	0.1551	
$P_{water,out}$ (kPa)	527.14	N/A	N/A	198.52	4.57	12816.04	0.1547	
P_{sat} (kPa)	344.77	345.72	344.40	345.37	3.05	12791.20	0.1296	15.00
$P_{bundle,in}$ (kPa)	345.76				2.84	12826.06	0.1298	
$P_{bundle,out}$ (kPa)	343.53				2.61	13153.21	0.1300	
m_{ref} (kg/s)	0.28				2.38	12695.21	0.1303	
	Path B	**Path C**	**Path D**	**Path E**	2.16	12362.69	0.1306	
$T_{water,in}$ (˚C)	5.91	5.89	5.89	5.97	1.42	5492.69	0.1125	
$T_{water,out}$ (˚C)	5.12	5.17	5.09	5.19	1.37	5489.82	0.1124	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.31	5447.79	0.1123	
	Pre-boiler				1.26	5412.30	0.1122	
$T_{water,in}$ (˚C)	7.71				1.21	5329.30	0.1122	
$T_{water,out}$ (˚C)	6.99							
m_{water} (kg/s)	2.54							
$T_{ref,in}$ (˚C)	0.67							
$P_{ref,in}$ (kPa)	365.07							
$P_{ref,out}$ (kPa)	358.89							

Point ID	R-134a, P/D 1.33, 15 5 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.62	4.83	4.49	4.38	17.41	21555.64	0.4390	
T_1 (˚C)	5.45	4.77	4.48	4.37	15.80	22340.64	0.4377	
T_2 (˚C)	5.31	4.70	4.45	4.36	14.09	23763.67	0.4363	
T_3 (˚C)	5.14	4.64	4.42	4.35	12.39	24732.43	0.4351	
T_4 (˚C)	5.00	4.57	4.40	4.34	10.78	24123.65	0.4341	
T_5 (˚C)	4.90	4.53	4.39	4.34	7.44	15027.48	0.3947	
T_{out} (˚C)	4.81	4.49	4.37	4.33	6.81	15397.22	0.3939	
m_{water} (kg/s)		0.24			6.15	15334.00	0.3931	
$P_{water,in}$ (kPa)	593.35	N/A	N/A	290.71	5.48	15302.92	0.3924	
$P_{water,out}$ (kPa)	486.00	N/A	N/A	188.40	4.85	14698.71	0.3917	
P_{sat} (kPa)	338.53	339.61	338.33	339.40	2.76	11996.46	0.3654	15.14
$P_{bundle,in}$ (kPa)		339.40			2.59	12323.25	0.3658	
$P_{bundle,out}$ (kPa)		337.57			2.42	13086.49	0.3662	
m_{ref} (kg/s)		0.29			2.25	13079.32	0.3666	
	Path B	Path C	Path D	Path E	2.09	13135.34	0.3671	
$T_{water,in}$ (˚C)	5.58	5.55	5.55	5.64	1.29	4952.75	0.3490	
$T_{water,out}$ (˚C)	4.60	4.62	4.59	4.67	1.22	4847.19	0.3489	
m_{water} (kg/s)	0.29	0.31	0.30	0.30	1.15	4687.46	0.3488	
		Pre-boiler			1.07	4540.58	0.3487	
$T_{water,in}$ (˚C)		21.48			1.00	4317.16	0.3486	
$T_{water,out}$ (˚C)		6.27						
m_{water} (kg/s)		0.35						
$T_{ref,in}$ (˚C)		-4.29						
$P_{ref,in}$ (kPa)		360.41						
$P_{ref,out}$ (kPa)		351.55						

Point ID	R-134a, P/D 1.33, 15 5 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.78	4.98	4.64	4.54	17.62	23356.43	0.6420	
T_1 (˚C)	5.60	4.91	4.63	4.53	15.95	24111.07	0.6406	
T_2 (˚C)	5.46	4.84	4.60	4.52	14.17	26088.06	0.6392	
T_3 (˚C)	5.29	4.78	4.57	4.51	12.40	27330.12	0.6379	
T_4 (˚C)	5.15	4.72	4.56	4.51	10.72	26674.83	0.6368	
T_5 (˚C)	5.05	4.68	4.54	4.50	7.48	16826.63	0.5975	
T_{out} (˚C)	4.96	4.64	4.53	4.50	6.81	17344.68	0.5967	
m_{water} (kg/s)		0.24			6.11	17300.88	0.5958	
$P_{water,in}$ (kPa)	592.82	N/A	N/A	290.38	5.41	17232.99	0.5951	
$P_{water,out}$ (kPa)	485.39	N/A	N/A	188.39	4.75	16627.54	0.5944	
P_{sat} (kPa)	340.73	341.87	340.66	341.75	2.61	13352.96	0.5682	15.22
$P_{bundle,in}$ (kPa)		341.52			2.43	13634.06	0.5685	
$P_{bundle,out}$ (kPa)		339.98			2.24	14471.46	0.5689	
m_{ref} (kg/s)		0.29			2.05	14220.94	0.5692	
	Path B	Path C	Path D	Path E	1.87	13998.34	0.5696	
$T_{water,in}$ (˚C)	5.71	5.70	5.71	5.80	1.16	4854.45	0.5518	
$T_{water,out}$ (˚C)	4.76	4.77	4.74	4.83	1.10	4758.43	0.5517	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	1.04	4610.70	0.5516	
		Pre-boiler			0.97	4476.97	0.5515	
$T_{water,in}$ (˚C)		22.28			0.92	4266.01	0.5514	
$T_{water,out}$ (˚C)		7.15						
m_{water} (kg/s)		0.54						
$T_{ref,in}$ (˚C)		-4.50						
$P_{ref,in}$ (kPa)		367.72						
$P_{ref,out}$ (kPa)		356.45						

Point ID	R-134a, P/D 1.33, 15 5 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.87	5.08	4.73	4.63	17.08	22321.96	0.7836	
T_1 (˚C)	5.70	5.01	4.71	4.62	15.62	23872.35	0.7825	
T_2 (˚C)	5.55	4.94	4.69	4.61	14.07	26138.40	0.7816	
T_3 (˚C)	5.39	4.88	4.66	4.60	12.52	27571.47	0.7807	
T_4 (˚C)	5.26	4.81	4.65	4.59	11.06	29016.99	0.7801	
T_5 (˚C)	5.15	4.77	4.63	4.59	7.71	17964.56	0.7392	
T_{out} (˚C)	5.06	4.73	4.62	4.58	7.00	18501.31	0.7383	
m_{water} (kg/s)		0.24			6.24	18448.46	0.7373	
$P_{water,in}$ (kPa)	592.52	N/A	N/A	290.29	5.48	18493.04	0.7365	
$P_{water,out}$ (kPa)	485.90	N/A	N/A	188.34	4.77	17504.13	0.7358	
P_{sat} (kPa)	341.84	342.99	341.82	342.98	2.67	14726.80	0.7087	15.09
$P_{bundle,in}$ (kPa)		342.55			2.48	15068.13	0.7090	
$P_{bundle,out}$ (kPa)		341.15			2.27	16048.02	0.7094	
m_{ref} (kg/s)		0.28			2.06	15724.88	0.7098	
	Path B	**Path C**	**Path D**	**Path E**	1.87	15388.88	0.7102	
$T_{water,in}$ (˚C)	5.82	5.81	5.82	5.90	1.22	5413.85	0.6918	
$T_{water,out}$ (˚C)	4.85	4.86	4.82	4.91	1.15	5265.01	0.6917	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	1.07	5049.63	0.6915	
		Pre-boiler			0.99	4861.44	0.6914	
$T_{water,in}$ (˚C)		22.01			0.92	4558.12	0.6913	
$T_{water,out}$ (˚C)		7.74						
m_{water} (kg/s)		0.69						
$T_{ref,in}$ (˚C)		-3.87						
$P_{ref,in}$ (kPa)		371.53						
$P_{ref,out}$ (kPa)		358.82						

Point ID	R-134a, P/D 1.33, 15 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.73	6.09	5.31	4.97	40.33	19616.28	0.3619	
T_1 (˚C)	7.42	5.94	5.24	4.94	37.33	20514.70	0.3606	
T_2 (˚C)	7.11	5.78	5.18	4.91	34.14	21746.58	0.3594	
T_3 (˚C)	6.79	5.64	5.10	4.88	30.96	22872.18	0.3587	
T_4 (˚C)	6.49	5.49	5.05	4.85	27.96	23142.37	0.3583	
T_5 (˚C)	6.28	5.38	5.00	4.82	20.22	17921.40	0.2438	
T_{out} (˚C)	6.08	5.30	4.96	4.80	18.51	18395.84	0.2419	
m_{water} (kg/s)		0.28			16.70	18443.06	0.2402	
$P_{water,in}$ (kPa)	778.96	N/A	N/A	362.19	14.89	18621.93	0.2386	
$P_{water,out}$ (kPa)	631.84	N/A	N/A	220.82	13.19	17873.85	0.2373	15.23
P_{sat} (kPa)	341.84	342.89	341.58	342.66	9.03	15452.33	0.1600	
$P_{bundle,in}$ (kPa)		342.77			8.36	15573.50	0.1608	
$P_{bundle,out}$ (kPa)		340.85			7.65	16092.14	0.1618	
m_{ref} (kg/s)		0.29			6.93	15726.66	0.1629	
	Path B	**Path C**	**Path D**	**Path E**	6.26	15345.86	0.1640	
$T_{water,in}$ (˚C)	7.72	7.70	7.71	7.78	4.20	8685.04	0.1101	
$T_{water,out}$ (˚C)	5.47	5.50	5.47	5.54	4.06	8875.98	0.1098	
m_{water} (kg/s)	0.41	0.42	0.38	0.41	3.90	9083.16	0.1096	
		Pre-boiler			3.74	9261.08	0.1093	
$T_{water,in}$ (˚C)		19.64			3.59	9476.45	0.1091	
$T_{water,out}$ (˚C)		4.84						
m_{water} (kg/s)		0.15						
$T_{ref,in}$ (˚C)		-4.94						
$P_{ref,in}$ (kPa)		362.50						
$P_{ref,out}$ (kPa)		356.40						

Point ID	R-134a, P/D 1.33, 15 15 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.91	6.12	5.23	4.87	40.53	18858.34	0.5923	
T_1 (˚C)	7.57	5.95	5.17	4.84	37.50	19995.91	0.5911	
T_2 (˚C)	7.22	5.77	5.09	4.80	34.28	21224.91	0.5903	
T_3 (˚C)	6.88	5.61	5.01	4.77	31.06	22415.72	0.5900	
T_4 (˚C)	6.57	5.44	4.95	4.74	28.03	23021.62	0.5901	
T_5 (˚C)	6.33	5.32	4.90	4.71	21.07	19216.64	0.4782	
T_{out} (˚C)	6.11	5.23	4.86	4.69	19.24	20058.65	0.4761	
m_{water} (kg/s)	0.26				17.30	20393.32	0.4740	
$P_{water,in}$ (kPa)	684.80	N/A	N/A	325.02	15.36	21071.23	0.4722	
$P_{water,out}$ (kPa)	557.43	N/A	N/A	203.35	13.53	20462.14	0.4708	
P_{sat} (kPa)	341.44	342.52	341.31	342.44	8.96	17353.40	0.3967	15.15
$P_{bundle,in}$ (kPa)	342.27				8.26	17834.69	0.3975	
$P_{bundle,out}$ (kPa)	340.62				7.52	19041.46	0.3985	
m_{ref} (kg/s)	0.29				6.78	18902.45	0.3997	
	Path B	**Path C**	**Path D**	**Path E**	6.08	18658.12	0.4008	
$T_{water,in}$ (˚C)	7.85	7.87	7.85	7.96	4.29	10776.28	0.3512	
$T_{water,out}$ (˚C)	5.30	5.36	5.29	5.36	3.99	10751.84	0.3508	
m_{water} (kg/s)	0.32	0.33	0.33	0.34	3.68	10659.48	0.3503	
	Pre-boiler				3.37	10487.06	0.3498	
$T_{water,in}$ (˚C)	22.46				3.08	10100.82	0.3493	
$T_{water,out}$ (˚C)	6.34							
m_{water} (kg/s)	0.33							
$T_{ref,in}$ (˚C)	-4.37							
$P_{ref,in}$ (kPa)	363.00							
$P_{ref,out}$ (kPa)	354.48							

Point ID	R-134a, P/D 1.33, 15 15 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.64	5.93	5.05	4.67	38.43	18317.12	0.7990	
T_1 (˚C)	7.31	5.76	4.97	4.63	35.67	19427.73	0.7979	
T_2 (˚C)	6.98	5.58	4.89	4.60	32.74	20624.96	0.7972	
T_3 (˚C)	6.66	5.42	4.80	4.57	29.80	21813.74	0.7970	
T_4 (˚C)	6.36	5.25	4.75	4.54	27.04	22542.39	0.7973	
T_5 (˚C)	6.13	5.13	4.70	4.51	20.89	19561.56	0.6850	
T_{out} (˚C)	5.91	5.04	4.66	4.50	19.14	20564.15	0.6832	
m_{water} (kg/s)	0.26				17.28	21127.82	0.6816	
$P_{water,in}$ (kPa)	684.71	N/A	N/A	325.15	15.42	22087.18	0.6802	
$P_{water,out}$ (kPa)	557.62	N/A	N/A	202.51	13.67	21844.83	0.6792	
P_{sat} (kPa)	339.43	340.52	339.38	340.57	9.80	21210.32	0.6044	14.87
$P_{bundle,in}$ (kPa)	340.11				8.81	21260.90	0.6049	
$P_{bundle,out}$ (kPa)	338.75				7.75	21926.61	0.6055	
m_{ref} (kg/s)	0.28				6.69	20549.43	0.6062	
	Path B	**Path C**	**Path D**	**Path E**	5.69	18819.59	0.6069	
$T_{water,in}$ (˚C)	7.58	7.60	7.57	7.69	4.26	11587.11	0.5578	
$T_{water,out}$ (˚C)	5.14	5.11	5.05	5.15	3.93	11469.41	0.5573	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	3.59	11287.30	0.5567	
	Pre-boiler				3.25	11014.74	0.5562	
$T_{water,in}$ (˚C)	22.24				2.93	10412.69	0.5557	
$T_{water,out}$ (˚C)	6.95							
m_{water} (kg/s)	0.52							
$T_{ref,in}$ (˚C)	-3.91							
$P_{ref,in}$ (kPa)	365.64							
$P_{ref,out}$ (kPa)	354.72							

Point ID	**R-134a, P/D 1.33, 15 29 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	10.86	7.73	6.01	5.17	69.68	16336.28	0.8073	
T_1 (˚C)	10.24	7.39	5.83	5.10	64.47	17032.98	0.8053	
T_2 (˚C)	9.64	7.05	5.67	5.03	58.93	17655.90	0.8041	
T_3 (˚C)	9.06	6.74	5.49	4.96	53.39	18023.49	0.8040	
T_4 (˚C)	8.56	6.42	5.37	4.89	48.17	18107.12	0.8048	
T_5 (˚C)	8.13	6.19	5.26	4.83	39.57	18212.05	0.5973	
T_{out} (˚C)	7.71	6.00	5.16	4.80	36.40	19089.89	0.5943	
m_{water} (kg/s)		0.26			33.03	19611.21	0.5917	
$P_{water,in}$ (kPa)	684.64	N/A	N/A	325.10	29.67	20441.21	0.5897	
$P_{water,out}$ (kPa)	557.01	N/A	N/A	202.83	26.50	20425.87	0.5883	
P_{sat} (kPa)	340.40	341.53	340.37	341.57	20.31	20669.00	0.4490	15.12
$P_{bundle,in}$ (kPa)		341.21			18.33	20950.94	0.4500	
$P_{bundle,out}$ (kPa)		339.80			16.24	21769.91	0.4513	
m_{ref} (kg/s)		0.29			14.14	20888.92	0.4529	
	Path B	**Path C**	**Path D**	**Path E**	12.17	19673.93	0.4547	
$T_{water,in}$ (˚C)	10.79	10.85	10.84	10.93	8.99	14084.48	0.3642	
$T_{water,out}$ (˚C)	5.95	5.99	5.92	6.00	8.31	14255.06	0.3631	
m_{water} (kg/s)	0.33	0.33	0.33	0.34	7.59	14392.29	0.3620	
		Pre-boiler			6.87	14386.63	0.3608	
$T_{water,in}$ (˚C)		21.87			6.20	14053.24	0.3597	
$T_{water,out}$ (˚C)		17.88						
m_{water} (kg/s)		1.36						
$T_{ref,in}$ (˚C)		-4.16						
$P_{ref,in}$ (kPa)		524.50						
$P_{ref,out}$ (kPa)		517.30						

Point ID	**R-134a, P/D 1.33, 15 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.62	8.18	6.27	5.35	76.27	15949.93	0.6075	
T_1 (˚C)	10.93	7.81	6.08	5.28	70.52	16516.34	0.6049	
T_2 (˚C)	10.28	7.44	5.90	5.21	64.42	17077.91	0.6032	
T_3 (˚C)	9.64	7.09	5.70	5.14	58.31	17382.35	0.6026	
T_4 (˚C)	9.08	6.73	5.56	5.07	52.57	17306.10	0.6031	
T_5 (˚C)	8.63	6.47	5.44	5.01	43.70	17826.99	0.3781	
T_{out} (˚C)	8.17	6.26	5.34	4.97	40.34	18627.15	0.3752	
m_{water} (kg/s)		0.26			36.76	19318.61	0.3728	
$P_{water,in}$ (kPa)	684.23	N/A	N/A	325.19	33.19	20275.23	0.3709	
$P_{water,out}$ (kPa)	557.75	N/A	N/A	202.67	29.82	20457.94	0.3697	
P_{sat} (kPa)	341.06	342.08	340.86	341.99	22.22	19653.44	0.2171	15.10
$P_{bundle,in}$ (kPa)		341.92			20.06	19760.60	0.2178	
$P_{bundle,out}$ (kPa)		340.19			17.77	20461.50	0.2189	
m_{ref} (kg/s)		0.28			15.48	19548.36	0.2202	
	Path B	**Path C**	**Path D**	**Path E**	13.32	18288.05	0.2217	
$T_{water,in}$ (˚C)	11.60	11.60	11.59	11.67	8.77	11464.33	0.1221	
$T_{water,out}$ (˚C)	6.19	6.15	6.22	6.16	8.23	11613.62	0.1212	
m_{water} (kg/s)	0.33	0.32	0.34	0.31	7.66	11785.58	0.1203	
		Pre-boiler			7.08	11849.79	0.1194	
$T_{water,in}$ (˚C)		19.61			6.54	11856.24	0.1185	
$T_{water,out}$ (˚C)		4.87						
m_{water} (kg/s)		0.15						
$T_{ref,in}$ (˚C)		-4.51						
$P_{ref,in}$ (kPa)		361.54						
$P_{ref,out}$ (kPa)		355.35						

Point ID	R-134a, P/D 1.33, 15 39 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².°C)	x	G (kg/m².s)
T_{in} (°C)	13.62	9.14	6.91	5.76	103.57	18112.60	0.7381	
T_1 (°C)	12.70	8.70	6.66	5.67	94.02	18625.75	0.7308	
T_2 (°C)	11.81	8.27	6.44	5.58	83.88	18958.81	0.7244	
T_3 (°C)	10.96	7.86	6.19	5.49	73.73	18704.20	0.7195	
T_4 (°C)	10.24	7.46	6.02	5.41	64.18	17800.33	0.7163	
T_5 (°C)	9.69	7.15	5.88	5.35	50.92	17426.05	0.4300	
T_{out} (°C)	9.13	6.89	5.75	5.30	47.00	18197.82	0.4269	
m_{water} (kg/s)	0.26				42.83	18758.89	0.4244	
$P_{water,in}$ (kPa)	685.55	N/A	N/A	326.05	38.66	19562.56	0.4227	
$P_{water,out}$ (kPa)	558.92	N/A	N/A	203.58	34.73	19654.34	0.4219	
P_{sat} (kPa)	344.12	345.22	344.01	345.22	28.09	21498.94	0.2327	14.98
$P_{bundle,in}$ (kPa)	345.04				25.19	21624.95	0.2337	
$P_{bundle,out}$ (kPa)	343.44				22.12	22238.16	0.2349	
m_{ref} (kg/s)	0.28				19.04	21127.02	0.2365	
	Path B	Path C	Path D	Path E	16.15	19486.10	0.2384	
$T_{water,in}$ (°C)	13.59	13.61	13.59	13.68	10.82	12782.86	0.1137	
$T_{water,out}$ (°C)	6.78	6.81	6.87	6.85	9.99	12801.17	0.1123	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	9.11	12746.82	0.1109	
	Pre-boiler				8.23	12534.39	0.1095	
$T_{water,in}$ (°C)	17.85				7.40	12127.77	0.1081	
$T_{water,out}$ (°C)	5.52							
m_{water} (kg/s)	0.15							
$T_{ref,in}$ (°C)	-2.03							
$P_{ref,in}$ (kPa)	365.13							
$P_{ref,out}$ (kPa)	358.97							

Point ID	R-134a, P/D 1.33, 20 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².°C)	x	G (kg/m².s)
T_{in} (°C)	5.59	4.95	4.67	4.55	14.72	19381.13	0.1614	
T_1 (°C)	5.45	4.90	4.64	4.54	13.46	19930.53	0.1606	
T_2 (°C)	5.33	4.83	4.62	4.53	12.13	20983.10	0.1598	
T_3 (°C)	5.20	4.78	4.59	4.52	10.79	21277.45	0.1590	
T_4 (°C)	5.09	4.73	4.57	4.51	9.54	20944.75	0.1584	
T_5 (°C)	5.00	4.69	4.56	4.50	6.57	13084.15	0.1309	
T_{out} (°C)	4.93	4.66	4.54	4.49	6.09	13465.72	0.1305	
m_{water} (kg/s)	0.25				5.59	13426.83	0.1301	
$P_{water,in}$ (kPa)	644.53	N/A	N/A	311.61	5.09	13524.41	0.1298	
$P_{water,out}$ (kPa)	526.41	N/A	N/A	198.16	4.61	13182.00	0.1295	
P_{sat} (kPa)	340.57	341.50	340.22	341.15	3.04	12751.50	0.1104	19.93
$P_{bundle,in}$ (kPa)	341.50				2.83	12780.77	0.1106	
$P_{bundle,out}$ (kPa)	339.27				2.60	13117.29	0.1108	
m_{ref} (kg/s)	0.38				2.38	12672.29	0.1110	
	Path B	Path C	Path D	Path E	2.16	12362.58	0.1112	
$T_{water,in}$ (°C)	5.55	5.54	5.55	5.61	1.40	5431.03	0.0976	
$T_{water,out}$ (°C)	4.77	4.81	4.73	4.83	1.35	5434.19	0.0975	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.30	5402.29	0.0975	
	Pre-boiler				1.25	5371.08	0.0974	
$T_{water,in}$ (°C)	17.03				1.20	5305.76	0.0973	
$T_{water,out}$ (°C)	5.03							
m_{water} (kg/s)	0.24							
$T_{ref,in}$ (°C)	-5.22							
$P_{ref,in}$ (kPa)	362.77							
$P_{ref,out}$ (kPa)	355.54							

Point ID	R-134a, P/D 1.33, 20 5 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.78	4.99	4.65	4.55	17.50	22764.09	0.4128	
T_1 (˚C)	5.61	4.93	4.64	4.54	15.85	23551.74	0.4118	
T_2 (˚C)	5.46	4.86	4.61	4.53	14.10	25323.46	0.4107	
T_3 (˚C)	5.30	4.80	4.59	4.52	12.34	26447.84	0.4098	
T_4 (˚C)	5.16	4.73	4.57	4.51	10.69	25780.95	0.4090	
T_5 (˚C)	5.06	4.69	4.55	4.51	7.40	15986.77	0.3797	
T_{out} (˚C)	4.97	4.65	4.54	4.50	6.77	16426.35	0.3790	
m_{water} (kg/s)	0.24				6.09	16430.03	0.3784	
$P_{water,in}$ (kPa)	592.84	N/A	N/A	291.10	5.42	16437.62	0.3779	
$P_{water,out}$ (kPa)	485.95	N/A	N/A	188.08	4.78	15846.85	0.3774	
P_{sat} (kPa)	340.77	341.87	340.61	341.71	2.66	12950.47	0.3580	20.06
$P_{bundle,in}$ (kPa)	341.61				2.50	13312.25	0.3583	
$P_{bundle,out}$ (kPa)	339.86				2.32	14226.88	0.3586	
m_{ref} (kg/s)	0.38				2.14	14197.67	0.3590	
	Path B	**Path C**	**Path D**	**Path E**	1.98	14195.60	0.3593	
$T_{water,in}$ (˚C)	5.73	5.71	5.71	5.80	1.21	5025.73	0.3464	
$T_{water,out}$ (˚C)	4.77	4.79	4.75	4.83	1.15	4891.87	0.3463	
m_{water} (kg/s)	0.29	0.31	0.30	0.30	1.07	4704.76	0.3462	
	Pre-boiler				1.00	4526.59	0.3461	
$T_{water,in}$ (˚C)	21.26				0.93	4268.74	0.3460	
$T_{water,out}$ (˚C)	7.25							
m_{water} (kg/s)	0.51							
$T_{ref,in}$ (˚C)	-4.48							
$P_{ref,in}$ (kPa)	371.07							
$P_{ref,out}$ (kPa)	359.02							

Point ID	R-134a, P/D 1.33, 20 5 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.65	4.85	4.51	4.41	17.79	24381.99	0.6203	
T_1 (˚C)	5.47	4.78	4.49	4.40	16.08	25128.79	0.6192	
T_2 (˚C)	5.33	4.71	4.47	4.39	14.27	27454.18	0.6181	
T_3 (˚C)	5.16	4.65	4.44	4.38	12.45	28868.33	0.6171	
T_4 (˚C)	5.02	4.59	4.43	4.37	10.75	28231.33	0.6163	
T_5 (˚C)	4.92	4.54	4.41	4.37	7.47	17416.30	0.5864	
T_{out} (˚C)	4.83	4.51	4.40	4.37	6.79	17930.94	0.5857	
m_{water} (kg/s)	0.24				6.08	17908.78	0.5851	
$P_{water,in}$ (kPa)	592.57	N/A	N/A	291.01	5.36	17706.55	0.5846	
$P_{water,out}$ (kPa)	486.17	N/A	N/A	187.99	4.68	17071.06	0.5841	
P_{sat} (kPa)	339.28	340.44	339.27	340.43	2.66	14591.53	0.5645	20.04
$P_{bundle,in}$ (kPa)	340.01				2.46	14842.48	0.5648	
$P_{bundle,out}$ (kPa)	338.67				2.24	15661.83	0.5651	
m_{ref} (kg/s)	0.38				2.03	15196.59	0.5654	
	Path B	**Path C**	**Path D**	**Path E**	1.83	14692.05	0.5657	
$T_{water,in}$ (˚C)	5.58	5.57	5.58	5.67	1.14	4928.28	0.5528	
$T_{water,out}$ (˚C)	4.63	4.63	4.60	4.70	1.07	4792.07	0.5527	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	1.00	4589.36	0.5526	
	Pre-boiler				0.93	4409.72	0.5525	
$T_{water,in}$ (˚C)	21.82				0.87	4147.34	0.5524	
$T_{water,out}$ (˚C)	8.42							
m_{water} (kg/s)	0.80							
$T_{ref,in}$ (˚C)	-4.42							
$P_{ref,in}$ (kPa)	380.01							
$P_{ref,out}$ (kPa)	363.63							

Point ID	R-134a, P/D 1.33, 20 5 0.70							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	6.22	5.45	5.11	5.00	16.10	21089.22	0.7651	
T_1 (˚C)	6.06	5.38	5.09	5.00	14.88	22959.77	0.7646	
T_2 (˚C)	5.91	5.31	5.07	4.99	13.58	25587.02	0.7642	
T_3 (˚C)	5.75	5.25	5.04	4.98	12.29	26241.44	0.7639	
T_4 (˚C)	5.66	5.18	5.02	4.97	11.07	30261.17	0.7638	
T_5 (˚C)	5.52	5.14	5.01	4.97	7.66	18215.44	0.7334	
T_{out} (˚C)	5.43	5.11	4.99	4.96	6.93	18699.45	0.7327	
m_{water} (kg/s)	0.24				6.15	18574.76	0.7320	
$P_{water,in}$ (kPa)	591.88	N/A	N/A	290.25	5.38	18503.43	0.7314	
$P_{water,out}$ (kPa)	484.78	N/A	N/A	187.87	4.65	17335.86	0.7309	
P_{sat} (kPa)	346.49	347.63	346.54	347.76	2.68	14735.45	0.7115	19.84
$P_{bundle,in}$ (kPa)	347.16				2.48	15015.22	0.7118	
$P_{bundle,out}$ (kPa)	345.95				2.26	15834.72	0.7121	
m_{ref} (kg/s)	0.37				2.04	15366.89	0.7124	
	Path B	Path C	Path D	Path E	1.83	14850.42	0.7127	
$T_{water,in}$ (˚C)	6.17	6.16	6.17	6.26	1.14	5038.45	0.7000	
$T_{water,out}$ (˚C)	5.23	5.23	5.20	5.28	1.07	4891.31	0.6999	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	1.00	4666.25	0.6998	
	Pre-boiler				0.93	4472.40	0.6997	
$T_{water,in}$ (˚C)	21.28				0.86	4184.68	0.6997	
$T_{water,out}$ (˚C)	9.71							
m_{water} (kg/s)	1.14							
$T_{ref,in}$ (˚C)	-3.84							
$P_{ref,in}$ (kPa)	391.81							
$P_{ref,out}$ (kPa)	373.18							

Point ID	R-134a, P/D 1.33, 20 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.60	5.96	5.18	4.84	40.52	20019.93	0.2897	
T_1 (˚C)	7.29	5.81	5.12	4.82	37.45	21003.49	0.2886	
T_2 (˚C)	6.97	5.65	5.06	4.79	34.19	22250.02	0.2876	
T_3 (˚C)	6.65	5.51	4.98	4.76	30.93	23419.01	0.2870	
T_4 (˚C)	6.36	5.36	4.93	4.73	27.87	23645.54	0.2867	
T_5 (˚C)	6.14	5.26	4.88	4.70	20.04	18208.21	0.2007	
T_{out} (˚C)	5.94	5.17	4.84	4.68	18.34	18703.88	0.1993	
m_{water} (kg/s)	0.28				16.53	18767.13	0.1979	
$P_{water,in}$ (kPa)	778.70	N/A	N/A	361.75	14.73	18989.42	0.1967	
$P_{water,out}$ (kPa)	631.57	N/A	N/A	220.13	13.03	18198.84	0.1958	
P_{sat} (kPa)	340.65	341.62	340.35	341.39	8.87	15609.55	0.1378	20.24
$P_{bundle,in}$ (kPa)	341.53				8.21	15737.43	0.1385	
$P_{bundle,out}$ (kPa)	339.59				7.51	16301.02	0.1392	
m_{ref} (kg/s)	0.38				6.81	15937.55	0.1400	
	Path B	Path C	Path D	Path E	6.15	15567.51	0.1409	
$T_{water,in}$ (˚C)	7.59	7.57	7.58	7.66	4.15	8941.41	0.1004	
$T_{water,out}$ (˚C)	5.35	5.39	5.34	5.42	3.99	9120.46	0.1002	
m_{water} (kg/s)	0.41	0.42	0.38	0.41	3.82	9307.86	0.1000	
	Pre-boiler				3.66	9460.21	0.0998	
$T_{water,in}$ (˚C)	19.49				3.50	9638.40	0.0996	
$T_{water,out}$ (˚C)	4.70							
m_{water} (kg/s)	0.19							
$T_{ref,in}$ (˚C)	-5.17							
$P_{ref,in}$ (kPa)	363.03							
$P_{ref,out}$ (kPa)	355.83							

Point ID	R-134a, P/D 1.33, 20 15 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.90	6.22	5.36	4.98	37.73	18356.72	0.7198	
T_1 (˚C)	7.58	6.05	5.27	4.95	35.04	19518.28	0.7191	
T_2 (˚C)	7.25	5.87	5.20	4.91	32.19	20776.46	0.7187	
T_3 (˚C)	6.94	5.72	5.11	4.88	29.33	22018.46	0.7187	
T_4 (˚C)	6.65	5.55	5.06	4.85	26.65	22839.18	0.7191	
T_5 (˚C)	6.42	5.44	5.01	4.83	20.55	19742.37	0.6374	
T_{out} (˚C)	6.20	5.34	4.97	4.81	18.82	20792.33	0.6361	
m_{water} (kg/s)		0.26			16.99	21374.02	0.6350	
$P_{water,in}$ (kPa)	684.95	N/A	N/A	324.68	15.16	22338.31	0.6340	
$P_{water,out}$ (kPa)	557.59	N/A	N/A	202.82	13.43	22146.15	0.6333	
P_{sat} (kPa)	343.48	344.57	343.45	344.66	9.71	21967.74	0.5799	20.06
$P_{bundle,in}$ (kPa)		344.13			8.71	22044.20	0.5803	
$P_{bundle,out}$ (kPa)		342.82			7.64	22715.55	0.5808	
m_{ref} (kg/s)		0.38			6.58	21278.64	0.5814	
	Path B	**Path C**	**Path D**	**Path E**	5.58	19394.90	0.5820	
$T_{water,in}$ (˚C)	7.85	7.86	7.84	7.95	4.15	11824.20	0.5479	
$T_{water,out}$ (˚C)	5.44	5.42	5.35	5.46	3.83	11659.45	0.5475	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	3.48	11392.65	0.5471	
		Pre-boiler			3.13	11050.94	0.5466	
$T_{water,in}$ (˚C)		21.84			2.80	10345.54	0.5462	
$T_{water,out}$ (˚C)		8.66						
m_{water} (kg/s)		0.80						
$T_{ref,in}$ (˚C)		-3.91						
$P_{ref,in}$ (kPa)		383.48						
$P_{ref,out}$ (kPa)		367.37						

Point ID	R-134a, P/D 1.33, 20 15 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.84	6.25	5.35	4.89	35.78	15789.46	0.8769	
T_1 (˚C)	7.56	6.08	5.25	4.84	33.61	16713.55	0.8766	
T_2 (˚C)	7.25	5.90	5.16	4.80	31.30	17664.51	0.8765	
T_3 (˚C)	6.95	5.74	5.06	4.76	28.98	18627.62	0.8768	
T_4 (˚C)	6.68	5.57	4.99	4.72	26.81	19345.32	0.8774	
T_5 (˚C)	6.46	5.45	4.93	4.70	21.25	17300.93	0.7947	
T_{out} (˚C)	6.24	5.34	4.88	4.67	19.74	18184.28	0.7938	
m_{water} (kg/s)		0.27			18.14	18797.92	0.7931	
$P_{water,in}$ (kPa)	715.04	N/A	N/A	336.35	16.54	19806.36	0.7925	
$P_{water,out}$ (kPa)	581.08	N/A	N/A	208.01	15.03	20125.93	0.7921	
P_{sat} (kPa)	341.32	342.52	341.54	342.72	12.02	22277.35	0.7365	19.91
$P_{bundle,in}$ (kPa)		341.96			10.79	22448.34	0.7367	
$P_{bundle,out}$ (kPa)		340.97			9.48	22914.80	0.7370	
m_{ref} (kg/s)		0.38			8.16	21481.88	0.7373	
	Path B	**Path C**	**Path D**	**Path E**	6.93	19642.51	0.7377	
$T_{water,in}$ (˚C)	7.80	7.82	7.82	7.91	5.41	13428.00	0.7013	
$T_{water,out}$ (˚C)	5.30	5.40	5.22	5.33	4.98	13324.35	0.7008	
m_{water} (kg/s)	0.34	0.34	0.33	0.33	4.52	13139.37	0.7002	
		Pre-boiler			4.07	12843.45	0.6997	
$T_{water,in}$ (˚C)		22.18			3.64	12128.07	0.6991	
$T_{water,out}$ (˚C)		10.86						
m_{water} (kg/s)		1.14						
$T_{ref,in}$ (˚C)		-1.99						
$P_{ref,in}$ (kPa)		407.59						
$P_{ref,out}$ (kPa)		389.40						

Point ID	**R-134a, P/D 1.33, 20 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.80	8.38	6.51	5.63	75.99	16308.62	0.4677	
T_1 (˚C)	11.11	8.02	6.32	5.56	70.22	16918.74	0.4658	
T_2 (˚C)	10.47	7.65	6.16	5.49	64.09	17537.39	0.4646	
T_3 (˚C)	9.83	7.31	5.96	5.42	57.96	17885.83	0.4642	
T_4 (˚C)	9.27	6.96	5.83	5.36	52.19	17834.85	0.4646	
T_5 (˚C)	8.83	6.70	5.72	5.30	43.09	18256.23	0.2985	
T_{out} (˚C)	8.37	6.50	5.62	5.26	39.69	19079.05	0.2963	
m_{water} (kg/s)	0.26				36.07	19779.19	0.2943	
$P_{water,in}$ (kPa)	684.17	N/A	N/A	325.34	32.45	20731.46	0.2928	
$P_{water,out}$ (kPa)	558.55	N/A	N/A	202.46	29.05	20842.03	0.2918	
P_{sat} (kPa)	344.85	345.94	344.69	345.85	21.33	19674.62	0.1802	20.22
$P_{bundle,in}$ (kPa)	345.74				19.25	19774.93	0.1808	
$P_{bundle,out}$ (kPa)	344.08				17.04	20487.99	0.1817	
m_{ref} (kg/s)	0.38				14.83	19544.16	0.1827	
	Path B	**Path C**	**Path D**	**Path E**	12.75	18266.92	0.1838	
$T_{water,in}$ (˚C)	11.78	11.78	11.77	11.85	8.52	11533.97	0.1115	
$T_{water,out}$ (˚C)	6.45	6.42	6.48	6.42	8.00	11700.87	0.1109	
m_{water} (kg/s)	0.33	0.32	0.34	0.31	7.44	11884.19	0.1102	
	Pre-boiler				6.89	11962.05	0.1096	
$T_{water,in}$ (˚C)	19.47				6.36	11985.22	0.1089	
$T_{water,out}$ (˚C)	5.16							
m_{water} (kg/s)	0.20							
$T_{ref,in}$ (˚C)	-4.59							
$P_{ref,in}$ (kPa)	367.36							
$P_{ref,out}$ (kPa)	359.90							

Point ID	**R-134a, P/D 1.33, 20 30 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.25	7.97	6.18	5.28	72.81	16245.71	0.7226	
T_1 (˚C)	10.60	7.63	5.99	5.20	67.41	16920.84	0.7211	
T_2 (˚C)	9.97	7.27	5.82	5.12	61.68	17555.96	0.7203	
T_3 (˚C)	9.37	6.94	5.62	5.04	55.95	17963.95	0.7202	
T_4 (˚C)	8.83	6.62	5.49	4.96	50.55	18067.74	0.7210	
T_5 (˚C)	8.39	6.37	5.37	4.91	41.07	17867.13	0.5534	
T_{out} (˚C)	7.96	6.17	5.27	4.87	37.86	18766.54	0.5512	
m_{water} (kg/s)	0.26				34.44	19334.66	0.5493	
$P_{water,in}$ (kPa)	686.23	N/A	N/A	325.52	31.02	20159.78	0.5478	
$P_{water,out}$ (kPa)	559.90	N/A	N/A	203.23	27.80	20240.46	0.5469	19.86
P_{sat} (kPa)	341.28	342.34	341.25	342.45	22.05	21430.04	0.4347	
$P_{bundle,in}$ (kPa)	341.96				19.87	21804.84	0.4354	
$P_{bundle,out}$ (kPa)	340.69				17.56	22696.84	0.4364	
m_{ref} (kg/s)	0.37				15.25	21798.22	0.4375	
	Path B	**Path C**	**Path D**	**Path E**	13.07	20465.05	0.4387	
$T_{water,in}$ (˚C)	11.18	11.23	11.22	11.31	9.92	15611.67	0.3647	
$T_{water,out}$ (˚C)	6.15	6.12	6.03	6.14	9.13	15826.23	0.3638	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	8.30	16053.21	0.3627	
	Pre-boiler				7.46	16109.22	0.3617	
$T_{water,in}$ (˚C)	25.22				6.67	15679.76	0.3607	
$T_{water,out}$ (˚C)	7.14							
m_{water} (kg/s)	0.39							
$T_{ref,in}$ (˚C)	-2.89							
$P_{ref,in}$ (kPa)	371.76							
$P_{ref,out}$ (kPa)	359.55							

Point ID	R-134a, P/D 1.33, 20 42 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	14.12	9.25	6.88	5.65	113.66	18673.19	0.6116	
T_1 (˚C)	13.10	8.78	6.61	5.55	102.77	19169.39	0.6050	
T_2 (˚C)	12.14	8.32	6.38	5.46	91.21	19459.84	0.5991	
T_3 (˚C)	11.20	7.90	6.11	5.36	79.64	19066.56	0.5944	
T_4 (˚C)	10.43	7.46	5.93	5.27	68.76	17956.67	0.5911	
T_5 (˚C)	9.84	7.14	5.77	5.20	53.85	17369.15	0.3604	
T_{out} (˚C)	9.24	6.86	5.64	5.15	49.73	18155.86	0.3581	
m_{water} (kg/s)	0.26				45.36	18734.56	0.3562	
$P_{water,in}$ (kPa)	685.71	N/A	N/A	326.22	40.99	19565.92	0.3550	
$P_{water,out}$ (kPa)	558.57	N/A	N/A	202.72	36.88	19708.18	0.3545	
P_{sat} (kPa)	342.12	343.25	342.06	343.24	30.08	21866.81	0.2030	20.06
$P_{bundle,in}$ (kPa)	343.04				26.96	22024.83	0.2038	
$P_{bundle,out}$ (kPa)	341.43				23.64	22681.43	0.2049	
m_{ref} (kg/s)	0.38				20.32	21545.24	0.2062	
	Path B	Path C	Path D	Path E	17.20	19838.32	0.2077	
$T_{water,in}$ (˚C)	14.11	14.12	14.10	14.19	11.77	13469.17	0.1081	
$T_{water,out}$ (˚C)	6.76	6.78	6.83	6.83	10.85	13519.57	0.1069	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	9.87	13500.43	0.1058	
	Pre-boiler				8.90	13322.33	0.1046	
$T_{water,in}$ (˚C)	16.38				7.98	12886.03	0.1035	
$T_{water,out}$ (˚C)	5.55							
m_{water} (kg/s)	0.22							
$T_{ref,in}$ (˚C)	-1.95							
$P_{ref,in}$ (kPa)	364.74							
$P_{ref,out}$ (kPa)	357.32							

Point ID	R-134a, P/D 1.33, 20 53 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	16.17	10.42	7.54	5.94	135.96	17814.75	0.7368	
T_1 (˚C)	14.93	9.85	7.21	5.81	123.36	18148.26	0.7301	
T_2 (˚C)	13.83	9.28	6.90	5.67	109.97	18313.49	0.7244	
T_3 (˚C)	12.75	8.78	6.57	5.54	96.58	17923.75	0.7201	
T_4 (˚C)	11.85	8.27	6.33	5.41	83.98	17007.84	0.7174	
T_5 (˚C)	11.14	7.88	6.12	5.31	66.61	16727.95	0.4326	
T_{out} (˚C)	10.41	7.53	5.93	5.25	61.50	17406.53	0.4292	
m_{water} (kg/s)	0.27				56.07	17741.77	0.4265	
$P_{water,in}$ (kPa)	714.68	N/A	N/A	336.03	50.64	18262.44	0.4245	
$P_{water,out}$ (kPa)	580.53	N/A	N/A	209.50	45.53	18179.37	0.4233	
P_{sat} (kPa)	341.44	342.55	341.41	342.66	39.07	21277.19	0.2360	20.03
$P_{bundle,in}$ (kPa)	342.25				35.37	21767.48	0.2375	
$P_{bundle,out}$ (kPa)	340.95				31.43	22693.53	0.2394	
m_{ref} (kg/s)	0.38				27.50	22172.00	0.2416	
	Path B	Path C	Path D	Path E	23.79	21202.86	0.2440	
$T_{water,in}$ (˚C)	16.09	16.20	16.18	16.26	17.11	16183.48	0.1179	
$T_{water,out}$ (˚C)	7.37	7.25	7.20	7.37	15.63	16223.67	0.1161	
m_{water} (kg/s)	0.35	0.33	0.33	0.33	14.06	16252.68	0.1142	
	Pre-boiler				12.49	16001.65	0.1123	
$T_{water,in}$ (˚C)	23.59				11.01	15315.22	0.1105	
$T_{water,out}$ (˚C)	5.78							
m_{water} (kg/s)	0.10							
$T_{ref,in}$ (˚C)	3.33							
$P_{ref,in}$ (kPa)	364.05							
$P_{ref,out}$ (kPa)	356.89							

Point ID	R-134a, P/D 1.33, 25 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.73	5.09	4.81	4.70	14.89	19844.94	0.1514	
T_1 (˚C)	5.60	5.04	4.79	4.69	13.59	20422.84	0.1507	
T_2 (˚C)	5.48	4.98	4.76	4.68	12.21	21451.98	0.1500	
T_3 (˚C)	5.34	4.93	4.74	4.67	10.82	21972.22	0.1493	
T_4 (˚C)	5.23	4.87	4.72	4.66	9.52	21263.37	0.1488	
T_5 (˚C)	5.15	4.83	4.70	4.65	6.58	13228.42	0.1268	
T_{out} (˚C)	5.07	4.80	4.69	4.64	6.09	13594.90	0.1265	
m_{water} (kg/s)	0.25				5.58	13524.85	0.1262	
$P_{water,in}$ (kPa)	645.30	N/A	N/A	311.41	5.06	13606.47	0.1259	
$P_{water,out}$ (kPa)	526.99	N/A	N/A	198.16	4.58	13197.63	0.1257	
P_{sat} (kPa)	342.37	343.29	341.98	342.95	3.00	12897.62	0.1106	24.95
$P_{bundle,in}$ (kPa)	343.26				2.79	12903.49	0.1107	
$P_{bundle,out}$ (kPa)	341.19				2.56	13217.81	0.1108	
m_{ref} (kg/s)	0.47				2.33	12712.73	0.1110	
	Path B	**Path C**	**Path D**	**Path E**	2.11	12333.65	0.1112	
$T_{water,in}$ (˚C)	5.70	5.68	5.69	5.76	1.37	5400.79	0.1004	
$T_{water,out}$ (˚C)	4.92	4.96	4.88	4.98	1.32	5365.44	0.1004	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.26	5292.85	0.1003	
	Pre-boiler				1.20	5219.20	0.1003	
$T_{water,in}$ (˚C)	16.65				1.15	5105.50	0.1002	
$T_{water,out}$ (˚C)	7.01							
m_{water} (kg/s)	0.38							
$T_{ref,in}$ (˚C)	-5.24							
$P_{ref,in}$ (kPa)	391.59							
$P_{ref,out}$ (kPa)	383.21							

Point ID	R-134a, P/D 1.33, 25 5 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.89	5.10	4.76	4.66	17.69	23658.96	0.4007	
T_1 (˚C)	5.71	5.03	4.74	4.65	15.99	24456.00	0.3998	
T_2 (˚C)	5.57	4.96	4.72	4.64	14.19	26474.06	0.3989	
T_3 (˚C)	5.40	4.90	4.69	4.63	12.38	27676.50	0.3981	
T_4 (˚C)	5.26	4.84	4.67	4.62	10.69	26934.53	0.3974	
T_5 (˚C)	5.16	4.79	4.66	4.62	7.42	16680.49	0.3740	
T_{out} (˚C)	5.08	4.76	4.65	4.61	6.77	17180.48	0.3735	
m_{water} (kg/s)	0.24				6.09	17249.69	0.3730	
$P_{water,in}$ (kPa)	593.84	N/A	N/A	291.09	5.40	17300.77	0.3726	
$P_{water,out}$ (kPa)	486.61	N/A	N/A	188.06	4.76	16732.60	0.3722	
P_{sat} (kPa)	342.16	343.32	342.08	343.19	2.60	13549.28	0.3568	25.11
$P_{bundle,in}$ (kPa)	342.95				2.42	13846.58	0.3570	
$P_{bundle,out}$ (kPa)	341.35				2.23	14720.68	0.3572	
m_{ref} (kg/s)	0.47				2.05	14515.41	0.3575	
	Path B	**Path C**	**Path D**	**Path E**	1.87	14298.09	0.3578	
$T_{water,in}$ (˚C)	5.84	5.81	5.82	5.91	1.18	4963.77	0.3476	
$T_{water,out}$ (˚C)	4.88	4.89	4.86	4.94	1.11	4819.82	0.3476	
m_{water} (kg/s)	0.29	0.31	0.30	0.30	1.04	4618.85	0.3475	
	Pre-boiler				0.96	4433.81	0.3474	
$T_{water,in}$ (˚C)	20.86				0.89	4161.07	0.3473	
$T_{water,out}$ (˚C)	8.48							
m_{water} (kg/s)	0.73							
$T_{ref,in}$ (˚C)	-4.56							
$P_{ref,in}$ (kPa)	383.77							
$P_{ref,out}$ (kPa)	367.63							

Point ID	R-134a, P/D 1.33, 25 5 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	6.11	5.32	4.99	4.89	17.33	23819.20	0.5839	
T_1 (°C)	5.93	5.25	4.97	4.88	15.71	24873.93	0.5831	
T_2 (°C)	5.79	5.18	4.95	4.87	13.99	27108.97	0.5824	
T_3 (°C)	5.63	5.12	4.92	4.86	12.27	28666.42	0.5818	
T_4 (°C)	5.49	5.07	4.90	4.85	10.65	28482.63	0.5813	
T_5 (°C)	5.39	5.02	4.89	4.85	7.52	17921.84	0.5577	
T_{out} (°C)	5.30	4.99	4.88	4.85	6.81	18396.79	0.5572	
m_{water} (kg/s)	0.24				6.07	18313.53	0.5567	
$P_{water,in}$ (kPa)	591.72	N/A	N/A	290.50	5.32	18064.64	0.5562	
$P_{water,out}$ (kPa)	485.05	N/A	N/A	187.39	4.61	17180.94	0.5558	
P_{sat} (kPa)	345.13	346.27	345.15	346.34	2.59	14205.21	0.5409	24.90
$P_{bundle,in}$ (kPa)	345.81				2.40	14454.82	0.5411	
$P_{bundle,out}$ (kPa)	344.49				2.19	15182.50	0.5414	
m_{ref} (kg/s)	0.47				1.98	14693.78	0.5417	
	Path B	**Path C**	**Path D**	**Path E**	1.78	14196.69	0.5420	
$T_{water,in}$ (°C)	6.05	6.04	6.05	6.14	1.12	4882.15	0.5326	
$T_{water,out}$ (°C)	5.11	5.12	5.08	5.17	1.06	4761.67	0.5326	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	0.99	4564.41	0.5325	
	Pre-boiler				0.93	4406.59	0.5324	
$T_{water,in}$ (°C)	21.19				0.86	4151.45	0.5324	
$T_{water,out}$ (°C)	10.38							
m_{water} (kg/s)	1.22							
$T_{ref,in}$ (°C)	-3.31							
$P_{ref,in}$ (kPa)	401.56							
$P_{ref,out}$ (kPa)	379.40							

Point ID	R-134a, P/D 1.33, 25 5 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	6.18	5.43	5.09	4.99	16.06	21591.26	0.7444	
T_1 (°C)	6.03	5.36	5.07	4.98	14.72	23400.84	0.7440	
T_2 (°C)	5.88	5.29	5.05	4.97	13.30	25318.75	0.7435	
T_3 (°C)	5.73	5.23	5.02	4.97	11.88	27367.33	0.7431	
T_4 (°C)	5.60	5.17	5.01	4.96	10.54	28268.35	0.7429	
T_5 (°C)	5.50	5.13	4.99	4.95	7.67	18554.36	0.7196	
T_{out} (°C)	5.42	5.09	4.98	4.95	6.93	19062.07	0.7191	
m_{water} (kg/s)	0.24				6.14	18914.46	0.7185	
$P_{water,in}$ (kPa)	592.08	N/A	N/A	291.08	5.36	18965.18	0.7180	
$P_{water,out}$ (kPa)	485.16	N/A	N/A	187.79	4.62	17558.90	0.7176	
P_{sat} (kPa)	346.39	347.63	346.50	347.73	2.70	15910.32	0.7026	24.64
$P_{bundle,in}$ (kPa)	347.07				2.48	16160.75	0.7028	
$P_{bundle,out}$ (kPa)	345.92				2.24	16917.49	0.7030	
m_{ref} (kg/s)	0.46				2.00	16166.56	0.7033	
	Path B	**Path C**	**Path D**	**Path E**	1.78	15393.57	0.7035	
$T_{water,in}$ (°C)	6.12	6.14	6.12	6.23	1.15	5082.81	0.6940	
$T_{water,out}$ (°C)	5.21	5.26	5.17	5.26	1.07	4909.34	0.6939	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	0.99	4644.80	0.6938	
	Pre-boiler				0.91	4404.40	0.6938	
$T_{water,in}$ (°C)	20.69				0.84	4078.62	0.6937	
$T_{water,out}$ (°C)	11.27							
m_{water} (kg/s)	1.60							
$T_{ref,in}$ (°C)	3.94							
$P_{ref,in}$ (kPa)	411.04							
$P_{ref,out}$ (kPa)	385.28							

Point ID	R-134a, P/D 1.33, 25 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.87	6.25	5.49	5.16	40.29	20372.82	0.2461	
T_1 (˚C)	7.56	6.10	5.43	5.14	37.16	21371.44	0.2451	
T_2 (˚C)	7.25	5.95	5.37	5.11	33.82	22596.30	0.2443	
T_3 (˚C)	6.93	5.81	5.29	5.07	30.49	23716.72	0.2437	
T_4 (˚C)	6.64	5.66	5.24	5.05	27.36	23809.36	0.2433	
T_5 (˚C)	6.43	5.56	5.19	5.02	19.57	18135.67	0.1751	
T_{out} (˚C)	6.23	5.48	5.15	5.00	17.90	18617.71	0.1740	
m_{water} (kg/s)	0.28				16.13	18656.88	0.1729	
$P_{water,in}$ (kPa)	778.58	N/A	N/A	361.09	14.36	18859.00	0.1720	
$P_{water,out}$ (kPa)	630.66	N/A	N/A	219.56	12.69	18022.97	0.1712	
P_{sat} (kPa)	344.60	345.59	344.32	345.39	8.71	15672.39	0.1254	25.19
$P_{bundle,in}$ (kPa)	345.51				8.06	15801.55	0.1259	
$P_{bundle,out}$ (kPa)	343.56				7.37	16383.51	0.1265	
m_{ref} (kg/s)	0.48				6.68	16012.57	0.1272	
	Path B	Path C	Path D	Path E	6.03	15634.34	0.1278	
$T_{water,in}$ (˚C)	7.87	7.86	7.86	7.94	4.10	9020.64	0.0957	
$T_{water,out}$ (˚C)	5.66	5.70	5.65	5.73	3.94	9188.12	0.0956	
m_{water} (kg/s)	0.40	0.42	0.38	0.41	3.77	9365.92	0.0954	
	Pre-boiler				3.59	9501.70	0.0952	
$T_{water,in}$ (˚C)	19.36				3.43	9655.68	0.0951	
$T_{water,out}$ (˚C)	5.06							
m_{water} (kg/s)	0.25							
$T_{ref,in}$ (˚C)	-5.21							
$P_{ref,in}$ (kPa)	369.53							
$P_{ref,out}$ (kPa)	361.00							

Point ID	R-134a, P/D 1.33, 25 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.88	6.14	5.26	4.89	39.46	19007.05	0.4862	
T_1 (˚C)	7.55	5.97	5.18	4.86	36.59	20263.03	0.4855	
T_2 (˚C)	7.21	5.78	5.11	4.83	33.53	21632.48	0.4851	
T_3 (˚C)	6.88	5.62	5.02	4.80	30.48	23006.74	0.4850	
T_4 (˚C)	6.58	5.46	4.97	4.77	27.61	23887.94	0.4851	
T_5 (˚C)	6.34	5.34	4.92	4.75	20.85	20141.73	0.4185	
T_{out} (˚C)	6.12	5.25	4.88	4.73	19.06	21189.46	0.4175	
m_{water} (kg/s)	0.26				17.16	21748.36	0.4165	
$P_{water,in}$ (kPa)	684.55	N/A	N/A	324.63	15.26	22734.62	0.4156	
$P_{water,out}$ (kPa)	557.52	N/A	N/A	202.86	13.48	22393.51	0.4150	
P_{sat} (kPa)	342.37	343.51	342.35	343.52	9.47	21345.91	0.3718	25.09
$P_{bundle,in}$ (kPa)	343.08				8.51	21375.87	0.3721	
$P_{bundle,out}$ (kPa)	341.67				7.49	22115.13	0.3726	
m_{ref} (kg/s)	0.47				6.47	20791.83	0.3731	
	Path B	Path C	Path D	Path E	5.51	19074.47	0.3736	
$T_{water,in}$ (˚C)	7.83	7.85	7.82	7.94	4.08	11335.78	0.3459	
$T_{water,out}$ (˚C)	5.32	5.35	5.28	5.38	3.77	11169.69	0.3456	
m_{water} (kg/s)	0.32	0.33	0.33	0.34	3.43	10911.04	0.3453	
	Pre-boiler				3.09	10557.78	0.3450	
$T_{water,in}$ (˚C)	22.08				2.78	9890.45	0.3447	
$T_{water,out}$ (˚C)	8.24							
m_{water} (kg/s)	0.65							
$T_{ref,in}$ (˚C)	-4.47							
$P_{ref,in}$ (kPa)	384.18							
$P_{ref,out}$ (kPa)	368.03							

Point ID	**R-134a, P/D 1.33, 25 15 0.55**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m^2.˚C)**	**x**	**G (kg/m^2.s)**
T_{in} (˚C)	8.03	6.36	5.50	5.12	37.47	18436.51	0.6871	
T_1 (˚C)	7.71	6.19	5.42	5.09	34.82	19643.64	0.6865	
T_2 (˚C)	7.39	6.01	5.34	5.06	32.00	20961.10	0.6863	
T_3 (˚C)	7.07	5.86	5.26	5.03	29.18	22257.74	0.6863	
T_4 (˚C)	6.78	5.70	5.20	5.00	26.53	23146.06	0.6866	
T_5 (˚C)	6.55	5.58	5.16	4.98	20.30	19788.53	0.6209	
T_{out} (˚C)	6.34	5.49	5.11	4.96	18.60	20836.62	0.6199	
m_{water} (kg/s)	0.26				16.79	21417.07	0.6190	
$P_{water,in}$ (kPa)	684.17	N/A	N/A	324.42	14.97	22373.35	0.6183	
$P_{water,out}$ (kPa)	557.42	N/A	N/A	202.72	13.27	22199.41	0.6178	
P_{sat} (kPa)	345.38	346.52	345.43	346.67	9.74	22664.75	0.5755	24.76
$P_{bundle,in}$ (kPa)	346.01				8.72	22832.31	0.5758	
$P_{bundle,out}$ (kPa)	344.82				7.64	23481.10	0.5762	
m_{ref} (kg/s)	0.47				6.55	21984.48	0.5766	
	Path B	**Path C**	**Path D**	**Path E**	5.53	19956.61	0.5772	
$T_{water,in}$ (˚C)	7.98	7.99	7.97	8.09	4.11	11938.15	0.5504	
$T_{water,out}$ (˚C)	5.59	5.58	5.49	5.60	3.79	11785.76	0.5501	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	3.44	11516.18	0.5497	
	Pre-boiler				3.10	11175.52	0.5494	
$T_{water,in}$ (˚C)	21.42				2.78	10469.04	0.5491	
$T_{water,out}$ (˚C)	10.25							
m_{water} (kg/s)	1.14							
$T_{ref,in}$ (˚C)	-1.29							
$P_{ref,in}$ (kPa)	401.06							
$P_{ref,out}$ (kPa)	379.05							

Point ID	**R-134a, P/D 1.33, 25 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m^2.˚C)**	**x**	**G (kg/m^2.s)**
T_{in} (˚C)	11.48	7.98	6.07	5.17	77.91	16459.28	0.4071	
T_1 (˚C)	10.78	7.61	5.88	5.10	71.92	17062.79	0.4055	
T_2 (˚C)	10.12	7.24	5.71	5.03	65.55	17669.27	0.4044	
T_3 (˚C)	9.46	6.88	5.51	4.95	59.18	17982.99	0.4041	
T_4 (˚C)	8.89	6.53	5.38	4.88	53.19	17887.14	0.4043	
T_5 (˚C)	8.44	6.27	5.26	4.83	43.88	18327.82	0.2678	
T_{out} (˚C)	7.97	6.06	5.16	4.78	40.41	19157.64	0.2660	
m_{water} (kg/s)	0.26				36.72	19864.45	0.2643	
$P_{water,in}$ (kPa)	685.10	N/A	N/A	326.18	33.03	20805.97	0.2631	
$P_{water,out}$ (kPa)	559.06	N/A	N/A	203.26	29.56	20915.18	0.2622	
P_{sat} (kPa)	339.18	340.29	339.05	340.19	21.89	20024.44	0.1705	25.11
$P_{bundle,in}$ (kPa)	340.05				19.76	20155.95	0.1711	
$P_{bundle,out}$ (kPa)	338.54				17.49	20942.82	0.1719	
m_{ref} (kg/s)	0.47				15.23	20019.01	0.1728	
	Path B	**Path C**	**Path D**	**Path E**	13.10	18738.95	0.1737	
$T_{water,in}$ (˚C)	11.46	11.46	11.45	11.53	8.95	12173.75	0.1144	
$T_{water,out}$ (˚C)	6.01	5.96	6.04	5.99	8.37	12330.57	0.1138	
m_{water} (kg/s)	0.33	0.32	0.34	0.31	7.75	12508.56	0.1132	
	Pre-boiler				7.12	12547.90	0.1126	
$T_{water,in}$ (˚C)	19.31				6.54	12487.18	0.1121	
$T_{water,out}$ (˚C)	5.05							
m_{water} (kg/s)	0.26							
$T_{ref,in}$ (˚C)	-4.59							
$P_{ref,in}$ (kPa)	364.68							
$P_{ref,out}$ (kPa)	355.32							

Point ID	R-134a, P/D 1.33, 25 30 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.39	8.11	6.35	5.46	72.77	16510.36	0.6359	
T_1 (˚C)	10.74	7.77	6.16	5.38	67.34	17221.55	0.6348	
T_2 (˚C)	10.11	7.41	5.99	5.30	61.58	17904.35	0.6343	
T_3 (˚C)	9.51	7.10	5.79	5.22	55.81	18315.49	0.6344	
T_4 (˚C)	8.98	6.77	5.66	5.15	50.38	18477.10	0.6351	
T_5 (˚C)	8.53	6.53	5.55	5.09	40.76	18195.66	0.5024	
T_{out} (˚C)	8.10	6.33	5.45	5.06	37.50	19130.36	0.5006	
m_{water} (kg/s)	0.26				34.03	19667.81	0.4990	
$P_{water,in}$ (kPa)	685.74	N/A	N/A	325.60	30.56	20461.10	0.4978	
$P_{water,out}$ (kPa)	558.80	N/A	N/A	203.84	27.30	20479.63	0.4970	
P_{sat} (kPa)	343.95	345.04	343.94	345.17	21.77	22018.09	0.4094	24.99
$P_{bundle,in}$ (kPa)	344.61				19.59	22445.85	0.4100	
$P_{bundle,out}$ (kPa)	343.35				17.28	23406.13	0.4108	
m_{ref} (kg/s)	0.47				14.97	22456.96	0.4118	
	Path B	Path C	Path D	Path E	12.79	21024.13	0.4129	
$T_{water,in}$ (˚C)	11.32	11.38	11.37	11.46	9.78	16208.31	0.3558	
$T_{water,out}$ (˚C)	6.32	6.27	6.19	6.32	8.96	16346.44	0.3550	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	8.09	16487.98	0.3542	
	Pre-boiler				7.21	16435.20	0.3533	
$T_{water,in}$ (˚C)	25.25				6.39	15753.07	0.3525	
$T_{water,out}$ (˚C)	8.33							
m_{water} (kg/s)	0.49							
$T_{ref,in}$ (˚C)	0.14							
$P_{ref,in}$ (kPa)	385.51							
$P_{ref,out}$ (kPa)	369.27							

Point ID	R-134a, P/D 1.33, 25 45 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	14.77	9.56	7.08	5.79	122.70	19171.87	0.5364	
T_1 (˚C)	13.67	9.07	6.80	5.68	110.52	19634.23	0.5301	
T_2 (˚C)	12.63	8.59	6.56	5.58	97.59	19870.30	0.5244	
T_3 (˚C)	11.63	8.15	6.27	5.48	84.65	19325.23	0.5197	
T_4 (˚C)	10.81	7.70	6.08	5.38	72.47	17998.83	0.5162	
T_5 (˚C)	10.19	7.36	5.92	5.30	56.21	17244.90	0.3184	
T_{out} (˚C)	9.55	7.06	5.77	5.25	51.93	18018.68	0.3165	
m_{water} (kg/s)	0.26				47.39	18582.76	0.3150	
$P_{water,in}$ (kPa)	685.72	N/A	N/A	326.20	42.84	19387.94	0.3140	
$P_{water,out}$ (kPa)	558.22	N/A	N/A	202.84	38.56	19529.61	0.3136	
P_{sat} (kPa)	343.05	344.19	342.99	344.19	31.70	21921.27	0.1842	24.84
$P_{bundle,in}$ (kPa)	343.94				28.43	22120.12	0.1849	
$P_{bundle,out}$ (kPa)	342.42				24.95	22831.77	0.1859	
m_{ref} (kg/s)	0.47				21.47	21749.42	0.1871	
	Path B	Path C	Path D	Path E	18.19	20090.65	0.1885	
$T_{water,in}$ (˚C)	14.75	14.77	14.76	14.85	12.67	14105.49	0.1032	
$T_{water,out}$ (˚C)	6.96	6.97	7.02	7.04	11.66	14176.15	0.1022	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	10.58	14185.44	0.1011	
	Pre-boiler				9.51	14008.07	0.1001	
$T_{water,in}$ (˚C)	14.89				8.50	13540.19	0.0991	
$T_{water,out}$ (˚C)	5.96							
m_{water} (kg/s)	0.32							
$T_{ref,in}$ (˚C)	-1.30							
$P_{ref,in}$ (kPa)	368.06							
$P_{ref,out}$ (kPa)	359.28							

Point ID	**R-134a, P/D 1.33, 35 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m^2.˚C)**	**x**	**G (kg/m^2.s)**
T_{in} (˚C)	5.66	5.02	4.74	4.63	15.04	20656.70	0.1387	
T_1 (˚C)	5.53	4.97	4.71	4.62	13.72	21384.48	0.1382	
T_2 (˚C)	5.41	4.90	4.69	4.61	12.32	22606.60	0.1377	
T_3 (˚C)	5.27	4.85	4.66	4.60	10.91	23460.42	0.1372	
T_4 (˚C)	5.15	4.80	4.65	4.59	9.59	22717.29	0.1368	
T_5 (˚C)	5.07	4.76	4.63	4.58	6.64	13997.95	0.1210	
T_{out} (˚C)	5.00	4.73	4.62	4.58	6.13	14409.09	0.1207	
m_{water} (kg/s)		0.25			5.58	14299.50	0.1205	
$P_{water,in}$ (kPa)	644.42	N/A	N/A	311.60	5.04	14371.04	0.1202	
$P_{water,out}$ (kPa)	526.59	N/A	N/A	198.51	4.53	13858.25	0.1200	
P_{sat} (kPa)	341.73	342.70	341.36	342.36	2.94	13907.77	0.1091	35.08
$P_{bundle,in}$ (kPa)		342.60			2.72	13905.42	0.1092	
$P_{bundle,out}$ (kPa)		340.58			2.48	14276.72	0.1093	
m_{ref} (kg/s)		0.66			2.25	13675.84	0.1094	
	Path B	**Path C**	**Path D**	**Path E**	2.03	13188.73	0.1095	
$T_{water,in}$ (˚C)	5.63	5.62	5.62	5.69	1.32	5480.52	0.1017	
$T_{water,out}$ (˚C)	4.85	4.88	4.80	4.91	1.26	5415.73	0.1017	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.20	5305.33	0.1016	
		Pre-boiler			1.14	5201.00	0.1016	
$T_{water,in}$ (˚C)		15.70			1.08	5038.79	0.1016	
$T_{water,out}$ (˚C)		8.71						
m_{water} (kg/s)		0.74						
$T_{ref,in}$ (˚C)		-5.28						
$P_{ref,in}$ (kPa)		412.92						
$P_{ref,out}$ (kPa)		401.98						

Point ID	**R-134a, P/D 1.33, 35 5 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m^2.˚C)**	**x**	**G (kg/m^2.s)**
T_{in} (˚C)	5.76	4.98	4.64	4.54	17.34	23788.32	0.3842	
T_1 (˚C)	5.60	4.91	4.62	4.53	15.73	25196.45	0.3836	
T_2 (˚C)	5.44	4.84	4.60	4.52	14.01	27281.74	0.3830	
T_3 (˚C)	5.29	4.78	4.57	4.51	12.30	29066.84	0.3826	
T_4 (˚C)	5.15	4.72	4.56	4.50	10.69	28869.64	0.3821	
T_5 (˚C)	5.05	4.67	4.54	4.50	7.52	18294.11	0.3650	
T_{out} (˚C)	4.96	4.64	4.53	4.50	6.81	18808.73	0.3647	
m_{water} (kg/s)		0.24			6.06	18733.69	0.3643	
$P_{water,in}$ (kPa)	593.02	N/A	N/A	291.36	5.31	18719.75	0.3640	
$P_{water,out}$ (kPa)	486.64	N/A	N/A	188.66	4.61	17651.26	0.3637	
P_{sat} (kPa)	340.95	342.04	340.94	342.06	2.61	15032.10	0.3524	34.95
$P_{bundle,in}$ (kPa)		341.72			2.41	15305.04	0.3525	
$P_{bundle,out}$ (kPa)		340.22			2.20	16139.37	0.3526	
m_{ref} (kg/s)		0.66			1.98	15620.59	0.3528	
	Path B	**Path C**	**Path D**	**Path E**	1.78	15115.16	0.3529	
$T_{water,in}$ (˚C)	5.70	5.70	5.71	5.79	1.13	5200.50	0.3452	
$T_{water,out}$ (˚C)	4.75	4.76	4.74	4.82	1.07	5096.81	0.3452	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	1.01	4923.37	0.3451	
		Pre-boiler			0.94	4792.99	0.3451	
$T_{water,in}$ (˚C)		20.30			0.88	4543.94	0.3450	
$T_{water,out}$ (˚C)		10.91						
m_{water} (kg/s)		1.31						
$T_{ref,in}$ (˚C)		-3.98						
$P_{ref,in}$ (kPa)		409.93						
$P_{ref,out}$ (kPa)		384.87						

Point ID	R-134a, P/D 1.33, 35 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.67	6.04	5.28	4.94	40.34	20536.41	0.2013	
T_1 (˚C)	7.35	5.90	5.21	4.92	37.19	21561.01	0.2006	
T_2 (˚C)	7.04	5.74	5.15	4.89	33.85	22813.90	0.2001	
T_3 (˚C)	6.72	5.60	5.07	4.86	30.50	23963.37	0.1997	
T_4 (˚C)	6.43	5.45	5.02	4.83	27.35	24054.58	0.1995	
T_5 (˚C)	6.22	5.35	4.98	4.80	19.75	18593.07	0.1505	
T_{out} (˚C)	6.02	5.27	4.94	4.78	18.09	19168.19	0.1497	
m_{water} (kg/s)	0.28				16.31	19305.14	0.1490	
$P_{water,in}$ (kPa)	779.23	N/A	N/A	360.55	14.54	19652.92	0.1483	
$P_{water,out}$ (kPa)	630.38	N/A	N/A	219.50	12.88	18892.52	0.1478	
P_{sat} (kPa)	342.15	343.25	341.95	343.02	8.79	16558.20	0.1151	35.23
$P_{bundle,in}$ (kPa)	343.06				8.11	16674.70	0.1154	
$P_{bundle,out}$ (kPa)	341.15				7.38	17330.32	0.1159	
m_{ref} (kg/s)	0.66				6.66	16882.38	0.1164	
	Path B	Path C	Path D	Path E	5.97	16395.36	0.1169	
$T_{water,in}$ (˚C)	7.66	7.65	7.65	7.73	4.21	9600.76	0.0943	
$T_{water,out}$ (˚C)	5.44	5.46	5.42	5.50	4.01	9708.43	0.0942	
m_{water} (kg/s)	0.40	0.42	0.38	0.41	3.79	9801.34	0.0941	
	Pre-boiler				3.58	9841.65	0.0939	
$T_{water,in}$ (˚C)	19.02				3.37	9841.26	0.0938	
$T_{water,out}$ (˚C)	5.59							
m_{water} (kg/s)	0.36							
$T_{ref,in}$ (˚C)	-5.27							
$P_{ref,in}$ (kPa)	374.68							
$P_{ref,out}$ (kPa)	362.29							

Point ID	R-134a, P/D 1.33, 35 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	8.11	6.42	5.57	5.21	38.12	19104.89	0.4434	
T_1 (˚C)	7.79	6.25	5.49	5.19	35.34	20401.36	0.4430	
T_2 (˚C)	7.46	6.08	5.43	5.16	32.39	21809.66	0.4428	
T_3 (˚C)	7.14	5.92	5.34	5.13	29.44	23213.77	0.4428	
T_4 (˚C)	6.85	5.77	5.29	5.10	26.67	24132.28	0.4429	
T_5 (˚C)	6.61	5.65	5.25	5.08	20.06	20179.76	0.3962	
T_{out} (˚C)	6.40	5.56	5.21	5.06	18.34	21239.54	0.3955	
m_{water} (kg/s)	0.26				16.52	21839.04	0.3948	
$P_{water,in}$ (kPa)	683.64	N/A	N/A	324.41	14.71	22828.21	0.3943	
$P_{water,out}$ (kPa)	557.39	N/A	N/A	203.03	12.99	22547.73	0.3938	
P_{sat} (kPa)	346.64	347.81	346.67	347.88	9.23	22184.52	0.3639	34.88
$P_{bundle,in}$ (kPa)	347.36				8.28	22266.26	0.3642	
$P_{bundle,out}$ (kPa)	346.07				7.26	22928.96	0.3645	
m_{ref} (kg/s)	0.66				6.25	21494.56	0.3649	
	Path B	Path C	Path D	Path E	5.29	19603.45	0.3653	
$T_{water,in}$ (˚C)	8.06	8.07	8.05	8.16	3.88	11321.81	0.3464	
$T_{water,out}$ (˚C)	5.68	5.67	5.59	5.69	3.57	11117.99	0.3462	
m_{water} (kg/s)	0.35	0.33	0.33	0.34	3.24	10800.34	0.3459	
	Pre-boiler				2.91	10391.94	0.3457	
$T_{water,in}$ (˚C)	21.42				2.60	9668.26	0.3455	
$T_{water,out}$ (˚C)	10.96							
m_{water} (kg/s)	1.17							
$T_{ref,in}$ (˚C)	-3.19							
$P_{ref,in}$ (kPa)	414.64							
$P_{ref,out}$ (kPa)	389.76							

Point ID	**R-134a, P/D 1.33, 35 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m²·s)**
T_{in} (°C)	11.66	8.20	6.34	5.47	76.98	16671.40	0.3085	
T_1 (°C)	10.96	7.84	6.16	5.40	71.09	17317.63	0.3075	
T_2 (°C)	10.31	7.47	6.00	5.33	64.84	17996.92	0.3069	
T_3 (°C)	9.67	7.13	5.80	5.25	58.58	18389.77	0.3068	
T_4 (°C)	9.10	6.78	5.67	5.19	52.69	18366.53	0.3072	
T_5 (°C)	8.65	6.53	5.56	5.13	43.08	18614.29	0.2104	
T_{out} (°C)	8.19	6.33	5.46	5.09	39.61	19455.74	0.2090	
m_{water} (kg/s)		0.26			35.92	20159.44	0.2078	
$P_{water,in}$ (kPa)	685.65	N/A	N/A	325.67	32.23	21084.51	0.2069	
$P_{water,out}$ (kPa)	558.22	N/A	N/A	202.65	28.76	21134.70	0.2063	
P_{sat} (kPa)	343.21	344.33	343.10	344.25	21.10	19966.38	0.1421	35.14
$P_{bundle,in}$ (kPa)		344.08			19.04	20082.37	0.1426	
$P_{bundle,out}$ (kPa)		342.43			16.85	20867.08	0.1432	
m_{ref} (kg/s)		0.66			14.66	19919.67	0.1439	
	Path B	**Path C**	**Path D**	**Path E**	12.60	18620.95	0.1447	
$T_{water,in}$ (°C)	11.64	11.63	11.63	11.71	9.00	12798.23	0.1037	
$T_{water,out}$ (°C)	6.14	6.24	6.32	6.27	8.37	12933.07	0.1033	
m_{water} (kg/s)	0.33	0.32	0.34	0.31	7.70	13071.29	0.1028	
		Pre-boiler			7.03	13060.02	0.1023	
$T_{water,in}$ (°C)		18.95			6.40	12900.56	0.1019	
$T_{water,out}$ (°C)		5.82						
m_{water} (kg/s)		0.38						
$T_{ref,in}$ (°C)		-4.56						
$P_{ref,in}$ (kPa)		375.92						
$P_{ref,out}$ (kPa)		363.64						

Point ID	**R-134a, P/D 1.33, 35 45 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m²·s)**
T_{in} (°C)	14.70	9.41	6.91	5.62	124.69	19453.84	0.4072	
T_1 (°C)	13.58	8.92	6.63	5.52	112.24	19936.87	0.4027	
T_2 (°C)	12.52	8.43	6.39	5.41	99.02	20197.87	0.3985	
T_3 (°C)	11.50	7.98	6.11	5.30	85.79	19646.73	0.3952	
T_4 (°C)	10.67	7.53	5.92	5.21	73.34	18293.81	0.3927	
T_5 (°C)	10.04	7.18	5.75	5.13	56.83	17545.82	0.2507	
T_{out} (°C)	9.40	6.89	5.61	5.07	52.45	18345.35	0.2492	
m_{water} (kg/s)		0.26			47.79	18943.52	0.2480	
$P_{water,in}$ (kPa)	684.51	N/A	N/A	326.09	43.14	19759.70	0.2472	
$P_{water,out}$ (kPa)	559.92	N/A	N/A	202.68	38.76	19904.77	0.2469	
P_{sat} (kPa)	341.17	342.33	341.16	342.34	31.51	21955.60	0.1543	34.94
$P_{bundle,in}$ (kPa)		342.05			28.24	22152.98	0.1548	
$P_{bundle,out}$ (kPa)		340.50			24.76	22846.18	0.1556	
m_{ref} (kg/s)		0.66			21.29	21717.41	0.1565	
	Path B	**Path C**	**Path D**	**Path E**	18.02	20016.28	0.1576	
$T_{water,in}$ (°C)	14.68	14.70	14.68	14.77	13.05	14801.11	0.0970	
$T_{water,out}$ (°C)	6.80	6.81	6.86	6.89	11.99	14901.68	0.0963	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	10.86	14948.14	0.0955	
		Pre-boiler			9.73	14798.94	0.0947	
$T_{water,in}$ (°C)		12.58			8.66	14303.35	0.0939	
$T_{water,out}$ (°C)		6.79						
m_{water} (kg/s)		0.59						
$T_{ref,in}$ (°C)		0.93						
$P_{ref,in}$ (kPa)		373.16						
$P_{ref,out}$ (kPa)		361.03						

Point ID	R-134a, P/D 1.33, 45 5 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.71	5.05	4.77	4.67	15.26	21608.94	0.1281	
T_1 (˚C)	5.57	5.00	4.75	4.66	13.89	22522.86	0.1277	
T_2 (˚C)	5.45	4.94	4.73	4.66	12.44	23904.36	0.1273	
T_3 (˚C)	5.31	4.89	4.71	4.65	11.00	24928.81	0.1269	
T_4 (˚C)	5.19	4.83	4.69	4.64	9.63	24176.60	0.1266	
T_5 (˚C)	5.11	4.80	4.68	4.63	6.70	14826.27	0.1142	
T_{out} (˚C)	5.04	4.77	4.66	4.63	6.15	15225.38	0.1140	
m_{water} (kg/s)	0.25				5.57	15047.58	0.1138	
$P_{water,in}$ (kPa)	644.99	N/A	N/A	311.59	4.99	15067.93	0.1136	
$P_{water,out}$ (kPa)	527.10	N/A	N/A	198.50	4.44	14362.20	0.1134	
P_{sat} (kPa)	342.34	343.38	342.04	343.07	2.81	14273.54	0.1050	44.93
$P_{bundle,in}$ (kPa)	343.25				2.59	14182.95	0.1051	
$P_{bundle,out}$ (kPa)	341.22				2.35	14519.42	0.1052	
m_{ref} (kg/s)	0.85				2.12	13788.98	0.1053	
	Path B	**Path C**	**Path D**	**Path E**	1.90	13163.52	0.1054	
$T_{water,in}$ (˚C)	5.67	5.67	5.68	5.75	1.26	5312.70	0.0995	
$T_{water,out}$ (˚C)	4.90	4.92	4.85	4.96	1.20	5230.13	0.0995	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.14	5099.68	0.0995	
	Pre-boiler				1.08	4994.20	0.0994	
$T_{water,in}$ (˚C)	15.36				1.02	4799.79	0.0994	
$T_{water,out}$ (˚C)	12.83							
m_{water} (kg/s)	2.57							
$T_{ref,in}$ (˚C)	-5.22							
$P_{ref,in}$ (kPa)	454.46							
$P_{ref,out}$ (kPa)	440.92							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	6.12	5.34	5.01	4.91	17.04	23829.26	0.3737	
T_1 (˚C)	5.95	5.27	5.00	4.91	15.46	25222.37	0.3733	
T_2 (˚C)	5.80	5.21	4.98	4.90	13.77	27356.76	0.3729	
T_3 (˚C)	5.65	5.15	4.95	4.89	12.09	29181.34	0.3725	
T_4 (˚C)	5.51	5.09	4.93	4.88	10.51	29030.20	0.3723	
T_5 (˚C)	5.41	5.05	4.92	4.88	7.39	18070.19	0.3593	
T_{out} (˚C)	5.33	5.01	4.91	4.87	6.68	18462.88	0.3589	
m_{water} (kg/s)	0.24				5.92	18274.58	0.3586	
$P_{water,in}$ (kPa)	592.83	N/A	N/A	290.76	5.17	18033.96	0.3583	
$P_{water,out}$ (kPa)	485.86	N/A	N/A	188.25	4.46	16852.41	0.3581	
P_{sat} (kPa)	345.53	346.69	345.58	346.79	2.55	14366.38	0.3498	44.63
$P_{bundle,in}$ (kPa)	346.27				2.36	14697.48	0.3500	
$P_{bundle,out}$ (kPa)	344.90				2.17	15560.74	0.3501	
m_{ref} (kg/s)	0.84				1.98	15241.51	0.3503	
	Path B	**Path C**	**Path D**	**Path E**	1.80	14974.16	0.3504	
$T_{water,in}$ (˚C)	6.06	6.06	6.07	6.15	1.15	5127.54	0.3451	
$T_{water,out}$ (˚C)	5.13	5.14	5.11	5.20	1.07	4931.07	0.3450	
m_{water} (kg/s)	0.29	0.31	0.30	0.31	0.98	4647.78	0.3450	
	Pre-boiler				0.90	4374.56	0.3449	
$T_{water,in}$ (˚C)	19.76				0.82	4025.25	0.3449	
$T_{water,out}$ (˚C)	13.95							
m_{water} (kg/s)	2.58							
$T_{ref,in}$ (˚C)	-1.51							
$P_{ref,in}$ (kPa)	444.38							
$P_{ref,out}$ (kPa)	410.21							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.48	5.85	5.08	4.74	40.43	20655.85	0.1892	
T_1 (˚C)	7.16	5.70	5.01	4.71	37.24	21681.32	0.1887	
T_2 (˚C)	6.85	5.54	4.95	4.68	33.84	22903.22	0.1882	
T_3 (˚C)	6.53	5.40	4.87	4.65	30.45	23992.21	0.1879	
T_4 (˚C)	6.24	5.25	4.82	4.62	27.25	23995.34	0.1877	
T_5 (˚C)	6.03	5.15	4.77	4.59	19.83	18812.05	0.1492	
T_{out} (˚C)	5.83	5.07	4.73	4.58	18.20	19476.39	0.1486	
m_{water} (kg/s)	0.28				16.47	19739.51	0.1481	
$P_{water,in}$ (kPa)	778.29	N/A	N/A	360.99	14.74	20279.42	0.1476	
$P_{water,out}$ (kPa)	629.86	N/A	N/A	219.82	13.11	19709.46	0.1472	
P_{sat} (kPa)	339.90	340.90	339.68	340.74	9.07	17599.38	0.1213	45.13
$P_{bundle,in}$ (kPa)	340.76				8.33	17670.22	0.1216	
$P_{bundle,out}$ (kPa)	338.94				7.53	18370.37	0.1220	
m_{ref} (kg/s)	0.85				6.74	17764.43	0.1223	
	Path B	**Path C**	**Path D**	**Path E**	5.99	17064.42	0.1227	
$T_{water,in}$ (˚C)	7.47	7.45	7.46	7.54	4.37	10576.21	0.1049	
$T_{water,out}$ (˚C)	5.23	5.25	5.20	5.30	4.11	10596.64	0.1048	
m_{water} (kg/s)	0.40	0.41	0.38	0.41	3.84	10595.30	0.1047	
	Pre-boiler				3.57	10539.20	0.1045	
$T_{water,in}$ (˚C)	18.58				3.32	10334.90	0.1044	
$T_{water,out}$ (˚C)	6.34							
m_{water} (kg/s)	0.53							
$T_{ref,in}$ (˚C)	-5.11							
$P_{ref,in}$ (kPa)	383.68							
$P_{ref,out}$ (kPa)	366.79							

Point ID	R-134a, P/D 1.33, 45 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	10.83	7.55	5.86	5.08	74.11	17919.27	0.2468	
T_1 (˚C)	10.18	7.21	5.68	5.02	68.20	18746.84	0.2458	
T_2 (˚C)	9.55	6.88	5.54	4.95	61.93	19558.11	0.2450	
T_3 (˚C)	8.92	6.56	5.37	4.89	55.65	20058.26	0.2447	
T_4 (˚C)	8.38	6.25	5.26	4.83	49.75	20001.62	0.2447	
T_5 (˚C)	7.96	6.02	5.16	4.78	39.63	19574.53	0.1741	
T_{out} (˚C)	7.53	5.84	5.07	4.74	36.31	20513.82	0.1730	
m_{water} (kg/s)	0.26				32.79	21229.84	0.1721	
$P_{water,in}$ (kPa)	686.59	N/A	N/A	326.54	29.26	22214.68	0.1714	
$P_{water,out}$ (kPa)	560.27	N/A	N/A	203.91	25.94	22083.72	0.1710	
P_{sat} (kPa)	340.00	341.13	339.92	341.08	19.24	21556.04	0.1246	45.02
$P_{bundle,in}$ (kPa)	340.86				17.21	21452.47	0.1248	
$P_{bundle,out}$ (kPa)	339.19				15.04	21846.80	0.1252	
m_{ref} (kg/s)	0.85				12.87	20385.78	0.1256	
	Path B	**Path C**	**Path D**	**Path E**	10.84	18480.49	0.1261	
$T_{water,in}$ (˚C)	10.80	10.80	10.79	10.88	8.13	13349.59	0.0966	
$T_{water,out}$ (˚C)	5.82	5.84	5.91	5.88	7.53	13453.41	0.0962	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	6.89	13538.34	0.0959	
	Pre-boiler				6.26	13451.41	0.0956	
$T_{water,in}$ (˚C)	18.66				5.66	13155.88	0.0952	
$T_{water,out}$ (˚C)	6.30							
m_{water} (kg/s)	0.48							
$T_{ref,in}$ (˚C)	-4.35							
$P_{ref,in}$ (kPa)	382.24							
$P_{ref,out}$ (kPa)	365.98							

Point ID	**R-134a, P/D 1.33, 55 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.62	4.96	4.68	4.59	15.41	22602.97	0.1252	
T_1 (˚C)	5.48	4.91	4.66	4.58	14.00	23650.68	0.1248	
T_2 (˚C)	5.35	4.85	4.64	4.57	12.50	25186.70	0.1245	
T_3 (˚C)	5.22	4.80	4.62	4.56	11.00	26309.03	0.1242	
T_4 (˚C)	5.10	4.74	4.60	4.55	9.59	25395.75	0.1239	
T_5 (˚C)	5.02	4.71	4.59	4.55	6.67	15484.73	0.1138	
T_{out} (˚C)	4.94	4.68	4.58	4.54	6.11	15857.92	0.1136	
m_{water} (kg/s)		0.25			5.52	15676.39	0.1134	
$P_{water,in}$ (kPa)	645.88	N/A	N/A	312.44	4.92	15698.45	0.1132	
$P_{water,out}$ (kPa)	527.71	N/A	N/A	199.20	4.36	14857.13	0.1131	
P_{sat} (kPa)	341.40	342.51	341.19	342.23	2.73	14889.01	0.1062	54.82
$P_{bundle,in}$ (kPa)		342.30			2.51	14735.19	0.1063	
$P_{bundle,out}$ (kPa)		340.38			2.27	15079.99	0.1063	
m_{ref} (kg/s)		1.03			2.03	14247.23	0.1064	
	Path B	**Path C**	**Path D**	**Path E**	1.81	13500.74	0.1065	
$T_{water,in}$ (˚C)	5.58	5.57	5.59	5.65	1.23	5290.60	0.1017	
$T_{water,out}$ (˚C)	4.81	4.83	4.76	4.87	1.17	5171.63	0.1017	
m_{water} (kg/s)	0.36	0.38	0.34	0.36	1.10	4997.89	0.1017	
		Pre-boiler			1.03	4855.88	0.1016	
$T_{water,in}$ (˚C)		18.00			0.97	4608.65	0.1016	
$T_{water,out}$ (˚C)		14.90						
m_{water} (kg/s)		2.58						
$T_{ref,in}$ (˚C)		-5.10						
$P_{ref,in}$ (kPa)		491.74						
$P_{ref,out}$ (kPa)		476.14						

Point ID	**R-134a, P/D 1.33, 55 15 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.47	5.83	5.06	4.72	40.65	20990.85	0.1725	
T_1 (˚C)	7.15	5.68	4.99	4.69	37.41	22067.58	0.1720	
T_2 (˚C)	6.83	5.53	4.93	4.66	33.96	23340.18	0.1716	
T_3 (˚C)	6.51	5.38	4.85	4.63	30.52	24456.74	0.1714	
T_4 (˚C)	6.23	5.23	4.80	4.60	27.28	24439.24	0.1712	
T_5 (˚C)	6.02	5.13	4.75	4.58	19.91	19278.02	0.1396	
T_{out} (˚C)	5.82	5.05	4.71	4.56	18.27	19982.14	0.1391	
m_{water} (kg/s)		0.28			16.53	20307.26	0.1387	
$P_{water,in}$ (kPa)	777.22	N/A	N/A	361.54	14.79	20948.58	0.1383	
$P_{water,out}$ (kPa)	630.80	N/A	N/A	219.70	13.16	20421.34	0.1380	
P_{sat} (kPa)	339.92	340.94	339.66	340.76	9.09	18559.81	0.1169	55.19
$P_{bundle,in}$ (kPa)		340.71			8.30	18594.54	0.1171	
$P_{bundle,out}$ (kPa)		338.98			7.47	19293.41	0.1174	
m_{ref} (kg/s)		1.04			6.63	18523.10	0.1177	
	Path B	**Path C**	**Path D**	**Path E**	5.85	17586.31	0.1180	
$T_{water,in}$ (˚C)	7.46	7.44	7.45	7.53	4.23	10639.72	0.1036	
$T_{water,out}$ (˚C)	5.22	5.23	5.17	5.28	3.98	10658.16	0.1035	
m_{water} (kg/s)	0.40	0.41	0.38	0.41	3.72	10641.09	0.1034	
		Pre-boiler			3.45	10568.17	0.1033	
$T_{water,in}$ (˚C)		17.96			3.20	10344.95	0.1032	
$T_{water,out}$ (˚C)		7.45						
m_{water} (kg/s)		0.76						
$T_{ref,in}$ (˚C)		-4.64						
$P_{ref,in}$ (kPa)		397.15						
$P_{ref,out}$ (kPa)		375.21						

Point ID	**R-134a, P/D 1.33, 55 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.69	8.12	6.32	5.49	81.21	18371.67	0.2312	
T_1 (˚C)	10.97	7.77	6.13	5.42	74.40	19160.13	0.2302	
T_2 (˚C)	10.28	7.41	5.98	5.35	67.16	19898.10	0.2294	
T_3 (˚C)	9.60	7.07	5.80	5.28	59.93	20225.44	0.2289	
T_4 (˚C)	9.02	6.74	5.68	5.21	53.11	19936.62	0.2287	
T_5 (˚C)	8.56	6.50	5.57	5.16	42.12	19515.00	0.1664	
T_{out} (˚C)	8.11	6.30	5.48	5.12	38.60	20486.54	0.1655	
m_{water} (kg/s)	0.26				34.87	21211.65	0.1647	
$P_{water,in}$ (kPa)	686.55	N/A	N/A	326.03	31.14	22198.17	0.1641	
$P_{water,out}$ (kPa)	558.64	N/A	N/A	203.65	27.63	22141.75	0.1637	
P_{sat} (kPa)	344.53	345.64	344.44	345.59	20.60	21820.88	0.1231	55.00
$P_{bundle,in}$ (kPa)	345.35				18.42	21801.11	0.1234	
$P_{bundle,out}$ (kPa)	343.73				16.10	22265.58	0.1238	
m_{ref} (kg/s)	1.04				13.77	20839.30	0.1242	
	Path B	**Path C**	**Path D**	**Path E**	11.59	18878.23	0.1247	
$T_{water,in}$ (˚C)	11.67	11.67	11.65	11.74	8.77	14076.17	0.0990	
$T_{water,out}$ (˚C)	6.29	6.30	6.36	6.34	8.08	14156.54	0.0987	
m_{water} (kg/s)	0.32	0.33	0.33	0.33	7.35	14190.61	0.0984	
	Pre-boiler				6.62	14060.36	0.0980	
$T_{water,in}$ (˚C)	18.20				5.93	13597.94	0.0977	
$T_{water,out}$ (˚C)	7.61							
m_{water} (kg/s)	0.68							
$T_{ref,in}$ (˚C)	-3.32							
$P_{ref,in}$ (kPa)	398.25							
$P_{ref,out}$ (kPa)	377.77							

Point ID	**R-134a, P/D 1.5, 10 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.70	5.10	4.82	4.68	14.20	16679.66	0.1820	
T_1 (˚C)	5.59	5.03	4.79	4.67	13.19	18069.59	0.1815	
T_2 (˚C)	5.45	4.98	4.77	4.66	12.11	18423.28	0.1811	
T_3 (˚C)	5.35	4.92	4.74	4.65	11.03	19198.63	0.1807	
T_4 (˚C)	5.24	4.88	4.71	4.63	10.02	19761.97	0.1805	
T_5 (˚C)	5.14	4.84	4.69	4.63	6.82	11519.19	0.1431	
T_{out} (˚C)	5.07	4.81	4.67	4.62	6.24	11195.74	0.1423	
m_{water} (kg/s)	0.26				5.63	11070.66	0.1416	
$P_{water,in}$ (kPa)	684.09	N/A	N/A	328.80	5.01	10242.97	0.1409	
$P_{water,out}$ (kPa)	562.29	N/A	N/A	203.59	4.44	9548.41	0.1404	
P_{sat} (kPa)	341.26	342.25	340.81	342.15	3.50	11061.18	0.1158	9.93
$P_{bundle,in}$ (kPa)	342.28				3.32	11252.80	0.1161	
$P_{bundle,out}$ (kPa)	339.79				3.14	11425.40	0.1165	
m_{ref} (kg/s)	0.28				2.95	11689.67	0.1169	
	Path B	**Path C**	**Path D**	**Path E**	2.77	11865.76	0.1173	
$T_{water,in}$ (˚C)	5.78	5.67	5.68	5.72	1.69	5171.60	0.0988	
$T_{water,out}$ (˚C)	4.84	4.98	4.82	4.86	1.63	5185.15	0.0987	
m_{water} (kg/s)	0.32	0.38	0.33	0.33	1.56	5125.77	0.0986	
	Pre-boiler				1.49	5093.19	0.0985	
$T_{water,in}$ (˚C)	9.27				1.43	4910.63	0.0984	
$T_{water,out}$ (˚C)	6.20							
m_{water} (kg/s)	0.53							
$T_{ref,in}$ (˚C)	0.44							
$P_{ref,in}$ (kPa)	362.60							
$P_{ref,out}$ (kPa)	356.58							

Point ID	R-134a, P/D 1.5, 10 5 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h ($W/m^2.^\circ C$)**	**x**	**G ($kg/m^2.s$)**
T_{in} (˚C)	5.69	5.04	4.77	4.64	15.40	19416.54	0.4475	
T_1 (˚C)	5.56	4.98	4.74	4.64	14.20	21118.26	0.4468	
T_2 (˚C)	5.41	4.92	4.71	4.62	12.93	21628.61	0.4462	
T_3 (˚C)	5.31	4.86	4.69	4.62	11.66	22664.57	0.4457	
T_4 (˚C)	5.19	4.82	4.67	4.61	10.46	23296.50	0.4453	
T_5 (˚C)	5.09	4.79	4.65	4.60	7.18	14583.14	0.4058	
T_{out} (˚C)	5.01	4.75	4.63	4.59	6.47	14077.20	0.4050	
m_{water} (kg/s)	0.26				5.71	13811.88	0.4041	
$P_{water,in}$ (kPa)	699.32	N/A	N/A	334.24	4.96	12456.26	0.4033	
$P_{water,out}$ (kPa)	575.49	N/A	N/A	206.07	4.25	11209.91	0.4026	
P_{sat} (kPa)	341.45	342.50	341.19	342.12	3.29	13420.59	0.3769	9.98
$P_{bundle,in}$ (kPa)	342.35				3.06	13523.02	0.3771	
$P_{bundle,out}$ (kPa)	340.24				2.82	13328.69	0.3774	
m_{ref} (kg/s)	0.29				2.57	13214.49	0.3777	
	Path B	**Path C**	**Path D**	**Path E**	2.34	12871.78	0.3780	
$T_{water,in}$ (˚C)	5.75	5.64	5.65	5.72	1.41	4999.23	0.3590	
$T_{water,out}$ (˚C)	4.82	4.92	4.76	4.85	1.35	4964.65	0.3589	
m_{water} (kg/s)	0.33	0.39	0.33	0.34	1.28	4844.59	0.3588	
	Pre-boiler				1.21	4757.37	0.3587	
$T_{water,in}$ (˚C)	21.85				1.15	4505.11	0.3586	
$T_{water,out}$ (˚C)	6.50							
m_{water} (kg/s)	0.37							
$T_{ref,in}$ (˚C)	-6.47							
$P_{ref,in}$ (kPa)	363.55							
$P_{ref,out}$ (kPa)	354.85							

Point ID	R-134a, P/D 1.5, 10 5 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h ($W/m^2.^\circ C$)**	**x**	**G ($kg/m^2.s$)**
T_{in} (˚C)	5.81	5.14	4.85	4.72	16.14	20605.76	0.6441	
T_1 (˚C)	5.69	5.07	4.82	4.72	14.89	22630.17	0.6434	
T_2 (˚C)	5.53	5.01	4.79	4.71	13.57	23494.63	0.6427	
T_3 (˚C)	5.42	4.95	4.77	4.70	12.25	25103.56	0.6422	
T_4 (˚C)	5.29	4.91	4.75	4.69	11.01	26224.21	0.6418	
T_5 (˚C)	5.19	4.87	4.73	4.69	7.64	16568.78	0.6025	
T_{out} (˚C)	5.11	4.83	4.71	4.67	6.86	16077.28	0.6016	
m_{water} (kg/s)	0.26				6.03	15841.57	0.6007	
$P_{water,in}$ (kPa)	699.13	N/A	N/A	333.71	5.19	14300.53	0.5998	
$P_{water,out}$ (kPa)	574.89	N/A	N/A	205.59	4.41	12792.98	0.5990	
P_{sat} (kPa)	342.53	343.63	342.39	343.37	3.42	15806.14	0.5741	10.06
$P_{bundle,in}$ (kPa)	343.62				3.14	15876.00	0.5742	
$P_{bundle,out}$ (kPa)	341.52				2.84	15507.57	0.5744	
m_{ref} (kg/s)	0.29				2.54	15093.06	0.5747	
	Path B	**Path C**	**Path D**	**Path E**	2.26	14326.35	0.5749	
$T_{water,in}$ (˚C)	5.87	5.78	5.78	5.86	1.40	5376.60	0.5568	
$T_{water,out}$ (˚C)	4.92	5.00	4.84	4.94	1.34	5346.59	0.5567	
m_{water} (kg/s)	0.33	0.39	0.33	0.34	1.27	5224.53	0.5566	
	Pre-boiler				1.20	5144.41	0.5565	
$T_{water,in}$ (˚C)	21.35				1.14	4863.59	0.5564	
$T_{water,out}$ (˚C)	7.45							
m_{water} (kg/s)	0.59							
$T_{ref,in}$ (˚C)	-3.82							
$P_{ref,in}$ (kPa)	369.71							
$P_{ref,out}$ (kPa)	358.53							

Point ID	R-134a, P/D 1.5, 10 5 0.70							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	5.63	4.97	4.68	4.56	15.95	20712.94	0.8001	
T_1 (˚C)	5.51	4.89	4.65	4.55	14.79	22908.61	0.7996	
T_2 (˚C)	5.35	4.84	4.62	4.54	13.57	24068.80	0.7991	
T_3 (˚C)	5.24	4.77	4.60	4.53	12.34	26160.65	0.7988	
T_4 (˚C)	5.12	4.74	4.58	4.52	11.19	27788.02	0.7985	
T_5 (˚C)	5.02	4.70	4.56	4.52	7.77	17439.40	0.7564	
T_{out} (˚C)	4.94	4.66	4.55	4.51	6.94	16837.55	0.7553	
m_{water} (kg/s)	0.27				6.06	16477.43	0.7543	
$P_{water,in}$ (kPa)	718.03	N/A	N/A	340.91	5.18	14663.17	0.7534	
$P_{water,out}$ (kPa)	589.36	N/A	N/A	208.69	4.35	12927.14	0.7525	
P_{sat} (kPa)	340.63	341.72	340.55	341.54	3.43	16085.86	0.7252	9.92
$P_{bundle,in}$ (kPa)	341.30				3.14	16172.09	0.7253	
$P_{bundle,out}$ (kPa)	339.74				2.84	15734.62	0.7255	
m_{ref} (kg/s)	0.28				2.53	15300.11	0.7257	
	Path B	**Path C**	**Path D**	**Path E**	2.24	14134.54	0.7260	
$T_{water,in}$ (˚C)	5.69	5.60	5.60	5.68	1.40	5460.36	0.7056	
$T_{water,out}$ (˚C)	4.75	4.84	4.67	4.77	1.35	5455.34	0.7055	
m_{water} (kg/s)	0.33	0.40	0.34	0.34	1.29	5357.01	0.7054	
	Pre-boiler				1.23	5302.83	0.7053	
$T_{water,in}$ (˚C)	21.66				1.17	5044.92	0.7052	
$T_{water,out}$ (˚C)	7.47							
m_{water} (kg/s)	0.67							
$T_{ref,in}$ (˚C)	2.21							
$P_{ref,in}$ (kPa)	370.98							
$P_{ref,out}$ (kPa)	357.94							

Point ID	R-134a, P/D 1.5, 10 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	8.10	6.22	5.44	5.11	44.30	20786.13	0.3441	
T_1 (˚C)	7.75	6.04	5.38	5.08	40.66	22621.91	0.3425	
T_2 (˚C)	7.33	5.88	5.32	5.05	36.79	23427.47	0.3411	
T_3 (˚C)	7.01	5.73	5.25	5.02	32.92	24566.16	0.3402	
T_4 (˚C)	6.69	5.61	5.19	4.99	29.28	25319.26	0.3397	
T_5 (˚C)	6.41	5.51	5.14	4.97	20.01	18751.76	0.2272	
T_{out} (˚C)	6.20	5.43	5.10	4.94	17.74	18321.38	0.2243	
m_{water} (kg/s)	0.27				15.33	17499.78	0.2214	
$P_{water,in}$ (kPa)	717.37	N/A	N/A	340.77	12.92	15894.95	0.2187	
$P_{water,out}$ (kPa)	590.27	N/A	N/A	207.91	10.66	13748.23	0.2164	
P_{sat} (kPa)	343.46	344.50	343.17	344.13	8.05	13443.56	0.1467	10.14
$P_{bundle,in}$ (kPa)	344.49				7.55	13857.51	0.1477	
$P_{bundle,out}$ (kPa)	342.18				7.03	14332.12	0.1490	
m_{ref} (kg/s)	0.29				6.51	14642.58	0.1503	
	Path B	**Path C**	**Path D**	**Path E**	6.01	14732.25	0.1516	
$T_{water,in}$ (˚C)	8.19	8.09	8.09	8.17	3.95	8117.06	0.1015	
$T_{water,out}$ (˚C)	5.59	5.71	5.55	5.61	3.76	8193.87	0.1012	
m_{water} (kg/s)	0.33	0.35	0.34	0.34	3.55	8216.22	0.1008	
	Pre-boiler				3.34	8201.75	0.1005	
$T_{water,in}$ (˚C)	12.93				3.15	8015.60	0.1002	
$T_{water,out}$ (˚C)	5.38							
m_{water} (kg/s)	0.31							
$T_{ref,in}$ (˚C)	-7.29							
$P_{ref,in}$ (kPa)	364.83							
$P_{ref,out}$ (kPa)	358.59							

Point ID	R-134a, P/D 1.5, 10 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.70	5.95	5.13	4.75	40.10	18554.39	0.5959	
T_1 (˚C)	7.39	5.76	5.05	4.72	37.33	20227.78	0.5955	
T_2 (˚C)	7.00	5.60	4.98	4.68	34.37	21152.43	0.5954	
T_3 (˚C)	6.71	5.44	4.90	4.65	31.42	22627.64	0.5958	
T_4 (˚C)	6.40	5.32	4.84	4.62	28.64	24018.18	0.5966	
T_5 (˚C)	6.14	5.20	4.79	4.60	20.26	18685.39	0.4828	
T_{out} (˚C)	5.92	5.11	4.74	4.58	18.22	18689.41	0.4803	
m_{water} (kg/s)	0.27				16.06	18447.57	0.4778	
$P_{water,in}$ (kPa)	718.30	N/A	N/A	340.03	13.89	17119.36	0.4756	
$P_{water,out}$ (kPa)	590.34	N/A	N/A	208.23	11.85	16002.98	0.4737	
P_{sat} (kPa)	339.80	340.78	339.58	340.59	9.24	16625.61	0.4024	9.94
$P_{bundle,in}$ (kPa)	340.59				8.50	17076.88	0.4034	
$P_{bundle,out}$ (kPa)	338.75				7.73	17540.90	0.4046	
m_{ref} (kg/s)	0.28				6.95	17531.63	0.4059	
	Path B	Path C	Path D	Path E	6.21	16727.20	0.4071	
$T_{water,in}$ (˚C)	7.81	7.70	7.69	7.76	4.26	9932.61	0.3581	
$T_{water,out}$ (˚C)	5.19	5.27	5.14	5.25	3.96	9858.38	0.3576	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.63	9659.23	0.3571	
	Pre-boiler				3.31	9330.18	0.3565	
$T_{water,in}$ (˚C)	11.34				3.01	8723.44	0.3561	
$T_{water,out}$ (˚C)	7.08							
m_{water} (kg/s)	1.33							
$T_{ref,in}$ (˚C)	-6.97							
$P_{ref,in}$ (kPa)	361.43							
$P_{ref,out}$ (kPa)	353.16							

Point ID	R-134a, P/D 1.5, 10 15 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.57	5.90	5.10	4.73	37.58	18245.73	0.7903	
T_1 (˚C)	7.27	5.72	5.03	4.70	35.15	19947.05	0.7899	
T_2 (˚C)	6.91	5.56	4.95	4.67	32.58	21054.54	0.7900	
T_3 (˚C)	6.63	5.41	4.87	4.64	30.00	22797.67	0.7905	
T_4 (˚C)	6.34	5.30	4.81	4.61	27.57	24554.21	0.7915	
T_5 (˚C)	6.09	5.18	4.77	4.59	19.71	19372.09	0.6816	
T_{out} (˚C)	5.88	5.09	4.72	4.57	17.76	19536.74	0.6794	
m_{water} (kg/s)	0.27				15.70	19469.74	0.6773	
$P_{water,in}$ (kPa)	716.23	N/A	N/A	339.21	13.63	18225.11	0.6754	
$P_{water,out}$ (kPa)	588.58	N/A	N/A	206.94	11.68	17265.74	0.6739	
P_{sat} (kPa)	340.09	341.15	339.98	340.99	9.41	19396.43	0.6045	9.92
$P_{bundle,in}$ (kPa)	340.79				8.57	19969.81	0.6050	
$P_{bundle,out}$ (kPa)	339.22				7.68	20536.01	0.6056	
m_{ref} (kg/s)	0.28				6.78	20286.25	0.6064	
	Path B	Path C	Path D	Path E	5.94	18879.07	0.6072	
$T_{water,in}$ (˚C)	7.66	7.56	7.56	7.62	4.07	10665.02	0.5586	
$T_{water,out}$ (˚C)	5.16	5.22	5.09	5.21	3.77	10598.53	0.5581	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.45	10391.39	0.5576	
	Pre-boiler				3.13	10062.54	0.5571	
$T_{water,in}$ (˚C)	18.67				2.83	9343.38	0.5566	
$T_{water,out}$ (˚C)	7.09							
m_{water} (kg/s)	0.65							
$T_{ref,in}$ (˚C)	2.06							
$P_{ref,in}$ (kPa)	367.08							
$P_{ref,out}$ (kPa)	355.81							

Point ID	R-134a, P/D 1.5, 10 30 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.13	7.69	5.92	5.15	76.84	17247.72	0.5855	
T_1 (˚C)	10.50	7.28	5.77	5.10	71.58	18578.05	0.5853	
T_2 (˚C)	9.77	6.93	5.61	5.04	65.99	19353.54	0.5861	
T_3 (˚C)	9.20	6.60	5.45	4.98	60.40	20409.86	0.5879	
T_4 (˚C)	8.62	6.32	5.33	4.92	55.14	21448.81	0.5905	
T_5 (˚C)	8.11	6.09	5.23	4.88	43.81	21660.61	0.3667	
T_{out} (˚C)	7.67	5.90	5.14	4.84	39.10	21926.91	0.3612	
m_{water} (kg/s)		0.27			34.09	21673.55	0.3560	
$P_{water,in}$ (kPa)	717.82	N/A	N/A	339.52	29.09	20477.49	0.3513	
$P_{water,out}$ (kPa)	589.84	N/A	N/A	206.71	24.38	18754.45	0.3474	
P_{sat} (kPa)	340.05	341.13	339.88	340.88	18.75	18806.19	0.2040	10.01
$P_{bundle,in}$ (kPa)		341.07			17.03	19266.71	0.2052	
$P_{bundle,out}$ (kPa)		339.02			15.20	19720.37	0.2068	
m_{ref} (kg/s)		0.29			13.37	19322.09	0.2086	
	Path B	**Path C**	**Path D**	**Path E**	11.64	18132.24	0.2104	
$T_{water,in}$ (˚C)	11.24	11.15	11.15	11.21	7.26	10321.86	0.1133	
$T_{water,out}$ (˚C)	6.04	6.16	5.98	6.08	6.80	10372.75	0.1126	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	6.31	10389.53	0.1118	
		Pre-boiler			5.82	10249.56	0.1110	
$T_{water,in}$ (˚C)		7.75			5.36	9938.16	0.1102	
$T_{water,out}$ (˚C)		6.17						
m_{water} (kg/s)		0.83						
$T_{ref,in}$ (˚C)		4.70						
$P_{ref,in}$ (kPa)		361.33						
$P_{ref,out}$ (kPa)		355.17						

Point ID	R-134a, P/D 1.5, 10 30 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	11.24	7.93	6.20	5.38	73.75	16779.69	0.8131	
T_1 (˚C)	10.62	7.54	6.04	5.31	68.71	18010.14	0.8129	
T_2 (˚C)	9.93	7.20	5.87	5.24	63.36	18666.73	0.8137	
T_3 (˚C)	9.38	6.87	5.70	5.17	58.01	19563.06	0.8155	
T_4 (˚C)	8.83	6.61	5.57	5.11	52.97	20468.53	0.8181	
T_5 (˚C)	8.34	6.37	5.47	5.07	42.22	20441.63	0.6020	
T_{out} (˚C)	7.91	6.19	5.37	5.02	37.89	20713.63	0.5971	
m_{water} (kg/s)		0.27			33.29	20592.29	0.5924	
$P_{water,in}$ (kPa)	716.24	N/A	N/A	340.77	28.69	19627.91	0.5883	
$P_{water,out}$ (kPa)	589.39	N/A	N/A	207.61	24.36	18270.84	0.5850	
P_{sat} (kPa)	343.09	344.12	342.96	344.04	19.99	20093.25	0.4463	10.14
$P_{bundle,in}$ (kPa)		343.86			18.16	20828.77	0.4475	
$P_{bundle,out}$ (kPa)		342.30			16.22	21571.78	0.4490	
m_{ref} (kg/s)		0.29			14.28	21416.36	0.4508	
	Path B	**Path C**	**Path D**	**Path E**	12.46	20374.49	0.4527	
$T_{water,in}$ (˚C)	11.34	11.25	11.25	11.32	8.55	13401.91	0.3581	
$T_{water,out}$ (˚C)	6.26	6.33	6.17	6.29	7.89	13510.95	0.3571	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	7.20	13560.35	0.3560	
		Pre-boiler			6.50	13337.33	0.3549	
$T_{water,in}$ (˚C)		17.95			5.85	12695.33	0.3538	
$T_{water,out}$ (˚C)		6.96						
m_{water} (kg/s)		0.49						
$T_{ref,in}$ (˚C)		-4.16						
$P_{ref,in}$ (kPa)		364.93						
$P_{ref,out}$ (kPa)		356.39						

Point ID	R-134a, P/D 1.5, 10 40 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	13.30	8.89	6.57	5.44	98.74	16570.17	0.7170	
T_1 (˚C)	12.47	8.37	6.35	5.36	91.65	17653.91	0.7159	
T_2 (˚C)	11.55	7.92	6.11	5.27	84.11	18189.72	0.7160	
T_3 (˚C)	10.82	7.49	5.88	5.18	76.58	18838.28	0.7175	
T_4 (˚C)	10.09	7.13	5.70	5.11	69.49	19428.66	0.7201	
T_5 (˚C)	9.44	6.82	5.57	5.05	55.73	19879.20	0.4333	
T_{out} (˚C)	8.88	6.56	5.44	5.00	50.19	20214.07	0.4275	
m_{water} (kg/s)	0.27				44.30	20150.26	0.4220	
$P_{water,in}$ (kPa)	716.47	N/A	N/A	340.91	38.41	19427.00	0.4173	
$P_{water,out}$ (kPa)	589.50	N/A	N/A	208.01	32.87	18263.70	0.4135	
P_{sat} (kPa)	340.67	341.65	340.49	341.60	27.58	20790.06	0.2294	10.18
$P_{bundle,in}$ (kPa)	341.54				24.91	21479.95	0.2309	
$P_{bundle,out}$ (kPa)	339.78				22.08	22071.63	0.2327	
m_{ref} (kg/s)	0.29				19.24	21609.65	0.2348	
	Path B	**Path C**	**Path D**	**Path E**	16.57	20223.73	0.2371	
$T_{water,in}$ (˚C)	13.42	13.34	13.33	13.40	10.70	12826.95	0.1127	
$T_{water,out}$ (˚C)	6.61	6.73	6.51	6.63	9.84	12781.18	0.1114	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	8.92	12663.16	0.1099	
	Pre-boiler				8.01	12238.06	0.1085	
$T_{water,in}$ (˚C)	13.79				7.15	11551.35	0.1071	
$T_{water,out}$ (˚C)	5.43							
m_{water} (kg/s)	0.25							
$T_{ref,in}$ (˚C)	-4.56							
$P_{ref,in}$ (kPa)	361.77							
$P_{ref,out}$ (kPa)	355.78							

Point ID	R-134a, P/D 1.5, 15 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.58	4.96	4.69	4.55	14.47	16731.34	0.1658	
T_1 (˚C)	5.47	4.90	4.65	4.54	13.45	18099.02	0.1654	
T_2 (˚C)	5.33	4.85	4.63	4.53	12.37	18552.52	0.1651	
T_3 (˚C)	5.22	4.78	4.60	4.52	11.28	19367.18	0.1649	
T_4 (˚C)	5.11	4.75	4.58	4.50	10.26	20015.94	0.1647	
T_5 (˚C)	5.01	4.71	4.56	4.50	7.00	12656.34	0.1391	
T_{out} (˚C)	4.94	4.67	4.54	4.49	6.37	12266.17	0.1385	
m_{water} (kg/s)	0.26				5.69	12107.16	0.1380	
$P_{water,in}$ (kPa)	682.37	N/A	N/A	328.34	5.02	11113.65	0.1375	
$P_{water,out}$ (kPa)	562.16	N/A	N/A	202.29	4.39	10208.84	0.1370	
P_{sat} (kPa)	339.93	340.90	339.58	340.41	3.46	11919.41	0.1200	14.94
$P_{bundle,in}$ (kPa)	340.90				3.26	12021.96	0.1201	
$P_{bundle,out}$ (kPa)	338.51				3.05	12173.65	0.1203	
m_{ref} (kg/s)	0.43				2.84	12305.37	0.1206	
	Path B	**Path C**	**Path D**	**Path E**	2.64	12340.53	0.1208	
$T_{water,in}$ (˚C)	5.65	5.55	5.55	5.61	1.56	5065.15	0.1078	
$T_{water,out}$ (˚C)	4.71	4.85	4.68	4.73	1.49	5049.86	0.1077	
m_{water} (kg/s)	0.32	0.38	0.33	0.33	1.42	4957.70	0.1076	
	Pre-boiler				1.35	4894.16	0.1075	
$T_{water,in}$ (˚C)	8.55				1.29	4675.49	0.1075	
$T_{water,out}$ (˚C)	6.68							
m_{water} (kg/s)	2.04							
$T_{ref,in}$ (˚C)	-8.26							
$P_{ref,in}$ (kPa)	363.56							
$P_{ref,out}$ (kPa)	355.53							

Point ID	R-134a, P/D 1.5, 15 5 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.68	5.03	4.76	4.64	15.67	20463.68	0.4131	
T_1 (˚C)	5.56	4.96	4.73	4.63	14.44	22428.90	0.4127	
T_2 (˚C)	5.41	4.91	4.70	4.62	13.13	23139.89	0.4122	
T_3 (˚C)	5.30	4.85	4.68	4.61	11.82	24500.21	0.4119	
T_4 (˚C)	5.18	4.81	4.66	4.60	10.59	25416.90	0.4116	
T_5 (˚C)	5.08	4.77	4.64	4.60	7.23	15585.59	0.3851	
T_{out} (˚C)	5.00	4.74	4.63	4.59	6.49	15026.63	0.3845	
m_{water} (kg/s)		0.26			5.70	14726.13	0.3839	
$P_{water,in}$ (kPa)	700.63	N/A	N/A	334.36	4.92	13205.43	0.3834	
$P_{water,out}$ (kPa)	575.85	N/A	N/A	206.32	4.18	11765.65	0.3829	
P_{sat} (kPa)	341.54	342.60	341.36	342.33	3.25	14244.06	0.3658	15.02
$P_{bundle,in}$ (kPa)		342.37			3.00	14274.05	0.3660	
$P_{bundle,out}$ (kPa)		340.45			2.74	13969.67	0.3662	
m_{ref} (kg/s)		0.43			2.48	13720.48	0.3664	
	Path B	**Path C**	**Path D**	**Path E**	2.23	13161.67	0.3666	
$T_{water,in}$ (˚C)	5.75	5.64	5.65	5.72	1.34	4963.25	0.3541	
$T_{water,out}$ (˚C)	4.82	4.91	4.75	4.84	1.28	4899.92	0.3540	
m_{water} (kg/s)	0.33	0.39	0.33	0.34	1.21	4752.00	0.3539	
		Pre-boiler			1.14	4635.71	0.3539	
$T_{water,in}$ (˚C)		20.60			1.08	4346.39	0.3538	
$T_{water,out}$ (˚C)		7.96						
m_{water} (kg/s)		0.68						
$T_{ref,in}$ (˚C)		-6.89						
$P_{ref,in}$ (kPa)		378.29						
$P_{ref,out}$ (kPa)		364.03						

Point ID	R-134a, P/D 1.5, 15 5 0.55							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.95	5.28	4.99	4.87	16.47	21018.47	0.6096	
T_1 (˚C)	5.83	5.21	4.96	4.86	15.26	23154.13	0.6092	
T_2 (˚C)	5.67	5.16	4.94	4.85	13.97	24230.76	0.6089	
T_3 (˚C)	5.56	5.09	4.92	4.84	12.69	26174.44	0.6088	
T_4 (˚C)	5.44	5.05	4.89	4.83	11.47	27513.15	0.6087	
T_5 (˚C)	5.34	5.01	4.88	4.83	7.90	17084.68	0.5801	
T_{out} (˚C)	5.26	4.98	4.86	4.82	7.08	16431.77	0.5795	
m_{water} (kg/s)		0.27			6.21	16196.68	0.5788	
$P_{water,in}$ (kPa)	742.37	N/A	N/A	350.33	5.34	14519.84	0.5782	
$P_{water,out}$ (kPa)	609.55	N/A	N/A	212.65	4.52	12886.96	0.5777	
P_{sat} (kPa)	344.42	345.49	344.33	345.37	3.56	15637.22	0.5599	14.92
$P_{bundle,in}$ (kPa)		345.08			3.27	15677.88	0.5601	
$P_{bundle,out}$ (kPa)		343.52			2.96	15247.34	0.5603	
m_{ref} (kg/s)		0.43			2.65	14871.51	0.5606	
	Path B	**Path C**	**Path D**	**Path E**	2.36	13902.92	0.5608	
$T_{water,in}$ (˚C)	6.04	5.92	5.93	6.00	1.44	5338.82	0.5483	
$T_{water,out}$ (˚C)	5.05	5.15	4.99	5.09	1.38	5326.11	0.5482	
m_{water} (kg/s)	0.34	0.40	0.34	0.35	1.31	5206.05	0.5481	
		Pre-boiler			1.25	5125.65	0.5481	
$T_{water,in}$ (˚C)		19.00			1.19	4856.59	0.5480	
$T_{water,out}$ (˚C)		9.88						
m_{water} (kg/s)		1.36						
$T_{ref,in}$ (˚C)		-6.69						
$P_{ref,in}$ (kPa)		392.84						
$P_{ref,out}$ (kPa)		373.72						

Point ID	R-134a, P/D 1.5, 15 5 0.70							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	6.07	5.43	5.16	5.05	15.36	21249.28	0.7440	
T_1 (˚C)	5.96	5.36	5.13	5.04	14.26	23641.54	0.7433	
T_2 (˚C)	5.81	5.31	5.11	5.03	13.08	24980.13	0.7427	
T_3 (˚C)	5.70	5.25	5.09	5.02	11.90	27378.50	0.7509	
T_4 (˚C)	5.58	5.22	5.07	5.01	10.79	29286.61	0.7509	
T_5 (˚C)	5.49	5.18	5.06	5.01	7.40	17746.86	0.7249	
T_{out} (˚C)	5.41	5.15	5.04	5.00	6.59	17019.01	0.7243	
m_{water} (kg/s)	0.27				5.72	16602.01	0.7152	
$P_{water,in}$ (kPa)	718.55	N/A	N/A	340.84	4.86	14557.29	0.7151	
$P_{water,out}$ (kPa)	589.11	N/A	N/A	209.22	4.04	12668.69	0.7150	
P_{sat} (kPa)	346.74	347.89	346.75	347.81	3.25	16383.75	0.6995	14.97
$P_{bundle,in}$ (kPa)	347.36				2.98	16538.02	0.6992	
$P_{bundle,out}$ (kPa)	346.02				2.70	16165.55	0.6990	
m_{ref} (kg/s)	0.43				2.42	15863.89	0.7076	
	Path B	**Path C**	**Path D**	**Path E**	2.16	14768.11	0.7078	
$T_{water,in}$ (˚C)	6.14	6.05	6.05	6.13	1.31	5265.71	0.6966	
$T_{water,out}$ (˚C)	5.24	5.33	5.16	5.26	1.25	5228.97	0.6965	
m_{water} (kg/s)	0.33	0.40	0.34	0.34	1.18	5080.64	0.6965	
	Pre-boiler				1.12	4977.93	0.6964	
$T_{water,in}$ (˚C)	19.95				1.06	4684.66	0.6963	
$T_{water,out}$ (˚C)	10.52							
m_{water} (kg/s)	1.50							
$T_{ref,in}$ (˚C)	2.76							
$P_{ref,in}$ (kPa)	403.27							
$P_{ref,out}$ (kPa)	380.33							

Point ID	R-134a, P/D 1.5, 15 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.74	5.86	5.08	4.74	44.35	21058.60	0.2644	
T_1 (˚C)	7.39	5.68	5.02	4.71	40.63	22915.35	0.2633	
T_2 (˚C)	6.96	5.52	4.95	4.68	36.69	23663.44	0.2623	
T_3 (˚C)	6.64	5.37	4.88	4.65	32.74	24715.22	0.2616	
T_4 (˚C)	6.32	5.25	4.82	4.62	29.02	25332.01	0.2612	
T_5 (˚C)	6.05	5.15	4.78	4.60	19.88	18898.37	0.1860	
T_{out} (˚C)	5.84	5.07	4.73	4.58	17.66	18519.72	0.1840	
m_{water} (kg/s)	0.27				15.30	17770.58	0.1821	
$P_{water,in}$ (kPa)	717.20	N/A	N/A	339.87	12.94	16231.96	0.1804	
$P_{water,out}$ (kPa)	589.32	N/A	N/A	208.21	10.72	14130.13	0.1789	
P_{sat} (kPa)	339.44	340.39	339.12	340.01	8.22	14171.47	0.1324	15.09
$P_{bundle,in}$ (kPa)	340.33				7.68	14595.74	0.1331	
$P_{bundle,out}$ (kPa)	338.15				7.11	15058.30	0.1339	
m_{ref} (kg/s)	0.43				6.53	15296.66	0.1348	
	Path B	**Path C**	**Path D**	**Path E**	5.99	15280.08	0.1358	
$T_{water,in}$ (˚C)	7.81	7.73	7.73	7.81	3.93	8507.21	0.1027	
$T_{water,out}$ (˚C)	5.23	5.34	5.17	5.25	3.72	8546.33	0.1025	
m_{water} (kg/s)	0.33	0.35	0.34	0.34	3.49	8508.37	0.1022	
	Pre-boiler				3.26	8431.83	0.1020	
$T_{water,in}$ (˚C)	13.42				3.04	8155.75	0.1017	
$T_{water,out}$ (˚C)	5.13							
m_{water} (kg/s)	0.44							
$T_{ref,in}$ (˚C)	-8.14							
$P_{ref,in}$ (kPa)	363.55							
$P_{ref,out}$ (kPa)	355.31							

Point ID	R-134a, P/D 1.5, 15 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.79	6.07	5.25	4.88	39.20	18723.67	0.5079	
T_1 (˚C)	7.47	5.88	5.18	4.85	36.52	20447.91	0.5076	
T_2 (˚C)	7.10	5.72	5.11	4.82	33.67	21472.60	0.5076	
T_3 (˚C)	6.81	5.56	5.03	4.79	30.81	23097.02	0.5079	
T_4 (˚C)	6.51	5.45	4.97	4.76	28.13	24635.81	0.5084	
T_5 (˚C)	6.25	5.33	4.93	4.74	20.01	19301.52	0.4337	
T_{out} (˚C)	6.04	5.24	4.87	4.72	18.00	19413.44	0.4321	
m_{water} (kg/s)	0.27				15.87	19246.98	0.4306	
$P_{water,in}$ (kPa)	717.26	N/A	N/A	340.36	13.74	17951.41	0.4293	
$P_{water,out}$ (kPa)	589.43	N/A	N/A	207.84	11.73	16871.90	0.4281	
P_{sat} (kPa)	341.85	342.89	341.72	342.76	9.26	18190.86	0.3814	14.96
$P_{bundle,in}$ (kPa)	342.61				8.47	18672.22	0.3819	
$P_{bundle,out}$ (kPa)	340.92				7.63	19208.02	0.3826	
m_{ref} (kg/s)	0.43				6.79	19049.74	0.3833	
	Path B	Path C	Path D	Path E	5.99	17889.43	0.3840	
$T_{water,in}$ (˚C)	7.89	7.78	7.78	7.84	4.11	10315.13	0.3518	
$T_{water,out}$ (˚C)	5.31	5.38	5.25	5.37	3.80	10219.46	0.3515	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.48	9983.00	0.3512	
	Pre-boiler				3.15	9623.62	0.3508	
$T_{water,in}$ (˚C)	15.98				2.85	8913.37	0.3505	
$T_{water,out}$ (˚C)	8.30							
m_{water} (kg/s)	1.08							
$T_{ref,in}$ (˚C)	-5.56							
$P_{ref,in}$ (kPa)	378.09							
$P_{ref,out}$ (kPa)	363.99							

Point ID	R-134a, P/D 1.5, 15 15 0.55							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	8.18	6.47	5.63	5.24	38.51	18035.71	0.6959	
T_1 (˚C)	7.87	6.28	5.55	5.21	36.05	19719.73	0.6959	
T_2 (˚C)	7.51	6.11	5.47	5.18	33.45	20849.11	0.6962	
T_3 (˚C)	7.22	5.95	5.39	5.15	30.84	22563.17	0.6968	
T_4 (˚C)	6.92	5.84	5.33	5.12	28.39	24357.76	0.6977	
T_5 (˚C)	6.66	5.71	5.29	5.10	20.51	19597.96	0.6229	
T_{out} (˚C)	6.44	5.62	5.23	5.08	18.47	19768.58	0.6214	
m_{water} (kg/s)	0.27				16.30	19712.37	0.6199	
$P_{water,in}$ (kPa)	716.77	N/A	N/A	339.47	14.13	18449.77	0.6187	
$P_{water,out}$ (kPa)	588.68	N/A	N/A	206.92	12.08	17424.32	0.6177	
P_{sat} (kPa)	346.42	347.53	346.39	347.46	9.92	20225.40	0.5718	15.00
$P_{bundle,in}$ (kPa)	347.01				8.98	20739.80	0.5723	
$P_{bundle,out}$ (kPa)	345.64				7.99	21182.73	0.5728	
m_{ref} (kg/s)	0.43				6.99	20713.56	0.5735	
	Path B	Path C	Path D	Path E	6.05	18914.29	0.5742	
$T_{water,in}$ (˚C)	8.27	8.17	8.17	8.24	4.13	10656.41	0.5436	
$T_{water,out}$ (˚C)	5.69	5.74	5.60	5.73	3.80	10517.93	0.5432	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.45	10207.78	0.5428	
	Pre-boiler				3.10	9744.55	0.5425	
$T_{water,in}$ (˚C)	17.86				2.77	8910.15	0.5421	
$T_{water,out}$ (˚C)	9.74							
m_{water} (kg/s)	1.34							
$T_{ref,in}$ (˚C)	3.89							
$P_{ref,in}$ (kPa)	395.25							
$P_{ref,out}$ (kPa)	375.54							

Point ID	R-134a, P/D 1.5, 15 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.26	7.75	5.98	5.21	78.90	17736.61	0.4304	
T_1 (˚C)	10.61	7.34	5.83	5.16	73.30	19126.04	0.4301	
T_2 (˚C)	9.86	6.99	5.67	5.10	67.35	19903.97	0.4304	
T_3 (˚C)	9.28	6.66	5.51	5.03	61.40	20937.05	0.4314	
T_4 (˚C)	8.69	6.39	5.39	4.98	55.81	21926.90	0.4330	
T_5 (˚C)	8.18	6.15	5.30	4.94	43.63	21686.29	0.2826	
T_{out} (˚C)	7.73	5.97	5.21	4.90	38.96	21967.23	0.2790	
m_{water} (kg/s)	0.27				33.99	21730.61	0.2755	
$P_{water,in}$ (kPa)	716.38	N/A	N/A	340.27	29.02	20558.26	0.2724	
$P_{water,out}$ (kPa)	589.10	N/A	N/A	207.45	24.34	18859.44	0.2699	
P_{sat} (kPa)	341.04	342.06	340.83	341.84	18.69	18903.74	0.1745	15.12
$P_{bundle,in}$ (kPa)	341.89				16.98	19361.21	0.1755	
$P_{bundle,out}$ (kPa)	339.98				15.15	19836.36	0.1767	
m_{ref} (kg/s)	0.43				13.33	19460.99	0.1780	
	Path B	**Path C**	**Path D**	**Path E**	11.62	18285.28	0.1794	
$T_{water,in}$ (˚C)	11.37	11.29	11.28	11.35	7.52	11025.47	0.1155	
$T_{water,out}$ (˚C)	6.12	6.22	6.05	6.15	7.02	11101.51	0.1150	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	6.50	11138.27	0.1144	
	Pre-boiler				5.97	11003.66	0.1139	
$T_{water,in}$ (˚C)	15.26				5.47	10647.00	0.1133	
$T_{water,out}$ (˚C)	6.34							
m_{water} (kg/s)	0.23							
$T_{ref,in}$ (˚C)	4.90							
$P_{ref,in}$ (kPa)	365.59							
$P_{ref,out}$ (kPa)	356.91							

Point ID	R-134a, P/D 1.5, 15 30 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.27	7.96	6.26	5.45	74.11	17221.31	0.6465	
T_1 (˚C)	10.65	7.58	6.10	5.38	68.97	18522.16	0.6464	
T_2 (˚C)	9.96	7.24	5.94	5.31	63.52	19239.29	0.6469	
T_3 (˚C)	9.41	6.93	5.77	5.24	58.06	20230.87	0.6481	
T_4 (˚C)	8.85	6.66	5.64	5.18	52.93	21189.52	0.6499	
T_5 (˚C)	8.36	6.44	5.54	5.14	41.26	20539.32	0.5057	
T_{out} (˚C)	7.94	6.25	5.44	5.10	37.06	20845.25	0.5026	
m_{water} (kg/s)	0.27				32.61	20775.10	0.4996	
$P_{water,in}$ (kPa)	716.58	N/A	N/A	340.51	28.15	19869.11	0.4970	
$P_{water,out}$ (kPa)	590.41	N/A	N/A	207.64	23.95	18585.64	0.4949	
P_{sat} (kPa)	344.47	345.52	344.41	345.50	19.84	20861.15	0.4043	15.15
$P_{bundle,in}$ (kPa)	345.18				18.02	21694.02	0.4053	
$P_{bundle,out}$ (kPa)	343.67				16.08	22635.02	0.4065	
m_{ref} (kg/s)	0.43				14.14	22566.23	0.4078	
	Path B	**Path C**	**Path D**	**Path E**	12.31	21499.08	0.4092	
$T_{water,in}$ (˚C)	11.38	11.29	11.29	11.36	8.65	14544.88	0.3487	
$T_{water,out}$ (˚C)	6.32	6.38	6.22	6.35	7.94	14645.41	0.3479	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	7.18	14666.76	0.3471	
	Pre-boiler				6.42	14374.06	0.3463	
$T_{water,in}$ (˚C)	15.87				5.71	13489.93	0.3455	
$T_{water,out}$ (˚C)	8.70							
m_{water} (kg/s)	1.10							
$T_{ref,in}$ (˚C)	-2.99							
$P_{ref,in}$ (kPa)	380.54							
$P_{ref,out}$ (kPa)	366.63							

Point ID	**R-134a, P/D 1.5, 15 45 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	14.51	9.56	7.05	5.81	112.27	17302.70	0.5630	
T_1 (˚C)	13.56	9.00	6.80	5.72	103.54	18401.71	0.5611	
T_2 (˚C)	12.51	8.51	6.55	5.62	94.27	18860.07	0.5601	
T_3 (˚C)	11.68	8.06	6.30	5.52	85.00	19327.05	0.5601	
T_4 (˚C)	10.88	7.66	6.10	5.44	76.27	19683.63	0.5611	
T_5 (˚C)	10.17	7.33	5.95	5.38	59.90	19706.67	0.3467	
T_{out} (˚C)	9.55	7.04	5.81	5.32	54.04	20076.95	0.3426	
m_{water} (kg/s)		0.27			47.82	20080.16	0.3389	
$P_{water,in}$ (kPa)	716.81	N/A	N/A	340.26	41.59	19476.06	0.3357	
$P_{water,out}$ (kPa)	589.30	N/A	N/A	207.74	35.74	18433.20	0.3332	
P_{sat} (kPa)	344.40	345.37	344.21	345.36	30.31	21448.25	0.1970	15.08
$P_{bundle,in}$ (kPa)		345.23			27.34	22205.27	0.1980	
$P_{bundle,out}$ (kPa)		343.46			24.18	22897.98	0.1994	
m_{ref} (kg/s)		0.43			21.03	22444.23	0.2009	
	Path B	**Path C**	**Path D**	**Path E**	18.06	21024.21	0.2027	
$T_{water,in}$ (˚C)	14.63	14.55	14.54	14.61	11.92	13938.67	0.1108	
$T_{water,out}$ (˚C)	7.10	7.22	7.00	7.12	10.92	13929.13	0.1097	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	9.87	13852.40	0.1086	
		Pre-boiler			8.81	13407.89	0.1075	
$T_{water,in}$ (˚C)		12.05			7.82	12634.29	0.1064	
$T_{water,out}$ (˚C)		6.22						
m_{water} (kg/s)		0.53						
$T_{ref,in}$ (˚C)		-3.67						
$P_{ref,in}$ (kPa)		368.30						
$P_{ref,out}$ (kPa)		360.26						

Point ID	**R-134a, P/D 1.5, 20 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.64	5.03	4.76	4.63	14.00	16893.61	0.1454	
T_1 (˚C)	5.53	4.97	4.73	4.63	13.03	18341.30	0.1452	
T_2 (˚C)	5.39	4.92	4.71	4.61	12.00	18944.63	0.1451	
T_3 (˚C)	5.29	4.85	4.69	4.60	10.97	19937.52	0.1450	
T_4 (˚C)	5.18	4.81	4.66	4.59	10.00	20791.66	0.1450	
T_5 (˚C)	5.08	4.78	4.64	4.59	7.05	13592.65	0.1265	
T_{out} (˚C)	5.01	4.75	4.62	4.58	6.32	12956.69	0.1261	
m_{water} (kg/s)		0.26			5.56	12561.52	0.1256	
$P_{water,in}$ (kPa)	671.45	N/A	N/A	323.54	4.79	11468.26	0.1252	
$P_{water,out}$ (kPa)	552.54	N/A	N/A	200.25	4.07	9949.71	0.1248	
P_{sat} (kPa)	341.12	342.10	340.79	341.66	3.31	12185.87	0.1127	20.14
$P_{bundle,in}$ (kPa)		342.10			3.10	12233.46	0.1128	
$P_{bundle,out}$ (kPa)		339.74			2.88	12303.82	0.1130	
m_{ref} (kg/s)		0.58			2.66	12357.06	0.1132	
	Path B	**Path C**	**Path D**	**Path E**	2.46	12280.96	0.1134	
$T_{water,in}$ (˚C)	5.70	5.61	5.62	5.67	1.46	4969.93	0.1043	
$T_{water,out}$ (˚C)	4.80	4.91	4.75	4.81	1.40	4929.06	0.1042	
m_{water} (kg/s)	0.32	0.38	0.32	0.33	1.33	4816.20	0.1042	
		Pre-boiler			1.26	4731.11	0.1041	
$T_{water,in}$ (˚C)		18.91			1.19	4480.65	0.1041	
$T_{water,out}$ (˚C)		5.30						
m_{water} (kg/s)		0.37						
$T_{ref,in}$ (˚C)		-8.10						
$P_{ref,in}$ (kPa)		370.46						
$P_{ref,out}$ (kPa)		359.73						

Point ID	**R-134a, P/D 1.5, 20 5 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.60	4.95	4.68	4.57	15.62	21349.05	0.3963	
T_1 (˚C)	5.48	4.88	4.65	4.56	14.37	23523.55	0.3959	
T_2 (˚C)	5.32	4.83	4.63	4.55	13.04	24336.48	0.3956	
T_3 (˚C)	5.21	4.77	4.61	4.54	11.71	25919.78	0.3953	
T_4 (˚C)	5.09	4.73	4.59	4.53	10.46	26902.65	0.3951	
T_5 (˚C)	5.00	4.70	4.57	4.53	7.14	16269.44	0.3754	
T_{out} (˚C)	4.92	4.66	4.56	4.52	6.39	15647.50	0.3750	
m_{water} (kg/s)		0.26			5.60	15390.96	0.3746	
$P_{water,in}$ (kPa)	698.71	N/A	N/A	333.89	4.81	13740.10	0.3742	
$P_{water,out}$ (kPa)	575.09	N/A	N/A	206.24	4.07	12157.07	0.3738	
P_{sat} (kPa)	340.88	341.99	340.73	341.71	3.19	15542.63	0.3615	19.88
$P_{bundle,in}$ (kPa)		341.60			2.93	15540.79	0.3616	
$P_{bundle,out}$ (kPa)		339.85			2.66	15143.48	0.3617	
m_{ref} (kg/s)		0.57			2.38	14808.05	0.3618	
	Path B	**Path C**	**Path D**	**Path E**	2.13	14057.89	0.3620	
$T_{water,in}$ (˚C)	5.66	5.56	5.56	5.63	1.28	4978.51	0.3531	
$T_{water,out}$ (˚C)	4.74	4.83	4.67	4.76	1.22	4943.34	0.3531	
m_{water} (kg/s)	0.32	0.39	0.33	0.34	1.16	4819.32	0.3530	
		Pre-boiler			1.10	4736.82	0.3530	
$T_{water,in}$ (˚C)		19.02			1.05	4464.50	0.3529	
$T_{water,out}$ (˚C)		9.90						
m_{water} (kg/s)		1.19						
$T_{ref,in}$ (˚C)		-4.30						
$P_{ref,in}$ (kPa)		396.65						
$P_{ref,out}$ (kPa)		375.93						

Point ID	**R-134a, P/D 1.5, 20 5 0.55**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	6.05	5.40	5.13	5.02	15.55	21437.06	0.5836	
T_1 (˚C)	5.93	5.33	5.10	5.01	14.40	23786.46	0.5835	
T_2 (˚C)	5.78	5.29	5.08	5.00	13.18	25090.54	0.5833	
T_3 (˚C)	5.67	5.22	5.06	5.00	11.96	27368.66	0.5832	
T_4 (˚C)	5.55	5.19	5.04	4.99	10.82	29063.05	0.5832	
T_5 (˚C)	5.46	5.15	5.03	4.99	7.37	17357.95	0.5635	
T_{out} (˚C)	5.38	5.12	5.01	4.98	6.57	16584.05	0.5630	
m_{water} (kg/s)		0.27			5.73	16268.95	0.5626	
$P_{water,in}$ (kPa)	717.01	N/A	N/A	340.93	4.88	14367.12	0.5621	
$P_{water,out}$ (kPa)	588.78	N/A	N/A	208.75	4.09	12572.76	0.5618	
P_{sat} (kPa)	346.47	347.56	346.45	347.55	3.22	15430.42	0.5500	20.00
$P_{bundle,in}$ (kPa)		347.09			2.96	15454.56	0.5502	
$P_{bundle,out}$ (kPa)		345.65			2.67	14943.97	0.5504	
m_{ref} (kg/s)		0.57			2.39	14488.94	0.5506	
	Path B	**Path C**	**Path D**	**Path E**	2.12	13437.69	0.5508	
$T_{water,in}$ (˚C)	6.13	6.02	6.03	6.10	1.26	4869.61	0.5430	
$T_{water,out}$ (˚C)	5.20	5.30	5.13	5.23	1.21	4868.52	0.5430	
m_{water} (kg/s)	0.33	0.40	0.34	0.34	1.16	4762.60	0.5429	
		Pre-boiler			1.11	4706.77	0.5429	
$T_{water,in}$ (˚C)		19.01			1.06	4479.40	0.5428	
$T_{water,out}$ (˚C)		12.16						
m_{water} (kg/s)		2.24						
$T_{ref,in}$ (˚C)		-0.27						
$P_{ref,in}$ (kPa)		423.15						
$P_{ref,out}$ (kPa)		394.00						

Point ID	R-134a, P/D 1.5, 20 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²,˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.65	5.85	5.09	4.74	42.08	20347.48	0.2238	
T_1 (˚C)	7.31	5.67	5.02	4.72	38.70	22129.60	0.2230	
T_2 (˚C)	6.91	5.52	4.95	4.68	35.11	22927.78	0.2222	
T_3 (˚C)	6.61	5.37	4.88	4.65	31.52	24109.23	0.2217	
T_4 (˚C)	6.30	5.27	4.82	4.62	28.15	24871.61	0.2214	
T_5 (˚C)	6.04	5.16	4.78	4.61	18.99	18045.23	0.1657	
T_{out} (˚C)	5.83	5.07	4.73	4.58	17.04	17930.54	0.1645	
m_{water} (kg/s)	0.27				14.97	17520.89	0.1634	
$P_{water,in}$ (kPa)	722.49	N/A	N/A	344.03	12.90	16021.52	0.1624	
$P_{water,out}$ (kPa)	595.97	N/A	N/A	211.70	10.95	14821.93	0.1615	
P_{sat} (kPa)	339.69	340.64	339.37	340.29	8.34	14872.72	0.1266	19.83
$P_{bundle,in}$ (kPa)	340.51				7.74	15211.22	0.1271	
$P_{bundle,out}$ (kPa)	338.43				7.09	15609.32	0.1276	
m_{ref} (kg/s)	0.57				6.45	15672.64	0.1282	
	Path B	**Path C**	**Path D**	**Path E**	5.84	15201.29	0.1288	
$T_{water,in}$ (˚C)	7.74	7.63	7.63	7.69	3.96	8852.60	0.1042	
$T_{water,out}$ (˚C)	5.18	5.29	5.16	5.23	3.71	8819.43	0.1040	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.45	8708.66	0.1038	
	Pre-boiler				3.19	8529.79	0.1035	
$T_{water,in}$ (˚C)	15.27				2.95	8116.44	0.1033	
$T_{water,out}$ (˚C)	5.57							
m_{water} (kg/s)	0.49							
$T_{ref,in}$ (˚C)	-7.41							
$P_{ref,in}$ (kPa)	368.67							
$P_{ref,out}$ (kPa)	358.05							

Point ID	R-134a, P/D 1.5, 20 15 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²,˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.83	6.15	5.35	4.98	38.31	18732.83	0.4665	
T_1 (˚C)	7.53	5.96	5.28	4.96	35.73	20503.90	0.4663	
T_2 (˚C)	7.16	5.81	5.20	4.92	32.99	21618.34	0.4663	
T_3 (˚C)	6.88	5.65	5.12	4.89	30.25	23346.12	0.4666	
T_4 (˚C)	6.58	5.54	5.06	4.87	27.67	25026.17	0.4670	
T_5 (˚C)	6.33	5.42	5.02	4.85	19.63	19496.06	0.4121	
T_{out} (˚C)	6.12	5.34	4.97	4.83	17.67	19622.36	0.4110	
m_{water} (kg/s)	0.27				15.58	19510.23	0.4100	
$P_{water,in}$ (kPa)	717.26	N/A	N/A	340.16	13.50	18228.22	0.4091	
$P_{water,out}$ (kPa)	589.57	N/A	N/A	207.17	11.53	17160.45	0.4084	
P_{sat} (kPa)	343.34	344.42	343.29	344.34	9.34	19390.75	0.3747	19.92
$P_{bundle,in}$ (kPa)	344.02				8.47	19790.29	0.3751	
$P_{bundle,out}$ (kPa)	342.54				7.54	20173.80	0.3755	
m_{ref} (kg/s)	0.57				6.62	19679.32	0.3760	
	Path B	**Path C**	**Path D**	**Path E**	5.75	17976.93	0.3765	
$T_{water,in}$ (˚C)	7.93	7.82	7.82	7.89	3.92	10119.47	0.3540	
$T_{water,out}$ (˚C)	5.41	5.47	5.34	5.46	3.62	9988.36	0.3537	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.30	9706.41	0.3535	
	Pre-boiler				2.98	9296.34	0.3532	
$T_{water,in}$ (˚C)	16.72				2.68	8546.06	0.3530	
$T_{water,out}$ (˚C)	10.10							
m_{water} (kg/s)	1.45							
$T_{ref,in}$ (˚C)	2.93							
$P_{ref,in}$ (kPa)	399.54							
$P_{ref,out}$ (kPa)	378.24							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.18	7.67	5.94	5.20	79.18	18197.50	0.3392	
T_1 (˚C)	10.53	7.28	5.80	5.14	73.44	19653.90	0.3388	
T_2 (˚C)	9.78	6.93	5.64	5.08	67.33	20457.36	0.3389	
T_3 (˚C)	9.20	6.61	5.49	5.02	61.22	21522.60	0.3395	
T_4 (˚C)	8.61	6.34	5.37	4.96	55.47	22525.62	0.3405	
T_5 (˚C)	8.10	6.11	5.28	4.92	42.81	21906.65	0.2281	
T_{out} (˚C)	7.66	5.93	5.19	4.88	38.19	22178.66	0.2254	
m_{water} (kg/s)	0.27				33.27	21919.22	0.2228	
$P_{water,in}$ (kPa)	716.88	N/A	N/A	340.37	28.36	20690.45	0.2206	
$P_{water,out}$ (kPa)	589.40	N/A	N/A	207.93	23.73	18919.20	0.2187	
P_{sat} (kPa)	341.09	342.11	340.91	341.90	18.28	19070.22	0.1481	20.07
$P_{bundle,in}$ (kPa)	341.93				16.60	19536.93	0.1488	
$P_{bundle,out}$ (kPa)	340.07				14.82	20045.67	0.1497	
m_{ref} (kg/s)	0.57				13.04	19675.55	0.1506	
	Path B	Path C	Path D	Path E	11.36	18511.02	0.1517	
$T_{water,in}$ (˚C)	11.28	11.20	11.19	11.26	7.48	11351.95	0.1043	
$T_{water,out}$ (˚C)	6.09	6.18	6.02	6.12	6.97	11428.92	0.1039	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	6.43	11460.98	0.1035	
	Pre-boiler				5.90	11317.05	0.1031	
$T_{water,in}$ (˚C)	9.58				5.39	10909.71	0.1027	
$T_{water,out}$ (˚C)	7.16							
m_{water} (kg/s)	1.24							
$T_{ref,in}$ (˚C)	2.26							
$P_{ref,in}$ (kPa)	370.45							
$P_{ref,out}$ (kPa)	359.51							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	14.52	9.54	7.04	5.82	113.36	17558.67	0.4348	
T_1 (˚C)	13.57	8.98	6.79	5.72	104.41	18684.50	0.4332	
T_2 (˚C)	12.50	8.50	6.54	5.62	94.90	19136.84	0.4323	
T_3 (˚C)	11.67	8.04	6.29	5.52	85.39	19588.47	0.4322	
T_4 (˚C)	10.86	7.65	6.10	5.44	76.43	19911.83	0.4328	
T_5 (˚C)	10.15	7.31	5.95	5.38	59.75	19826.21	0.2737	
T_{out} (˚C)	9.53	7.03	5.81	5.32	53.90	20210.27	0.2707	
m_{water} (kg/s)	0.27				47.68	20228.80	0.2679	
$P_{water,in}$ (kPa)	715.87	N/A	N/A	340.64	41.46	19627.02	0.2656	
$P_{water,out}$ (kPa)	589.20	N/A	N/A	207.59	35.61	18582.84	0.2638	
P_{sat} (kPa)	344.53	345.52	344.38	345.53	30.00	21410.79	0.1630	20.37
$P_{bundle,in}$ (kPa)	345.36				27.05	22139.24	0.1639	
$P_{bundle,out}$ (kPa)	343.68				23.92	22801.55	0.1649	
m_{ref} (kg/s)	0.58				20.78	22304.05	0.1661	
	Path B	Path C	Path D	Path E	17.83	20856.17	0.1674	
$T_{water,in}$ (˚C)	14.64	14.57	14.55	14.62	11.94	14041.16	0.1000	
$T_{water,out}$ (˚C)	7.10	7.21	7.00	7.12	10.96	14070.46	0.0992	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	9.91	14045.09	0.0984	
	Pre-boiler				8.86	13658.47	0.0975	
$T_{water,in}$ (˚C)	9.95				7.88	12914.28	0.0968	
$T_{water,out}$ (˚C)	7.27							
m_{water} (kg/s)	1.38							
$T_{ref,in}$ (˚C)	-2.05							
$P_{ref,in}$ (kPa)	373.33							
$P_{ref,out}$ (kPa)	362.73							

Point ID	**R-134a, P/D 1.5, 25 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.74	5.11	4.84	4.70	15.03	18489.59	0.1391	
T_1 (˚C)	5.63	5.05	4.81	4.70	13.88	20000.23	0.1388	
T_2 (˚C)	5.48	5.00	4.78	4.69	12.66	20409.91	0.1386	
T_3 (˚C)	5.37	4.93	4.76	4.68	11.44	21240.70	0.1384	
T_4 (˚C)	5.26	4.90	4.73	4.67	10.29	21728.14	0.1383	
T_5 (˚C)	5.16	4.86	4.71	4.66	7.09	13706.52	0.1226	
T_{out} (˚C)	5.09	4.82	4.70	4.65	6.43	13285.35	0.1223	
m_{water} (kg/s)	0.26				5.73	13071.66	0.1219	
$P_{water,in}$ (kPa)	699.53	N/A	N/A	334.24	5.02	11967.58	0.1216	
$P_{water,out}$ (kPa)	574.75	N/A	N/A	205.78	4.36	10942.71	0.1214	
P_{sat} (kPa)	342.05	343.03	341.76	342.72	3.39	12692.24	0.1110	24.87
$P_{bundle,in}$ (kPa)	342.99				3.18	12890.31	0.1111	
$P_{bundle,out}$ (kPa)	340.71				2.97	12938.84	0.1113	
m_{ref} (kg/s)	0.71				2.75	13117.82	0.1114	
	Path B	**Path C**	**Path D**	**Path E**	2.55	13080.14	0.1115	
$T_{water,in}$ (˚C)	5.82	5.71	5.71	5.78	1.48	5143.18	0.1038	
$T_{water,out}$ (˚C)	4.87	4.99	4.83	4.91	1.42	5119.30	0.1037	
m_{water} (kg/s)	0.33	0.39	0.33	0.34	1.35	5017.64	0.1037	
	Pre-boiler				1.29	4946.55	0.1036	
$T_{water,in}$ (˚C)	21.66				1.22	4703.95	0.1036	
$T_{water,out}$ (˚C)	5.64							
m_{water} (kg/s)	0.38							
$T_{ref,in}$ (˚C)	-7.58							
$P_{ref,in}$ (kPa)	378.71							
$P_{ref,out}$ (kPa)	364.75							

Point ID	**R-134a, P/D 1.5, 25 5 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	5.85	5.21	4.94	4.83	15.61	21624.59	0.3821	
T_1 (˚C)	5.73	5.14	4.91	4.82	14.34	23859.45	0.3818	
T_2 (˚C)	5.58	5.09	4.89	4.81	13.00	24675.92	0.3815	
T_3 (˚C)	5.47	5.03	4.87	4.81	11.66	26281.45	0.3813	
T_4 (˚C)	5.35	4.99	4.85	4.80	10.39	27159.24	0.3812	
T_5 (˚C)	5.26	4.96	4.83	4.80	7.11	16465.73	0.3657	
T_{out} (˚C)	5.18	4.92	4.82	4.79	6.35	15739.31	0.3654	
m_{water} (kg/s)	0.26				5.55	15450.63	0.3650	
$P_{water,in}$ (kPa)	700.46	N/A	N/A	334.15	4.75	13682.09	0.3647	
$P_{water,out}$ (kPa)	576.09	N/A	N/A	205.95	3.99	12011.91	0.3645	
P_{sat} (kPa)	344.04	345.23	343.99	345.01	3.17	15421.95	0.3550	25.00
$P_{bundle,in}$ (kPa)	344.88				2.90	15320.06	0.3551	
$P_{bundle,out}$ (kPa)	343.15				2.61	14745.91	0.3552	
m_{ref} (kg/s)	0.71				2.32	14184.60	0.3553	
	Path B	**Path C**	**Path D**	**Path E**	2.05	13240.97	0.3554	
$T_{water,in}$ (˚C)	5.92	5.81	5.82	5.89	1.21	4542.58	0.3488	
$T_{water,out}$ (˚C)	5.01	5.09	4.93	5.02	1.16	4528.52	0.3488	
m_{water} (kg/s)	0.32	0.39	0.33	0.34	1.11	4421.95	0.3488	
	Pre-boiler				1.06	4360.51	0.3487	
$T_{water,in}$ (˚C)	17.95				1.01	4138.62	0.3487	
$T_{water,out}$ (˚C)	12.32							
m_{water} (kg/s)	2.35							
$T_{ref,in}$ (˚C)	-2.58							
$P_{ref,in}$ (kPa)	422.62							
$P_{ref,out}$ (kPa)	394.37							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.64	5.86	5.09	4.75	41.61	20176.75	0.2019	
T_1 (˚C)	7.31	5.68	5.03	4.72	38.34	21985.28	0.2013	
T_2 (˚C)	6.92	5.53	4.96	4.68	34.87	22842.99	0.2009	
T_3 (˚C)	6.61	5.38	4.89	4.65	31.39	24127.88	0.2006	
T_4 (˚C)	6.30	5.28	4.83	4.62	28.13	25062.74	0.2006	
T_5 (˚C)	6.04	5.16	4.78	4.60	19.08	18230.98	0.1561	
T_{out} (˚C)	5.83	5.08	4.74	4.58	17.12	18137.72	0.1551	
m_{water} (kg/s)		0.27			15.03	17726.97	0.1541	
$P_{water,in}$ (kPa)	718.10	N/A	N/A	340.53	12.95	16252.14	0.1533	
$P_{water,out}$ (kPa)	590.47	N/A	N/A	207.88	10.99	15013.80	0.1526	
P_{sat} (kPa)	339.76	340.76	339.50	340.46	8.48	15410.97	0.1250	24.90
$P_{bundle,in}$ (kPa)		340.58			7.87	15794.74	0.1254	
$P_{bundle,out}$ (kPa)		338.53			7.21	16299.73	0.1259	
m_{ref} (kg/s)		0.71			6.56	16432.97	0.1264	
	Path B	**Path C**	**Path D**	**Path E**	5.94	16031.82	0.1269	
$T_{water,in}$ (˚C)	7.73	7.63	7.63	7.68	4.08	9331.12	0.1077	
$T_{water,out}$ (˚C)	5.18	5.27	5.14	5.22	3.82	9315.20	0.1075	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.55	9214.36	0.1073	
		Pre-boiler			3.27	9029.32	0.1071	
$T_{water,in}$ (˚C)		20.84			3.01	8580.55	0.1070	
$T_{water,out}$ (˚C)		5.74						
m_{water} (kg/s)		0.39						
$T_{ref,in}$ (˚C)		-6.61						
$P_{ref,in}$ (kPa)		376.67						
$P_{ref,out}$ (kPa)		362.77						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	7.93	6.30	5.53	5.17	37.24	19013.91	0.4332	
T_1 (˚C)	7.64	6.11	5.45	5.14	34.72	20858.83	0.4330	
T_2 (˚C)	7.28	5.97	5.38	5.11	32.04	22059.28	0.4331	
T_3 (˚C)	7.00	5.82	5.30	5.08	29.36	23890.01	0.4333	
T_4 (˚C)	6.71	5.71	5.25	5.06	26.84	25645.35	0.4337	
T_5 (˚C)	6.47	5.60	5.21	5.04	18.94	19859.07	0.3915	
T_{out} (˚C)	6.27	5.51	5.16	5.02	17.06	19986.42	0.3907	
m_{water} (kg/s)		0.27			15.05	20009.57	0.3899	
$P_{water,in}$ (kPa)	716.83	N/A	N/A	339.68	13.05	18691.21	0.3892	
$P_{water,out}$ (kPa)	589.60	N/A	N/A	207.11	11.16	17691.21	0.3887	
P_{sat} (kPa)	345.86	347.01	345.89	346.93	9.10	20600.47	0.3632	25.01
$P_{bundle,in}$ (kPa)		346.57			8.24	21161.17	0.3635	
$P_{bundle,out}$ (kPa)		345.14			7.33	21692.83	0.3639	
m_{ref} (kg/s)		0.71			6.41	21218.50	0.3643	
	Path B	**Path C**	**Path D**	**Path E**	5.56	19304.82	0.3647	
$T_{water,in}$ (˚C)	8.03	7.92	7.92	7.99	3.72	10314.01	0.3481	
$T_{water,out}$ (˚C)	5.59	5.65	5.51	5.63	3.43	10171.76	0.3479	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.13	9856.25	0.3477	
		Pre-boiler			2.82	9420.06	0.3475	
$T_{water,in}$ (˚C)		16.65			2.53	8623.23	0.3473	
$T_{water,out}$ (˚C)		12.11						
m_{water} (kg/s)		2.58						
$T_{ref,in}$ (˚C)		3.81						
$P_{ref,in}$ (kPa)		424.39						
$P_{ref,out}$ (kPa)		395.62						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.23	7.76	6.06	5.30	78.47	18276.03	0.3050	
T_1 (˚C)	10.58	7.37	5.91	5.24	72.73	19733.46	0.3046	
T_2 (˚C)	9.84	7.03	5.76	5.18	66.63	20530.19	0.3046	
T_3 (˚C)	9.26	6.71	5.60	5.12	60.54	21587.45	0.3051	
T_4 (˚C)	8.68	6.45	5.48	5.06	54.80	22569.84	0.3059	
T_5 (˚C)	8.18	6.22	5.38	5.02	42.00	21699.23	0.2166	
T_{out} (˚C)	7.74	6.04	5.29	4.98	37.50	21960.78	0.2145	
m_{water} (kg/s)	0.27				32.72	21726.46	0.2126	
$P_{water,in}$ (kPa)	717.26	N/A	N/A	340.06	27.93	20541.54	0.2108	
$P_{water,out}$ (kPa)	589.97	N/A	N/A	207.58	23.43	18845.65	0.2094	
P_{sat} (kPa)	342.65	343.69	342.50	343.49	18.49	19758.85	0.1536	25.10
$P_{bundle,in}$ (kPa)	343.46				16.79	20332.30	0.1541	
$P_{bundle,out}$ (kPa)	341.67				14.98	21009.43	0.1548	
m_{ref} (kg/s)	0.72				13.17	20726.07	0.1556	
	Path B	Path C	Path D	Path E	11.47	19561.78	0.1564	
$T_{water,in}$ (˚C)	11.34	11.25	11.24	11.31	7.75	12392.47	0.1190	
$T_{water,out}$ (˚C)	6.19	6.27	6.10	6.22	7.19	12469.53	0.1186	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	6.59	12495.95	0.1182	
	Pre-boiler				5.99	12322.52	0.1178	
$T_{water,in}$ (˚C)	13.48				5.42	11777.81	0.1175	
$T_{water,out}$ (˚C)	7.63							
m_{water} (kg/s)	0.82							
$T_{ref,in}$ (˚C)	0.23							
$P_{ref,in}$ (kPa)	381.12							
$P_{ref,out}$ (kPa)	366.14							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.54	4.92	4.66	4.54	14.46	18975.94	0.1305	
T_1 (˚C)	5.43	4.86	4.63	4.53	13.33	20634.32	0.1303	
T_2 (˚C)	5.28	4.81	4.60	4.52	12.14	21183.78	0.1302	
T_3 (˚C)	5.17	4.74	4.58	4.51	10.94	22211.34	0.1300	
T_4 (˚C)	5.06	4.71	4.56	4.50	9.82	22818.07	0.1299	
T_5 (˚C)	4.97	4.67	4.54	4.50	6.80	14197.24	0.1193	
T_{out} (˚C)	4.90	4.64	4.53	4.49	6.13	13679.72	0.1190	
m_{water} (kg/s)	0.26				5.41	13434.96	0.1188	
$P_{water,in}$ (kPa)	670.96	N/A	N/A	323.11	4.69	12098.59	0.1186	
$P_{water,out}$ (kPa)	553.25	N/A	N/A	200.77	4.02	10862.94	0.1184	
P_{sat} (kPa)	340.25	341.26	340.02	341.01	3.12	12860.61	0.1115	34.83
$P_{bundle,in}$ (kPa)	341.14				2.90	12886.48	0.1115	
$P_{bundle,out}$ (kPa)	339.02				2.67	12721.18	0.1116	
m_{ref} (kg/s)	1.00				2.44	12655.81	0.1117	
	Path B	Path C	Path D	Path E	2.22	12315.11	0.1118	
$T_{water,in}$ (˚C)	5.62	5.50	5.51	5.57	1.28	4577.14	0.1067	
$T_{water,out}$ (˚C)	4.70	4.80	4.64	4.73	1.22	4521.30	0.1067	
m_{water} (kg/s)	0.32	0.38	0.32	0.33	1.16	4386.67	0.1067	
	Pre-boiler				1.09	4280.56	0.1067	
$T_{water,in}$ (˚C)	20.70				1.03	4023.05	0.1066	
$T_{water,out}$ (˚C)	6.98							
m_{water} (kg/s)	0.62							
$T_{ref,in}$ (˚C)	-7.16							
$P_{ref,in}$ (kPa)	395.87							
$P_{ref,out}$ (kPa)	374.77							

Point ID	R-134a, P/D 1.5, 35 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.74	5.99	5.22	4.88	41.27	20365.37	0.1677	
T_1 (˚C)	7.42	5.81	5.16	4.85	37.99	22190.92	0.1673	
T_2 (˚C)	7.03	5.66	5.09	4.82	34.51	23071.36	0.1669	
T_3 (˚C)	6.73	5.51	5.02	4.79	31.03	24350.40	0.1667	
T_4 (˚C)	6.42	5.41	4.96	4.76	27.75	25273.89	0.1667	
T_5 (˚C)	6.16	5.29	4.91	4.74	18.84	18404.28	0.1355	
T_{out} (˚C)	5.96	5.21	4.87	4.72	16.92	18364.72	0.1349	
m_{water} (kg/s)	0.27				14.89	18027.84	0.1342	
$P_{water,in}$ (kPa)	717.34	N/A	N/A	340.14	12.85	16592.32	0.1337	
$P_{water,out}$ (kPa)	590.92	N/A	N/A	207.46	10.93	15418.11	0.1332	
P_{sat} (kPa)	341.61	342.61	341.35	342.29	8.58	16426.68	0.1141	35.17
$P_{bundle,in}$ (kPa)	342.39				7.92	16802.85	0.1144	
$P_{bundle,out}$ (kPa)	340.39				7.21	17322.56	0.1147	
m_{ref} (kg/s)	1.01				6.50	17362.07	0.1150	
	Path B	Path C	Path D	Path E	5.83	16750.88	0.1153	
$T_{water,in}$ (˚C)	7.83	7.73	7.73	7.79	4.00	9616.39	0.1021	
$T_{water,out}$ (˚C)	5.30	5.39	5.25	5.34	3.74	9606.80	0.1020	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.46	9499.96	0.1019	
	Pre-boiler				3.18	9308.42	0.1018	
$T_{water,in}$ (˚C)	19.03				2.92	8812.01	0.1017	
$T_{water,out}$ (˚C)	7.18							
m_{water} (kg/s)	0.68							
$T_{ref,in}$ (˚C)	-6.06							
$P_{ref,in}$ (kPa)	396.02							
$P_{ref,out}$ (kPa)	375.24							

Point ID	R-134a, P/D 1.5, 35 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	11.24	7.86	6.20	5.45	75.84	17944.01	0.2402	
T_1 (˚C)	10.61	7.48	6.06	5.40	70.51	19397.71	0.2401	
T_2 (˚C)	9.90	7.15	5.90	5.33	64.86	20255.43	0.2403	
T_3 (˚C)	9.34	6.84	5.75	5.27	59.20	21429.92	0.2407	
T_4 (˚C)	8.77	6.59	5.62	5.21	53.87	22564.17	0.2414	
T_5 (˚C)	8.27	6.37	5.53	5.17	40.93	21292.42	0.1785	
T_{out} (˚C)	7.85	6.19	5.45	5.13	36.57	21527.38	0.1770	
m_{water} (kg/s)	0.27				31.93	21274.68	0.1756	
$P_{water,in}$ (kPa)	716.62	N/A	N/A	340.35	27.30	20105.40	0.1744	
$P_{water,out}$ (kPa)	589.13	N/A	N/A	207.09	22.94	18457.63	0.1735	
P_{sat} (kPa)	344.73	345.75	344.58	345.61	18.48	19829.68	0.1344	34.93
$P_{bundle,in}$ (kPa)	345.50				16.74	20379.78	0.1348	
$P_{bundle,out}$ (kPa)	343.72				14.90	20970.10	0.1353	
m_{ref} (kg/s)	1.00				13.05	20577.30	0.1359	
	Path B	Path C	Path D	Path E	11.31	19254.51	0.1365	
$T_{water,in}$ (˚C)	11.34	11.25	11.25	11.32	7.77	12509.96	0.1106	
$T_{water,out}$ (˚C)	6.31	6.38	6.21	6.33	7.17	12534.67	0.1103	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	6.54	12493.09	0.1100	
	Pre-boiler				5.91	12218.31	0.1097	
$T_{water,in}$ (˚C)	15.54				5.31	11546.02	0.1094	
$T_{water,out}$ (˚C)	9.17							
m_{water} (kg/s)	1.25							
$T_{ref,in}$ (˚C)	-4.72							
$P_{ref,in}$ (kPa)	400.52							
$P_{ref,out}$ (kPa)	379.61							

Point ID	R-134a, P/D 1.5, 45 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.56	4.96	4.71	4.60	13.78	19423.52	0.1171	
T_1 (˚C)	5.44	4.89	4.68	4.59	12.67	21179.70	0.1169	
T_2 (˚C)	5.30	4.85	4.66	4.58	11.50	21776.97	0.1168	
T_3 (˚C)	5.20	4.79	4.64	4.57	10.32	22875.40	0.1167	
T_4 (˚C)	5.09	4.76	4.62	4.56	9.22	23495.20	0.1166	
T_5 (˚C)	5.00	4.72	4.60	4.56	6.27	14307.86	0.1089	
T_{out} (˚C)	4.93	4.69	4.59	4.55	5.64	13748.11	0.1087	
m_{water} (kg/s)		0.25			4.96	13532.76	0.1085	
$P_{water,in}$ (kPa)	644.32	N/A	N/A	313.31	4.29	12134.60	0.1084	
$P_{water,out}$ (kPa)	531.02	N/A	N/A	196.06	3.66	10857.20	0.1082	
P_{sat} (kPa)	341.28	342.32	341.05	341.94	2.81	13322.45	0.1033	44.92
$P_{bundle,in}$ (kPa)		342.14			2.61	13349.41	0.1034	
$P_{bundle,out}$ (kPa)		339.97			2.39	13141.67	0.1034	
m_{ref} (kg/s)		1.28			2.18	13086.22	0.1035	
	Path B	Path C	Path D	Path E	1.98	12687.67	0.1035	
$T_{water,in}$ (˚C)	5.63	5.52	5.53	5.59	1.15	4488.49	0.0999	
$T_{water,out}$ (˚C)	4.76	4.86	4.70	4.79	1.11	4474.85	0.0999	
m_{water} (kg/s)	0.31	0.37	0.31	0.32	1.06	4389.38	0.0999	
		Pre-boiler			1.01	4346.60	0.0998	
$T_{water,in}$ (˚C)		19.59			0.97	4129.34	0.0998	
$T_{water,out}$ (˚C)		8.77						
m_{water} (kg/s)		0.96						
$T_{ref,in}$ (˚C)		-6.36						
$P_{ref,in}$ (kPa)		416.43						
$P_{ref,out}$ (kPa)		388.69						

Point ID	R-134a, P/D 1.5, 45 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	7.77	6.02	5.26	4.91	41.12	20572.57	0.1496	
T_1 (˚C)	7.44	5.84	5.19	4.89	37.82	22426.92	0.1493	
T_2 (˚C)	7.05	5.69	5.12	4.86	34.32	23322.66	0.1490	
T_3 (˚C)	6.75	5.55	5.05	4.82	30.82	24595.39	0.1488	
T_4 (˚C)	6.45	5.45	4.99	4.80	27.52	25502.14	0.1487	
T_5 (˚C)	6.19	5.33	4.95	4.78	18.59	18442.46	0.1245	
T_{out} (˚C)	5.99	5.25	4.90	4.76	16.73	18440.66	0.1240	
m_{water} (kg/s)		0.27			14.74	18136.03	0.1235	
$P_{water,in}$ (kPa)	716.84	N/A	N/A	340.22	12.76	16795.08	0.1232	
$P_{water,out}$ (kPa)	590.02	N/A	N/A	207.70	10.90	15693.87	0.1228	
P_{sat} (kPa)	342.24	343.31	342.06	343.01	8.72	17380.65	0.1081	45.02
$P_{bundle,in}$ (kPa)		343.04			8.00	17715.39	0.1082	
$P_{bundle,out}$ (kPa)		341.07			7.23	18181.16	0.1085	
m_{ref} (kg/s)		1.29			6.46	18070.06	0.1087	
	Path B	Path C	Path D	Path E	5.73	17163.08	0.1090	
$T_{water,in}$ (˚C)	7.85	7.76	7.76	7.81	3.90	9572.72	0.0989	
$T_{water,out}$ (˚C)	5.34	5.42	5.28	5.37	3.64	9516.82	0.0988	
m_{water} (kg/s)	0.33	0.34	0.34	0.34	3.36	9363.12	0.0987	
		Pre-boiler			3.08	9115.89	0.0986	
$T_{water,in}$ (˚C)		16.01			2.81	8557.46	0.0985	
$T_{water,out}$ (˚C)		9.82						
m_{water} (kg/s)		1.62						
$T_{ref,in}$ (˚C)		-5.72						
$P_{ref,in}$ (kPa)		417.43						
$P_{ref,out}$ (kPa)		389.39						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	5.80	5.21	4.97	4.86	13.67	19995.49	0.1110	
T_1 (˚C)	5.69	5.15	4.94	4.86	12.54	21827.68	0.1109	
T_2 (˚C)	5.55	5.10	4.92	4.85	11.34	22385.06	0.1108	
T_3 (˚C)	5.45	5.05	4.90	4.84	10.14	23503.96	0.1107	
T_4 (˚C)	5.34	5.02	4.88	4.83	9.01	23968.59	0.1106	
T_5 (˚C)	5.25	4.98	4.87	4.83	6.09	14360.10	0.1045	
T_{out} (˚C)	5.18	4.95	4.85	4.82	5.47	13730.90	0.1044	
m_{water} (kg/s)	0.25				4.81	13475.90	0.1042	
$P_{water,in}$ (kPa)	644.56	N/A	N/A	313.20	4.15	12016.49	0.1041	
$P_{water,out}$ (kPa)	531.13	N/A	N/A	195.92	3.52	10696.21	0.1040	
P_{sat} (kPa)	344.50	345.56	344.31	345.25	2.73	13333.09	0.1002	54.81
$P_{bundle,in}$ (kPa)	345.45				2.53	13291.05	0.1002	
$P_{bundle,out}$ (kPa)	343.33				2.31	12957.64	0.1003	
m_{ref} (kg/s)	1.57				2.09	12764.37	0.1003	
	Path B	**Path C**	**Path D**	**Path E**	1.88	12200.89	0.1004	
$T_{water,in}$ (˚C)	5.88	5.77	5.78	5.84	1.07	4190.93	0.0976	
$T_{water,out}$ (˚C)	5.03	5.12	4.96	5.05	1.03	4168.77	0.0976	
m_{water} (kg/s)	0.31	0.37	0.31	0.32	0.99	4071.50	0.0976	
	Pre-boiler				0.94	4013.40	0.0976	
$T_{water,in}$ (˚C)	17.43				0.90	3800.83	0.0976	
$T_{water,out}$ (˚C)	11.84							
m_{water} (kg/s)	2.18							
$T_{ref,in}$ (˚C)	-5.55							
$P_{ref,in}$ (kPa)	444.38							
$P_{ref,out}$ (kPa)	408.53							

Point ID	R-123, P/D 1.167, 15 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.48	15.74	14.97	14.67	40.81	17606.78	0.5342	
T_1 (˚C)	17.14	15.59	14.91	14.67	37.91	18504.45	0.5285	
T_2 (˚C)	16.81	15.42	14.86	14.66	34.82	19592.51	0.5226	
T_3 (˚C)	16.48	15.24	14.80	14.66	31.73	20591.16	0.5171	
T_4 (˚C)	16.19	15.15	14.76	14.65	28.82	21556.58	0.5134	
T_5 (˚C)	15.93	15.04	14.73	14.65	20.08	18417.96	0.2689	
T_{out} (˚C)	15.72	14.96	14.70	14.64	17.93	18535.28	0.2679	
m_{water} (kg/s)	0.28				15.65	18743.21	0.2677	
$P_{water,in}$ (kPa)	752.97	N/A	N/A	343.85	13.37	17072.83	0.2675	
$P_{water,out}$ (kPa)	614.27	N/A	N/A	200.79	11.22	15612.81	0.2675	
P_{sat} (kPa)	60.39	60.33	59.90	59.76	7.18	14784.07	0.1154	14.96
$P_{bundle,in}$ (kPa)	60.64				6.44	14404.71	0.1128	
$P_{bundle,out}$ (kPa)	62.35				5.65	13964.70	0.1099	
m_{ref} (kg/s)	0.14				4.86	12712.39	0.1071	
	Path B	**Path C**	**Path D**	**Path E**	4.12	11188.26	0.1044	
$T_{water,in}$ (˚C)	17.53	17.51	17.58	17.53	0.00	0.00	0.0897	
$T_{water,out}$ (˚C)	15.07	15.22	15.13	15.09	0.00	0.00	0.0897	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.0897	
	Pre-boiler				0.00	0.00	0.0897	
$T_{water,in}$ (˚C)	21.26				0.00	0.00	0.0897	
$T_{water,out}$ (˚C)	20.57							
m_{water} (kg/s)	1.57							
$T_{ref,in}$ (˚C)	-1.29							
$P_{ref,in}$ (kPa)	78.67							
$P_{ref,out}$ (kPa)	73.12							

Point ID	R-123, P/D 1.167, 15 15 0.30							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.88	16.18	15.39	15.06	39.73	17012.45	0.7715	
T_1 (˚C)	17.55	16.04	15.32	15.06	36.96	17866.25	0.7698	
T_2 (˚C)	17.23	15.86	15.26	15.04	34.01	18817.25	0.7689	
T_3 (˚C)	16.91	15.68	15.20	15.03	31.06	19734.26	0.7690	
T_4 (˚C)	16.62	15.58	15.15	15.01	28.29	20673.89	0.7699	
T_5 (˚C)	16.36	15.47	15.12	15.01	20.38	17997.14	0.5455	
T_{out} (˚C)	16.16	15.39	15.08	15.00	18.28	18316.75	0.5411	
m_{water} (kg/s)	0.28				16.06	18656.45	0.5369	
$P_{water,in}$ (kPa)	750.63	N/A	N/A	342.77	13.83	17212.51	0.5333	
$P_{water,out}$ (kPa)	610.86	N/A	N/A	196.69	11.73	15958.04	0.5304	
P_{sat} (kPa)	61.28	61.29	60.90	60.79	8.39	17236.57	0.3934	15.96
$P_{bundle,in}$ (kPa)	61.43				7.44	16796.74	0.3943	
$P_{bundle,out}$ (kPa)	63.43				6.43	16043.55	0.3954	
m_{ref} (kg/s)	0.15				5.42	14523.51	0.3968	
	Path B	**Path C**	**Path D**	**Path E**	4.48	12379.85	0.3983	
$T_{water,in}$ (˚C)	17.93	17.92	17.99	17.94	1.90	5403.31	0.3114	
$T_{water,out}$ (˚C)	15.46	15.58	15.52	15.49	1.80	5305.49	0.3110	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	1.69	5152.48	0.3107	
	Pre-boiler				1.58	4979.89	0.3103	
$T_{water,in}$ (˚C)	28.38				1.48	4656.64	0.3100	
$T_{water,out}$ (˚C)	20.33							
m_{water} (kg/s)	0.34							
$T_{ref,in}$ (˚C)	-6.33							
$P_{ref,in}$ (kPa)	77.47							
$P_{ref,out}$ (kPa)	71.19							

Point ID	R-123, P/D 1.167, 20 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.72	15.85	15.02	14.71	43.44	17724.34	0.5239	
T_1 (˚C)	17.35	15.69	14.96	14.70	40.36	18652.65	0.5220	
T_2 (˚C)	17.00	15.51	14.90	14.69	37.09	19796.76	0.5210	
T_3 (˚C)	16.65	15.32	14.84	14.68	33.81	20849.02	0.5208	
T_4 (˚C)	16.34	15.22	14.80	14.67	30.73	21900.91	0.5215	
T_5 (˚C)	16.06	15.10	14.76	14.67	21.60	19068.55	0.3240	
T_{out} (˚C)	15.84	15.02	14.73	14.66	19.28	19238.51	0.3198	
m_{water} (kg/s)		0.28			16.83	19582.80	0.3158	
$P_{water,in}$ (kPa)	752.60	N/A	N/A	343.94	14.37	17928.03	0.3123	
$P_{water,out}$ (kPa)	613.97	N/A	N/A	201.97	12.05	16442.13	0.3096	
P_{sat} (kPa)	60.46	60.41	59.97	59.82	7.86	16081.64	0.1870	19.96
$P_{bundle,in}$ (kPa)		60.64			7.02	15728.01	0.1878	
$P_{bundle,out}$ (kPa)		62.41			6.13	15297.18	0.1888	
m_{ref} (kg/s)		0.19			5.23	13886.31	0.1900	
	Path B	**Path C**	**Path D**	**Path E**	4.39	12125.95	0.1914	
$T_{water,in}$ (˚C)	17.76	17.75	17.82	17.77	0.00	0.00	0.1092	
$T_{water,out}$ (˚C)	15.13	15.27	15.19	15.15	0.00	0.00	0.1092	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.1092	
		Pre-boiler			0.00	0.00	0.1092	
$T_{water,in}$ (˚C)		21.04			0.00	0.00	0.1092	
$T_{water,out}$ (˚C)		20.39						
m_{water} (kg/s)		2.44						
$T_{ref,in}$ (˚C)		-1.35						
$P_{ref,in}$ (kPa)		77.63						
$P_{ref,out}$ (kPa)		71.50						

Point ID	R-123, P/D 1.167, 20 15 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	18.00	16.14	15.30	14.94	43.18	17313.69	0.7501	
T_1 (˚C)	17.62	15.99	15.23	14.93	40.14	18134.02	0.7485	
T_2 (˚C)	17.29	15.80	15.16	14.91	36.91	19219.03	0.7477	
T_3 (˚C)	16.93	15.60	15.09	14.89	33.68	20113.30	0.7478	
T_4 (˚C)	16.63	15.50	15.04	14.87	30.64	21125.01	0.7487	
T_5 (˚C)	16.35	15.38	15.01	14.86	22.04	18587.33	0.5557	
T_{out} (˚C)	16.12	15.29	14.97	14.85	19.67	18925.86	0.5518	
m_{water} (kg/s)		0.28			17.16	19246.12	0.5482	
$P_{water,in}$ (kPa)	750.18	N/A	N/A	341.82	14.64	17535.24	0.5451	
$P_{water,out}$ (kPa)	611.46	N/A	N/A	197.41	12.28	15999.07	0.5426	
P_{sat} (kPa)	60.90	60.95	60.56	60.42	9.15	17910.09	0.4248	20.49
$P_{bundle,in}$ (kPa)		61.04			8.06	17437.09	0.4253	
$P_{bundle,out}$ (kPa)		63.11			6.90	16763.13	0.4260	
m_{ref} (kg/s)		0.20			5.73	14740.84	0.4269	
	Path B	**Path C**	**Path D**	**Path E**	4.64	12318.76	0.4279	
$T_{water,in}$ (˚C)	18.05	18.05	18.11	18.06	2.55	7121.03	0.3518	
$T_{water,out}$ (˚C)	15.37	15.47	15.41	15.40	2.43	7128.01	0.3515	
m_{water} (kg/s)	0.34	0.32	0.34	0.35	2.30	7101.48	0.3511	
		Pre-boiler			2.18	7091.17	0.3508	
$T_{water,in}$ (˚C)		29.99			2.05	6774.58	0.3505	
$T_{water,out}$ (˚C)		28.55						
m_{water} (kg/s)		2.64						
$T_{ref,in}$ (˚C)		-6.37						
$P_{ref,in}$ (kPa)		85.41						
$P_{ref,out}$ (kPa)		77.42						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.48	15.68	14.88	14.58	42.05	17830.47	0.3720	
T_1 (˚C)	17.13	15.52	14.82	14.58	39.06	18773.02	0.3684	
T_2 (˚C)	16.79	15.36	14.77	14.57	35.88	19929.47	0.3648	
T_3 (˚C)	16.45	15.17	14.71	14.56	32.70	21002.93	0.3618	
T_4 (˚C)	16.15	15.07	14.67	14.55	29.70	22071.46	0.3595	
T_5 (˚C)	15.88	14.96	14.64	14.55	20.81	19176.35	0.2085	
T_{out} (˚C)	15.67	14.88	14.60	14.54	18.57	19345.14	0.2083	
m_{water} (kg/s)	0.28				16.19	19679.99	0.2083	
$P_{water,in}$ (kPa)	752.05	N/A	N/A	342.18	13.81	17973.18	0.2085	
$P_{water,out}$ (kPa)	614.53	N/A	N/A	199.99	11.57	16471.51	0.2089	
P_{sat} (kPa)	60.22	60.17	59.72	59.57	7.48	16392.50	0.1170	25.07
$P_{bundle,in}$ (kPa)	60.41				6.68	16059.81	0.1153	
$P_{bundle,out}$ (kPa)	62.13				5.83	15651.43	0.1134	
m_{ref} (kg/s)	0.24				4.98	14235.70	0.1116	
	Path B	**Path C**	**Path D**	**Path E**	4.19	12448.27	0.1099	
$T_{water,in}$ (˚C)	17.53	17.52	17.59	17.54	0.00	0.00	0.1010	
$T_{water,out}$ (˚C)	14.99	15.14	15.06	15.02	0.00	0.00	0.1010	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.1010	
	Pre-boiler				0.00	0.00	0.1010	
$T_{water,in}$ (˚C)	21.55				0.00	0.00	0.1010	
$T_{water,out}$ (˚C)	20.76							
m_{water} (kg/s)	2.44							
$T_{ref,in}$ (˚C)	-1.53							
$P_{ref,in}$ (kPa)	78.87							
$P_{ref,out}$ (kPa)	72.46							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.66	15.99	15.24	14.94	39.05	17308.19	0.6039	
T_1 (˚C)	17.32	15.85	15.18	14.93	36.32	18142.71	0.6003	
T_2 (˚C)	17.02	15.68	15.12	14.91	33.42	19246.55	0.5970	
T_3 (˚C)	16.70	15.51	15.06	14.90	30.52	20221.85	0.5942	
T_4 (˚C)	16.42	15.41	15.02	14.89	27.79	21250.85	0.5918	
T_5 (˚C)	16.16	15.31	14.99	14.88	19.56	18310.26	0.4509	
T_{out} (˚C)	15.97	15.24	14.96	14.87	17.46	18586.03	0.4507	
m_{water} (kg/s)	0.28				15.23	18848.19	0.4507	
$P_{water,in}$ (kPa)	749.83	N/A	N/A	340.66	13.00	17109.06	0.4508	
$P_{water,out}$ (kPa)	611.66	N/A	N/A	195.81	10.90	15591.58	0.4512	
P_{sat} (kPa)	61.01	61.06	60.63	60.46	7.82	17369.47	0.3638	25.23
$P_{bundle,in}$ (kPa)	61.15				6.89	16833.05	0.3619	
$P_{bundle,out}$ (kPa)	63.12				5.90	16131.07	0.3598	
m_{ref} (kg/s)	0.24				4.92	14163.73	0.3577	
	Path B	**Path C**	**Path D**	**Path E**	3.99	11795.12	0.3557	
$T_{water,in}$ (˚C)	17.70	17.69	17.76	17.71	0.00	0.00	0.3472	
$T_{water,out}$ (˚C)	15.33	15.44	15.37	15.35	0.00	0.00	0.3472	
m_{water} (kg/s)	0.34	0.32	0.34	0.35	0.00	0.00	0.3472	
	Pre-boiler				0.00	0.00	0.3472	
$T_{water,in}$ (˚C)	28.59				0.00	0.00	0.3472	
$T_{water,out}$ (˚C)	26.78							
m_{water} (kg/s)	2.63							
$T_{ref,in}$ (˚C)	-6.91							
$P_{ref,in}$ (kPa)	93.74							
$P_{ref,out}$ (kPa)	83.11							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	19.32	16.87	15.65	15.13	55.62	16139.31	0.7959	
T_1 (˚C)	18.86	16.64	15.54	15.09	52.29	17112.57	0.7970	
T_2 (˚C)	18.41	16.37	15.44	15.05	48.75	18318.94	0.7991	
T_3 (˚C)	17.95	16.10	15.34	15.02	45.21	19522.42	0.8021	
T_4 (˚C)	17.54	15.93	15.26	14.98	41.88	20998.76	0.8058	
T_5 (˚C)	17.15	15.77	15.20	14.97	31.62	19692.92	0.5905	
T_{out} (˚C)	16.85	15.65	15.14	14.94	28.21	20115.80	0.5852	
m_{water} (kg/s)	0.28				24.58	20572.98	0.5800	
$P_{water,in}$ (kPa)	750.32	N/A	N/A	342.97	20.96	19114.64	0.5754	
$P_{water,out}$ (kPa)	612.31	N/A	N/A	197.51	17.54	17487.47	0.5715	
P_{sat} (kPa)	60.99	61.06	60.69	60.58	12.95	18342.08	0.4384	25.07
$P_{bundle,in}$ (kPa)	61.10				11.67	18457.00	0.4398	
$P_{bundle,out}$ (kPa)	63.27				10.32	18507.62	0.4416	
m_{ref} (kg/s)	0.24				8.97	17711.52	0.4436	
	Path B	**Path C**	**Path D**	**Path E**	7.69	16298.26	0.4456	
$T_{water,in}$ (˚C)	19.37	19.37	19.43	19.38	5.00	11363.24	0.3595	
$T_{water,out}$ (˚C)	15.74	15.79	15.75	15.76	4.56	11166.98	0.3586	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	4.09	10786.63	0.3576	
	Pre-boiler				3.62	10241.66	0.3566	
$T_{water,in}$ (˚C)	38.67				3.18	9187.15	0.3556	
$T_{water,out}$ (˚C)	24.83							
m_{water} (kg/s)	0.34							
$T_{ref,in}$ (˚C)	-6.71							
$P_{ref,in}$ (kPa)	93.96							
$P_{ref,out}$ (kPa)	83.30							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.26	17.90	16.15	15.38	74.00	15336.80	0.7216	
T_1 (˚C)	20.64	17.56	16.00	15.34	70.34	16330.44	0.7254	
T_2 (˚C)	20.06	17.19	15.85	15.28	66.45	17808.28	0.7308	
T_3 (˚C)	19.41	16.80	15.69	15.23	62.56	19305.99	0.7378	
T_4 (˚C)	18.85	16.55	15.58	15.18	58.90	21218.62	0.7457	
T_5 (˚C)	18.32	16.33	15.49	15.15	45.08	20692.33	0.4397	
T_{out} (˚C)	17.89	16.15	15.40	15.12	40.20	21136.50	0.4321	
m_{water} (kg/s)	0.28				35.02	21771.29	0.4249	
$P_{water,in}$ (kPa)	751.60	N/A	N/A	344.62	29.84	20532.43	0.4186	
$P_{water,out}$ (kPa)	613.60	N/A	N/A	199.29	24.96	18912.62	0.4132	
P_{sat} (kPa)	61.27	61.32	60.94	60.83	18.97	20014.21	0.2247	24.99
$P_{bundle,in}$ (kPa)	61.35				17.15	20611.30	0.2265	
$P_{bundle,out}$ (kPa)	63.51				15.21	21398.76	0.2288	
m_{ref} (kg/s)	0.24				13.28	20957.91	0.2314	
	Path B	**Path C**	**Path D**	**Path E**	11.46	19890.64	0.2341	
$T_{water,in}$ (˚C)	21.34	21.33	21.38	21.34	6.75	12691.72	0.1105	
$T_{water,out}$ (˚C)	16.28	16.28	16.24	16.32	6.16	12587.59	0.1093	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	5.54	12360.77	0.1079	
	Pre-boiler				4.91	11885.93	0.1066	
$T_{water,in}$ (˚C)	21.96				4.32	10860.92	0.1053	
$T_{water,out}$ (˚C)	21.07							
m_{water} (kg/s)	2.61							
$T_{ref,in}$ (˚C)	-9.23							
$P_{ref,in}$ (kPa)	79.68							
$P_{ref,out}$ (kPa)	73.46							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	17.72	15.80	14.95	14.63	44.48	17694.67	0.3077	
T_1 (˚C)	17.34	15.63	14.89	14.62	41.36	18645.42	0.3051	
T_2 (˚C)	16.99	15.45	14.82	14.61	38.06	19827.35	0.3027	
T_3 (˚C)	16.62	15.26	14.76	14.60	34.75	20937.07	0.3006	
T_4 (˚C)	16.30	15.15	14.72	14.59	31.64	22079.93	0.2991	
T_5 (˚C)	16.02	15.03	14.68	14.59	22.27	19673.69	0.1839	
T_{out} (˚C)	15.79	14.95	14.65	14.58	19.86	19891.16	0.1836	
m_{water} (kg/s)	0.28				17.29	20303.98	0.1834	
$P_{water,in}$ (kPa)	752.69	N/A	N/A	343.67	14.73	18560.19	0.1833	
$P_{water,out}$ (kPa)	613.69	N/A	N/A	200.81	12.31	17020.34	0.1834	
P_{sat} (kPa)	60.27	60.26	59.80	59.60	8.09	17340.04	0.1127	35.14
$P_{bundle,in}$ (kPa)	60.44				7.23	17107.66	0.1114	
$P_{bundle,out}$ (kPa)	62.19				6.32	16842.14	0.1100	
m_{ref} (kg/s)	0.34				5.40	15438.81	0.1086	
	Path B	**Path C**	**Path D**	**Path E**	4.54	13575.15	0.1073	
$T_{water,in}$ (˚C)	17.77	17.76	17.82	17.78	0.00	0.00	0.1004	
$T_{water,out}$ (˚C)	15.06	15.20	15.13	15.09	0.00	0.00	0.1004	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.1004	
	Pre-boiler				0.00	0.00	0.1004	
$T_{water,in}$ (˚C)	23.27				0.00	0.00	0.1004	
$T_{water,out}$ (˚C)	22.36							
m_{water} (kg/s)	2.62							
$T_{ref,in}$ (˚C)	2.30							
$P_{ref,in}$ (kPa)	83.93							
$P_{ref,out}$ (kPa)	76.31							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	18.47	16.44	15.52	15.12	47.10	17060.33	0.6055	
T_1 (˚C)	18.08	16.27	15.44	15.11	43.91	17942.74	0.6050	
T_2 (˚C)	17.70	16.06	15.36	15.08	40.53	19110.69	0.6049	
T_3 (˚C)	17.31	15.84	15.28	15.06	37.14	20162.70	0.6054	
T_4 (˚C)	16.97	15.73	15.23	15.03	33.96	21354.43	0.6065	
T_5 (˚C)	16.66	15.60	15.19	15.02	24.28	18979.87	0.4822	
T_{out} (˚C)	16.42	15.51	15.15	15.00	21.63	19291.92	0.4794	
m_{water} (kg/s)	0.28				18.82	19609.81	0.4769	
$P_{water,in}$ (kPa)	748.79	N/A	N/A	340.02	16.02	17907.12	0.4747	
$P_{water,out}$ (kPa)	610.44	N/A	N/A	193.02	13.37	16277.85	0.4729	
P_{sat} (kPa)	61.29	61.35	60.91	60.71	9.77	17904.75	0.3972	35.19
$P_{bundle,in}$ (kPa)	61.42				8.68	17686.29	0.3977	
$P_{bundle,out}$ (kPa)	63.40				7.53	17358.13	0.3984	
m_{ref} (kg/s)	0.34				6.38	15706.43	0.3991	
	Path B	**Path C**	**Path D**	**Path E**	5.29	13634.84	0.4000	
$T_{water,in}$ (˚C)	18.53	18.52	18.58	18.54	3.20	8720.13	0.3509	
$T_{water,out}$ (˚C)	15.58	15.69	15.63	15.61	3.01	8689.17	0.3506	
m_{water} (kg/s)	0.34	0.32	0.34	0.35	2.80	8595.50	0.3503	
	Pre-boiler				2.59	8500.53	0.3500	
$T_{water,in}$ (˚C)	34.62				2.39	7979.96	0.3497	
$T_{water,out}$ (˚C)	32.12							
m_{water} (kg/s)	2.65							
$T_{ref,in}$ (˚C)	-7.05							
$P_{ref,in}$ (kPa)	113.38							
$P_{ref,out}$ (kPa)	99.03							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.92	17.35	15.63	14.86	81.48	16857.37	0.5672	
T_1 (˚C)	20.23	17.01	15.48	14.82	76.16	17798.34	0.5675	
T_2 (˚C)	19.58	16.65	15.33	14.77	70.51	19012.79	0.5689	
T_3 (˚C)	18.90	16.26	15.17	14.71	64.86	20166.83	0.5715	
T_4 (˚C)	18.31	16.02	15.06	14.67	59.54	21503.26	0.5750	
T_5 (˚C)	17.77	15.80	14.97	14.65	44.40	20534.66	0.3476	
T_{out} (˚C)	17.33	15.62	14.88	14.62	39.61	20951.37	0.3423	
m_{water} (kg/s)		0.28			34.52	21570.83	0.3372	
$P_{water,in}$ (kPa)	750.27	N/A	N/A	344.31	29.43	20299.76	0.3327	
$P_{water,out}$ (kPa)	613.88	N/A	N/A	198.09	24.64	18682.88	0.3290	
P_{sat} (kPa)	60.04	60.09	59.67	59.47	18.68	20008.22	0.1895	34.77
$P_{bundle,in}$ (kPa)		60.14			16.90	20631.43	0.1911	
$P_{bundle,out}$ (kPa)		62.18			15.02	21464.28	0.1930	
m_{ref} (kg/s)		0.33			13.13	21070.05	0.1951	
	Path B	**Path C**	**Path D**	**Path E**	11.35	20055.13	0.1974	
$T_{water,in}$ (˚C)	20.99	20.98	21.04	20.99	6.56	12454.47	0.1056	
$T_{water,out}$ (˚C)	15.69	15.80	15.76	15.72	5.96	12237.00	0.1047	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	5.31	11859.24	0.1037	
		Pre-boiler			4.67	11226.02	0.1027	
$T_{water,in}$ (˚C)		23.07			4.06	10069.92	0.1018	
$T_{water,out}$ (˚C)		22.07						
m_{water} (kg/s)		2.62						
$T_{ref,in}$ (˚C)		-1.89						
$P_{ref,in}$ (kPa)		83.16						
$P_{ref,out}$ (kPa)		75.59						

Point ID	**R-123, P/D 1.167, 35 30 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.01	18.25	16.29	15.38	55.09	10536.81	0.7754	
T_1 (˚C)	20.56	17.88	16.10	15.32	54.55	11410.66	0.7826	
T_2 (˚C)	20.10	17.46	15.93	15.24	53.97	12733.75	0.7912	
T_3 (˚C)	19.55	17.02	15.74	15.17	53.39	13784.06	0.8007	
T_4 (˚C)	19.17	16.74	15.60	15.11	52.85	15459.56	0.8107	
T_5 (˚C)	18.71	16.49	15.50	15.07	50.23	19962.98	0.6111	
T_{out} (˚C)	18.23	16.29	15.40	15.02	44.95	20405.33	0.6053	
m_{water} (kg/s)		0.28			39.33	21089.17	0.5996	
$P_{water,in}$ (kPa)	748.34	N/A	N/A	340.09	33.72	19978.65	0.5944	
$P_{water,out}$ (kPa)	610.29	N/A	N/A	194.80	28.44	18572.92	0.5901	
P_{sat} (kPa)	60.99	61.09	60.66	60.48	22.52	20999.23	0.4550	34.96
$P_{bundle,in}$ (kPa)		61.09			20.24	21485.27	0.4555	
$P_{bundle,out}$ (kPa)		63.18			17.81	22155.01	0.4562	
m_{ref} (kg/s)		0.33			15.39	21706.11	0.4571	
	Path B	**Path C**	**Path D**	**Path E**	13.11	20230.81	0.4582	
$T_{water,in}$ (˚C)	21.07	21.07	21.14	21.09	9.09	15599.64	0.3689	
$T_{water,out}$ (˚C)	16.22	16.14	16.13	16.30	8.32	15886.67	0.3677	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	7.50	15960.85	0.3665	
		Pre-boiler			6.68	15911.26	0.3652	
$T_{water,in}$ (˚C)		34.73			5.90	15012.91	0.3640	
$T_{water,out}$ (˚C)		32.22						
m_{water} (kg/s)		2.65						
$T_{ref,in}$ (˚C)		-6.21						
$P_{ref,in}$ (kPa)		113.46						
$P_{ref,out}$ (kPa)		99.20						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	24.30	23.36	18.98	16.40	18.66	1919.99	0.6916	
T_1 (˚C)	24.09	22.48	18.51	16.17	18.18	1898.89	0.7050	
T_2 (˚C)	23.93	21.65	18.02	15.94	17.66	1867.41	0.7204	
T_3 (˚C)	23.81	20.71	17.48	15.71	17.15	1833.76	0.7370	
T_4 (˚C)	23.69	20.07	17.07	15.51	16.66	1812.89	0.7537	
T_5 (˚C)	23.53	19.48	16.72	15.36	106.55	16366.09	0.5735	
T_{out} (˚C)	23.36	18.99	16.42	15.25	96.55	16494.93	0.5608	
m_{water} (kg/s)		0.28			85.93	16830.68	0.5479	
$P_{water,in}$ (kPa)	747.71	N/A	N/A	342.69	75.31	16210.58	0.5356	
$P_{water,out}$ (kPa)	611.74	N/A	N/A	196.74	65.31	15440.81	0.5248	
P_{sat} (kPa)	60.29	60.36	59.92	59.78	60.68	19663.28	0.3003	34.78
$P_{bundle,in}$ (kPa)		60.38			55.96	20848.79	0.3007	
$P_{bundle,out}$ (kPa)		62.48			50.96	22741.62	0.3014	
m_{ref} (kg/s)		0.33			45.95	23934.24	0.3023	
	Path B	**Path C**	**Path D**	**Path E**	41.24	24900.90	0.3035	
$T_{water,in}$ (˚C)	24.39	24.40	24.44	24.40	29.22	21741.54	0.1402	
$T_{water,out}$ (˚C)	17.41	16.90	17.12	17.63	26.31	22614.06	0.1357	
m_{water} (kg/s)	0.34	0.32	0.34	0.35	23.21	23362.35	0.1309	
		Pre-boiler			20.12	23616.21	0.1261	
$T_{water,in}$ (˚C)		29.13			17.20	22531.92	0.1217	
$T_{water,out}$ (˚C)		22.11						
m_{water} (kg/s)		0.41						
$T_{ref,in}$ (˚C)		-5.69						
$P_{ref,in}$ (kPa)		82.79						
$P_{ref,out}$ (kPa)		76.00						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.23	15.51	14.76	14.49	40.23	17801.13	0.2502	
T_1 (˚C)	16.89	15.36	14.71	14.49	37.39	18748.17	0.2483	
T_2 (˚C)	16.57	15.20	14.66	14.48	34.38	19935.97	0.2466	
T_3 (˚C)	16.25	15.03	14.60	14.48	31.36	21037.64	0.2451	
T_4 (˚C)	15.96	14.93	14.57	14.47	28.53	22144.98	0.2439	
T_5 (˚C)	15.70	14.83	14.54	14.47	19.79	19550.28	0.1627	
T_{out} (˚C)	15.50	14.76	14.51	14.46	17.59	19740.11	0.1623	
m_{water} (kg/s)		0.28			15.27	19980.93	0.1620	
$P_{water,in}$ (kPa)	750.79	N/A	N/A	341.45	12.94	18072.08	0.1619	
$P_{water,out}$ (kPa)	612.62	N/A	N/A	197.48	10.75	16384.87	0.1618	
P_{sat} (kPa)	60.02	60.00	59.55	59.32	6.68	15682.89	0.1116	44.74
$P_{bundle,in}$ (kPa)		60.16			5.96	15238.30	0.1107	
$P_{bundle,out}$ (kPa)		61.93			5.20	14729.12	0.1098	
m_{ref} (kg/s)		0.43			4.43	13283.92	0.1089	
	Path B	**Path C**	**Path D**	**Path E**	3.71	11508.95	0.1080	
$T_{water,in}$ (˚C)	17.27	17.26	17.33	17.28	0.00	0.00	0.1036	
$T_{water,out}$ (˚C)	14.87	15.00	14.93	14.89	0.00	0.00	0.1036	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.1036	
		Pre-boiler			0.00	0.00	0.1036	
$T_{water,in}$ (˚C)		25.82			0.00	0.00	0.1036	
$T_{water,out}$ (˚C)		24.00						
m_{water} (kg/s)		1.72						
$T_{ref,in}$ (˚C)		1.92						
$P_{ref,in}$ (kPa)		90.67						
$P_{ref,out}$ (kPa)		81.39						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	18.09	16.29	15.47	15.13	41.90	16907.86	0.5260	
T_1 (˚C)	17.74	16.14	15.40	15.11	39.06	17828.75	0.5255	
T_2 (˚C)	17.40	15.95	15.33	15.09	36.05	18850.66	0.5254	
T_3 (˚C)	17.07	15.77	15.27	15.07	33.03	19821.68	0.5257	
T_4 (˚C)	16.76	15.66	15.22	15.05	30.19	20964.40	0.5263	
T_5 (˚C)	16.49	15.55	15.19	15.05	21.40	18346.45	0.4397	
T_{out} (˚C)	16.27	15.47	15.15	15.03	19.13	18698.33	0.4379	
m_{water} (kg/s)		0.28			16.72	18975.48	0.4361	
$P_{water,in}$ (kPa)	750.86	N/A	N/A	342.86	14.31	17368.12	0.4346	
$P_{water,out}$ (kPa)	612.22	N/A	N/A	196.62	12.03	15938.16	0.4333	
P_{sat} (kPa)	61.36	61.44	61.00	60.80	8.59	17597.29	0.3801	44.69
$P_{bundle,in}$ (kPa)		61.49			7.66	17335.21	0.3804	
$P_{bundle,out}$ (kPa)		63.51			6.66	16763.68	0.3808	
m_{ref} (kg/s)		0.43			5.66	15389.32	0.3814	
	Path B	**Path C**	**Path D**	**Path E**	4.72	13329.50	0.3820	
$T_{water,in}$ (˚C)	18.13	18.13	18.20	18.15	2.75	7848.34	0.3470	
$T_{water,out}$ (˚C)	15.52	15.64	15.58	15.56	2.54	7640.60	0.3468	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	2.32	7304.36	0.3465	
		Pre-boiler			2.10	6928.89	0.3462	
$T_{water,in}$ (˚C)		40.04			1.89	6248.20	0.3460	
$T_{water,out}$ (˚C)		36.91						
m_{water} (kg/s)		2.66						
$T_{ref,in}$ (˚C)		-6.59						
$P_{ref,in}$ (kPa)		129.63						
$P_{ref,out}$ (kPa)		115.93						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.28	17.79	16.11	15.37	79.72	16926.65	0.4483	
T_1 (˚C)	20.59	17.46	15.97	15.33	74.47	17845.85	0.4485	
T_2 (˚C)	19.96	17.11	15.83	15.28	68.90	19076.06	0.4495	
T_3 (˚C)	19.30	16.73	15.67	15.24	63.33	20224.01	0.4514	
T_4 (˚C)	18.72	16.49	15.56	15.20	58.08	21570.34	0.4540	
T_5 (˚C)	18.19	16.28	15.47	15.17	43.06	20524.32	0.2822	
T_{out} (˚C)	17.77	16.11	15.39	15.15	38.43	20964.93	0.2783	
m_{water} (kg/s)		0.28			33.51	21612.14	0.2745	
$P_{water,in}$ (kPa)	750.66	N/A	N/A	343.10	28.59	20362.87	0.2713	
$P_{water,out}$ (kPa)	612.67	N/A	N/A	199.66	23.96	18795.91	0.2686	
P_{sat} (kPa)	61.37	61.42	60.98	60.74	18.19	20527.71	0.1641	44.88
$P_{bundle,in}$ (kPa)		61.48			16.46	21243.87	0.1652	
$P_{bundle,out}$ (kPa)		63.43			14.61	22224.15	0.1665	
m_{ref} (kg/s)		0.43			12.77	21947.04	0.1681	
	Path B	**Path C**	**Path D**	**Path E**	11.04	20950.23	0.1698	
$T_{water,in}$ (˚C)	21.35	21.35	21.40	21.36	6.10	12154.00	0.1010	
$T_{water,out}$ (˚C)	16.19	16.30	16.26	16.22	5.52	11888.74	0.1003	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	4.90	11427.98	0.0996	
		Pre-boiler			4.28	10712.71	0.0989	
$T_{water,in}$ (˚C)		25.82			3.70	9494.79	0.0982	
$T_{water,out}$ (˚C)		23.85						
m_{water} (kg/s)		1.72						
$T_{ref,in}$ (˚C)		-1.75						
$P_{ref,in}$ (kPa)		90.06						
$P_{ref,out}$ (kPa)		81.46						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.64	17.48	15.80	15.04	69.24	14643.46	0.6775	
T_1 (˚C)	20.03	17.16	15.64	14.98	65.80	15468.58	0.6797	
T_2 (˚C)	19.50	16.80	15.50	14.92	62.14	16723.91	0.6828	
T_3 (˚C)	18.89	16.42	15.34	14.86	58.49	17834.34	0.6867	
T_4 (˚C)	18.39	16.18	15.23	14.81	55.05	19401.47	0.6912	
T_5 (˚C)	17.89	15.96	15.14	14.78	43.58	20026.44	0.5302	
T_{out} (˚C)	17.47	15.79	15.05	14.75	38.87	20418.90	0.5259	
m_{water} (kg/s)		0.28			33.86	20916.07	0.5219	
$P_{water,in}$ (kPa)	750.68	N/A	N/A	344.02	28.85	19557.52	0.5183	
$P_{water,out}$ (kPa)	613.86	N/A	N/A	199.02	24.13	17914.81	0.5153	
P_{sat} (kPa)	60.36	60.45	60.03	59.78	18.62	19719.17	0.4147	44.96
$P_{bundle,in}$ (kPa)		60.46			16.82	20127.28	0.4157	
$P_{bundle,out}$ (kPa)		62.54			14.90	20658.60	0.4170	
m_{ref} (kg/s)		0.43			12.98	20166.07	0.4185	
	Path B	**Path C**	**Path D**	**Path E**	11.17	18964.15	0.4200	
$T_{water,in}$ (˚C)	20.69	20.69	20.76	20.72	7.70	14281.65	0.3542	
$T_{water,out}$ (˚C)	15.75	15.83	15.83	15.82	6.94	14138.83	0.3533	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	6.13	13623.61	0.3523	
		Pre-boiler			5.32	12869.58	0.3513	
$T_{water,in}$ (˚C)		39.94			4.55	11419.49	0.3504	
$T_{water,out}$ (˚C)		36.86						
m_{water} (kg/s)		2.66						
$T_{ref,in}$ (˚C)		-4.99						
$P_{ref,in}$ (kPa)		129.57						
$P_{ref,out}$ (kPa)		115.74						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	22.87	22.36	19.05	16.72	9.61	1196.65	0.7293	
T_1 (˚C)	22.78	21.65	18.57	16.52	9.68	1218.14	0.7368	
T_2 (˚C)	22.70	21.02	18.15	16.31	9.75	1238.69	0.7456	
T_3 (˚C)	22.62	20.37	17.67	16.11	9.83	1259.15	0.7552	
T_4 (˚C)	22.55	19.92	17.31	15.93	9.89	1280.16	0.7649	
T_5 (˚C)	22.48	19.46	17.01	15.80	79.10	14126.25	0.6512	
T_{out} (˚C)	22.37	19.03	16.74	15.70	72.12	14165.56	0.6455	
m_{water} (kg/s)		0.28			64.69	14144.52	0.6397	
$P_{water,in}$ (kPa)	754.21	N/A	N/A	347.54	57.27	13464.84	0.6344	
$P_{water,out}$ (kPa)	616.69	N/A	N/A	204.47	50.28	12855.84	0.6299	44.81
P_{sat} (kPa)	61.58	61.68	61.27	61.07	55.91	20723.12	0.4951	
$P_{bundle,in}$ (kPa)		61.70			50.91	21459.48	0.4941	
$P_{bundle,out}$ (kPa)		63.88			45.59	22862.49	0.4933	
m_{ref} (kg/s)		0.43			40.28	23315.02	0.4926	
	Path B	**Path C**	**Path D**	**Path E**	35.28	23195.14	0.4922	
$T_{water,in}$ (˚C)	22.94	22.95	23.00	22.94	25.95	21072.23	0.3899	
$T_{water,out}$ (˚C)	17.04	16.75	17.08	17.32	23.37	21896.07	0.3868	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	20.64	22405.57	0.3835	
		Pre-boiler			17.90	22536.82	0.3803	
$T_{water,in}$ (˚C)		40.88			15.33	21441.00	0.3772	
$T_{water,out}$ (˚C)		37.68						
m_{water} (kg/s)		2.66						
$T_{ref,in}$ (˚C)		-5.69						
$P_{ref,in}$ (kPa)		129.60						
$P_{ref,out}$ (kPa)		118.40						

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	29.88	29.78	29.64	28.04	1.92	128.34	0.8076	
T_1 (˚C)	29.85	29.77	29.16	26.80	1.92	128.36	0.8113	
T_2 (˚C)	29.85	29.71	28.64	25.60	1.92	128.45	0.8153	
T_3 (˚C)	29.84	29.68	28.49	24.54	1.92	128.51	0.8195	
T_4 (˚C)	29.83	29.66	28.44	23.44	1.92	128.65	0.8237	
T_5 (˚C)	29.82	29.62	28.32	22.49	4.44	300.69	0.6956	
T_{out} (˚C)	29.79	29.60	28.07	21.82	4.25	288.44	0.6940	
m_{water} (kg/s)	0.28				4.04	274.92	0.6926	
$P_{water,in}$ (kPa)	752.39	N/A	N/A	344.79	3.83	261.19	0.6911	
$P_{water,out}$ (kPa)	614.52	N/A	N/A	200.18	3.64	248.45	0.6899	
P_{sat} (kPa)	62.17	62.29	61.91	61.74	46.30	3459.60	0.5924	44.45
$P_{bundle,in}$ (kPa)	62.24				37.38	2875.57	0.5922	
$P_{bundle,out}$ (kPa)	64.52				27.90	2147.49	0.5920	
m_{ref} (kg/s)	0.42				18.42	1407.46	0.5918	
	Path B	**Path C**	**Path D**	**Path E**	9.50	725.26	0.5917	
$T_{water,in}$ (˚C)	30.02	30.06	30.07	30.03	145.46	15444.27	0.5410	
$T_{water,out}$ (˚C)	24.99	21.86	23.46	25.07	134.77	16059.93	0.5281	
m_{water} (kg/s)	0.33	0.32	0.34	0.35	123.40	16415.23	0.5143	
	Pre-boiler				112.04	16981.47	0.5006	
$T_{water,in}$ (˚C)	40.93				101.35	17408.61	0.4877	
$T_{water,out}$ (˚C)	37.79							
m_{water} (kg/s)	2.67							
$T_{ref,in}$ (˚C)	-3.46							
$P_{ref,in}$ (kPa)	129.82							
$P_{ref,out}$ (kPa)	118.82							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	24.76	20.14	17.19	15.74	92.66	11497.60	0.6181	
T_1 (˚C)	23.91	19.57	16.91	15.63	91.54	12363.82	0.6274	
T_2 (˚C)	23.24	18.95	16.63	15.51	90.35	13800.36	0.6385	
T_3 (˚C)	22.36	18.31	16.33	15.39	89.16	15329.56	0.6511	
T_4 (˚C)	21.61	17.87	16.11	15.29	88.03	17463.17	0.6641	
T_5 (˚C)	20.82	17.49	15.92	15.23	74.61	19507.22	0.4027	
T_{out} (˚C)	20.12	17.19	15.75	15.17	66.86	19938.81	0.3957	
m_{water} (kg/s)	0.28				58.63	20521.95	0.3890	
$P_{water,in}$ (kPa)	750.47	N/A	N/A	345.40	50.39	19594.62	0.3830	
$P_{water,out}$ (kPa)	613.46	N/A	N/A	199.32	42.64	18292.81	0.3780	44.68
P_{sat} (kPa)	60.95	61.04	60.58	60.34	34.86	20757.41	0.2117	
$P_{bundle,in}$ (kPa)	61.01				31.81	21807.85	0.2135	
$P_{bundle,out}$ (kPa)	63.08				28.58	23433.58	0.2157	
m_{ref} (kg/s)	0.43				25.35	23993.85	0.2182	
	Path B	**Path C**	**Path D**	**Path E**	22.30	24055.74	0.2208	
$T_{water,in}$ (˚C)	24.87	24.87	24.91	24.87	14.87	18558.62	0.1104	
$T_{water,out}$ (˚C)	16.91	16.91	16.92	16.97	13.34	18763.59	0.1086	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	11.73	18711.49	0.1067	
	Pre-boiler				10.11	18136.29	0.1047	
$T_{water,in}$ (˚C)	33.26				8.59	16450.22	0.1029	
$T_{water,out}$ (˚C)	21.43							
m_{water} (kg/s)	0.31							
$T_{ref,in}$ (˚C)	-4.67							
$P_{ref,in}$ (kPa)	90.66							
$P_{ref,out}$ (kPa)	81.62							

Point ID	R-123, P/D 1.167, 55 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.51	15.73	14.95	14.68	41.52	17837.71	0.2104	
T_1 (˚C)	17.16	15.58	14.90	14.67	38.63	18823.62	0.2089	
T_2 (˚C)	16.83	15.41	14.85	14.67	35.57	20078.79	0.2076	
T_3 (˚C)	16.49	15.23	14.79	14.66	32.51	21267.16	0.2065	
T_4 (˚C)	16.19	15.13	14.76	14.65	29.63	22514.85	0.2056	
T_5 (˚C)	15.93	15.03	14.73	14.65	20.52	20062.08	0.1375	
T_{out} (˚C)	15.72	14.95	14.70	14.64	18.23	20312.08	0.1372	
m_{water} (kg/s)		0.28			15.81	20613.25	0.1370	
$P_{water,in}$ (kPa)	752.05	N/A	N/A	344.16	13.38	18677.97	0.1368	
$P_{water,out}$ (kPa)	614.13	N/A	N/A	200.95	11.09	16938.96	0.1368	
P_{sat} (kPa)	60.49	60.46	60.01	59.75	6.87	16250.36	0.0953	55.05
$P_{bundle,in}$ (kPa)		60.64			6.13	15863.79	0.0946	
$P_{bundle,out}$ (kPa)		62.38			5.35	15438.83	0.0938	
m_{ref} (kg/s)		0.53			4.56	13967.84	0.0930	
	Path B	**Path C**	**Path D**	**Path E**	3.83	12140.02	0.0923	
$T_{water,in}$ (˚C)	17.56	17.55	17.62	17.57	0.00	0.00	0.0886	
$T_{water,out}$ (˚C)	15.07	15.20	15.13	15.09	0.00	0.00	0.0886	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	0.00	0.00	0.0886	
		Pre-boiler			0.00	0.00	0.0886	
$T_{water,in}$ (˚C)		26.58			0.00	0.00	0.0886	
$T_{water,out}$ (˚C)		25.22						
m_{water} (kg/s)		2.63						
$T_{ref,in}$ (˚C)		1.70						
$P_{ref,in}$ (kPa)		95.41						
$P_{ref,out}$ (kPa)		85.67						

Point ID	R-123, P/D 1.167, 55 30 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.92	17.45	15.81	15.09	79.56	17191.04	0.3788	
T_1 (˚C)	20.24	17.13	15.67	15.04	74.21	18173.62	0.3788	
T_2 (˚C)	19.60	16.78	15.53	15.00	68.54	19376.89	0.3795	
T_3 (˚C)	18.96	16.42	15.38	14.96	62.86	20519.06	0.3809	
T_4 (˚C)	18.38	16.19	15.27	14.92	57.52	21848.93	0.3829	
T_5 (˚C)	17.85	15.97	15.19	14.90	42.12	20614.38	0.2432	
T_{out} (˚C)	17.43	15.81	15.11	14.88	37.63	21144.60	0.2402	
m_{water} (kg/s)		0.28			32.87	21799.85	0.2373	
$P_{water,in}$ (kPa)	751.99	N/A	N/A	344.52	28.10	20559.63	0.2348	
$P_{water,out}$ (kPa)	613.88	N/A	N/A	199.56	23.61	19124.71	0.2328	
P_{sat} (kPa)	60.80	60.82	60.36	60.11	17.81	21064.93	0.1489	54.77
$P_{bundle,in}$ (kPa)		60.89			16.04	21712.75	0.1499	
$P_{bundle,out}$ (kPa)		62.77			14.15	22632.89	0.1510	
m_{ref} (kg/s)		0.52			12.27	22083.61	0.1523	
	Path B	**Path C**	**Path D**	**Path E**	10.49	20679.25	0.1537	
$T_{water,in}$ (˚C)	20.99	20.99	21.05	21.00	5.73	12366.18	0.0999	
$T_{water,out}$ (˚C)	15.87	16.02	15.95	15.90	5.17	11905.62	0.0993	
m_{water} (kg/s)	0.34	0.34	0.34	0.35	4.57	11376.73	0.0987	
		Pre-boiler			3.97	10599.71	0.0982	
$T_{water,in}$ (˚C)		28.51			3.41	9284.78	0.0976	
$T_{water,out}$ (˚C)		24.82						
m_{water} (kg/s)		1.29						
$T_{ref,in}$ (˚C)		-7.16						
$P_{ref,in}$ (kPa)		96.45						
$P_{ref,out}$ (kPa)		86.46						

Point ID	R-123, P/D 1.167, 55 38 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	22.87	18.50	16.34	15.35	98.53	16263.09	0.4670	
T_1 (°C)	22.02	18.08	16.15	15.28	92.42	17134.65	0.4679	
T_2 (°C)	21.25	17.63	15.96	15.20	85.93	18370.60	0.4697	
T_3 (°C)	20.42	17.16	15.75	15.13	79.44	19515.43	0.4725	
T_4 (°C)	19.70	16.84	15.60	15.07	73.33	20930.97	0.4760	
T_5 (°C)	19.02	16.56	15.48	15.04	55.02	20279.71	0.2963	
T_{out} (°C)	18.49	16.34	15.36	15.00	49.23	20770.66	0.2921	
m_{water} (kg/s)	0.28				43.08	21461.22	0.2882	
$P_{water,in}$ (kPa)	748.71	N/A	N/A	341.02	36.92	20430.02	0.2849	
$P_{water,out}$ (kPa)	614.13	N/A	N/A	199.02	31.13	19033.79	0.2822	
P_{sat} (kPa)	60.88	60.93	60.47	60.20	24.30	21073.84	0.1725	54.84
$P_{bundle,in}$ (kPa)	60.95				22.07	22011.99	0.1738	
$P_{bundle,out}$ (kPa)	62.90				19.70	23405.58	0.1754	
m_{ref} (kg/s)	0.52				17.33	23587.38	0.1773	
	Path B	**Path C**	**Path D**	**Path E**	15.10	23107.93	0.1792	
$T_{water,in}$ (°C)	22.95	22.96	23.01	22.96	9.18	15600.22	0.1073	
$T_{water,out}$ (°C)	16.32	16.43	16.43	16.38	8.27	15486.96	0.1064	
m_{water} (kg/s)	0.34	0.33	0.34	0.35	7.29	15151.25	0.1055	
	Pre-boiler				6.32	14438.78	0.1045	
$T_{water,in}$ (°C)	27.75				5.41	12883.40	0.1036	
$T_{water,out}$ (°C)	25.98							
m_{water} (kg/s)	2.63							
$T_{ref,in}$ (°C)	-5.51							
$P_{ref,in}$ (kPa)	97.55							
$P_{ref,out}$ (kPa)	87.51							

Point ID	R-123, P/D 1.33, 15 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·°C)**	**x**	**G (kg/m².s)**
T_{in} (°C)	17.97	15.90	15.11	14.87	49.43	20005.92	0.3469	
T_1 (°C)	17.58	15.74	15.08	14.87	44.83	21183.81	0.3412	
T_2 (°C)	17.14	15.56	15.03	14.87	39.95	22386.08	0.3357	
T_3 (°C)	16.72	15.41	14.98	14.87	35.06	22366.23	0.3307	
T_4 (°C)	16.41	15.31	14.94	14.87	30.47	22184.90	0.3264	
T_5 (°C)	16.13	15.19	14.93	14.87	19.42	18880.22	0.1935	
T_{out} (°C)	15.89	15.12	14.90	14.86	17.33	19509.40	0.1933	
m_{water} (kg/s)	0.27				15.12	19327.45	0.1932	
$P_{water,in}$ (kPa)	736.28	N/A	N/A	337.93	12.90	17764.75	0.1934	
$P_{water,out}$ (kPa)	601.83	N/A	N/A	190.48	10.81	16734.18	0.1937	
P_{sat} (kPa)	61.22	60.84	60.45	60.07	5.51	11530.51	0.1149	15.07
$P_{bundle,in}$ (kPa)	60.73				5.01	11437.78	0.1140	
$P_{bundle,out}$ (kPa)	60.33				4.47	11240.08	0.1130	
m_{ref} (kg/s)	0.28				3.94	10513.90	0.1121	
	Path B	**Path C**	**Path D**	**Path E**	3.43	9350.68	0.1112	
$T_{water,in}$ (°C)	18.01	17.99	18.07	18.01	0.00	0.00	0.1050	
$T_{water,out}$ (°C)	15.26	15.34	15.31	15.26	0.00	0.00	0.1050	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	0.00	0.00	0.1050	
	Pre-boiler				0.00	0.00	0.1050	
$T_{water,in}$ (°C)	27.77				0.00	0.00	0.1050	
$T_{water,out}$ (°C)	20.14							
m_{water} (kg/s)	0.36							
$T_{ref,in}$ (°C)	-7.37							
$P_{ref,in}$ (kPa)	83.09							
$P_{ref,out}$ (kPa)	78.93							

Point ID	**R-123, P/D 1.33, 15 15 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.69	15.77	15.04	14.79	45.79	19972.12	0.5864	
T_1 (˚C)	17.33	15.63	15.01	14.80	41.47	21114.16	0.5807	
T_2 (˚C)	16.92	15.47	14.96	14.79	36.88	22198.74	0.5750	
T_3 (˚C)	16.53	15.33	14.90	14.79	32.29	22068.51	0.5698	
T_4 (˚C)	16.24	15.24	14.87	14.78	27.97	21731.02	0.5654	
T_5 (˚C)	15.98	15.12	14.85	14.79	17.91	18300.19	0.4379	
T_{out} (˚C)	15.77	15.05	14.82	14.78	16.03	18896.20	0.4379	
m_{water} (kg/s)	0.27				14.03	18753.07	0.4382	
$P_{water,in}$ (kPa)	736.37	N/A	N/A	338.02	12.04	17263.16	0.4387	
$P_{water,out}$ (kPa)	602.74	N/A	N/A	190.90	10.16	16362.39	0.4393	
P_{sat} (kPa)	61.00	60.70	60.38	60.05	5.91	12899.30	0.3633	14.66
$P_{bundle,in}$ (kPa)	60.36				5.34	12871.49	0.3623	
$P_{bundle,out}$ (kPa)	60.34				4.73	12665.03	0.3611	
m_{ref} (kg/s)	0.28				4.12	11717.28	0.3600	
	Path B	**Path C**	**Path D**	**Path E**	3.55	10391.07	0.3590	
$T_{water,in}$ (˚C)	17.73	17.71	17.79	17.71	0.00	0.00	0.3524	
$T_{water,out}$ (˚C)	15.16	15.22	15.18	15.16	0.00	0.00	0.3524	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	0.00	0.00	0.3524	
	Pre-boiler				0.00	0.00	0.3524	
$T_{water,in}$ (˚C)	31.17				0.00	0.00	0.3524	
$T_{water,out}$ (˚C)	28.66							
m_{water} (kg/s)	2.18							
$T_{ref,in}$ (˚C)	-6.74							
$P_{ref,in}$ (kPa)	101.70							
$P_{ref,out}$ (kPa)	92.64							

Point ID	**R-123, P/D 1.33, 15 25 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.74	17.53	16.17	15.63	74.77	19041.29	0.7942	
T_1 (˚C)	20.16	17.26	16.08	15.61	68.39	20266.86	0.7906	
T_2 (˚C)	19.49	16.96	15.97	15.58	61.60	21674.88	0.7880	
T_3 (˚C)	18.84	16.70	15.86	15.55	54.81	22217.50	0.7867	
T_4 (˚C)	18.34	16.51	15.78	15.52	48.43	22509.95	0.7867	
T_5 (˚C)	17.91	16.31	15.72	15.51	33.30	20404.85	0.5675	
T_{out} (˚C)	17.53	16.18	15.66	15.49	29.76	21259.61	0.5631	
m_{water} (kg/s)	0.27				26.01	21498.31	0.5591	
$P_{water,in}$ (kPa)	736.72	N/A	N/A	338.33	22.25	20247.21	0.5558	
$P_{water,out}$ (kPa)	602.28	N/A	N/A	191.62	18.72	19469.33	0.5534	
P_{sat} (kPa)	62.58	62.34	62.07	61.80	12.75	17400.89	0.4249	15.02
$P_{bundle,in}$ (kPa)	61.89				11.55	17948.83	0.4265	
$P_{bundle,out}$ (kPa)	62.16				10.28	18498.16	0.4285	
m_{ref} (kg/s)	0.28				9.01	18029.03	0.4307	
	Path B	**Path C**	**Path D**	**Path E**	7.81	16867.03	0.4331	
$T_{water,in}$ (˚C)	20.80	20.80	20.87	20.79	3.81	11277.48	0.3519	
$T_{water,out}$ (˚C)	16.25	16.29	16.25	16.28	3.50	11193.45	0.3514	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	3.17	10976.78	0.3508	
	Pre-boiler				2.84	10668.71	0.3502	
$T_{water,in}$ (˚C)	31.34				2.53	9621.38	0.3496	
$T_{water,out}$ (˚C)	29.26							
m_{water} (kg/s)	2.64							
$T_{ref,in}$ (˚C)	-5.87							
$P_{ref,in}$ (kPa)	103.53							
$P_{ref,out}$ (kPa)	94.50							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	21.55	17.66	15.96	15.27	90.05	18676.67	0.6607	
T_1 (˚C)	20.83	17.30	15.84	15.24	82.48	19817.36	0.6568	
T_2 (˚C)	20.04	16.94	15.70	15.20	74.44	21136.22	0.6542	
T_3 (˚C)	19.25	16.62	15.55	15.16	66.40	21700.17	0.6533	
T_4 (˚C)	18.65	16.39	15.45	15.13	58.84	22024.46	0.6539	
T_5 (˚C)	18.12	16.13	15.37	15.12	41.21	20460.15	0.3832	
T_{out} (˚C)	17.65	15.97	15.29	15.09	36.89	21311.56	0.3779	
m_{water} (kg/s)		0.27			32.30	21588.33	0.3730	
$P_{water,in}$ (kPa)	739.93	N/A	N/A	341.31	27.71	20419.98	0.3690	
$P_{water,out}$ (kPa)	604.83	N/A	N/A	193.42	23.39	19852.54	0.3661	
P_{sat} (kPa)	61.48	61.17	60.87	60.61	16.34	18249.06	0.2070	14.88
$P_{bundle,in}$ (kPa)		60.85			14.80	18907.17	0.2091	
$P_{bundle,out}$ (kPa)		60.95			13.16	19627.10	0.2116	
m_{ref} (kg/s)		0.28			11.52	19434.45	0.2145	
	Path B	**Path C**	**Path D**	**Path E**	9.98	18317.42	0.2175	
$T_{water,in}$ (˚C)	21.60	21.60	21.67	21.60	4.68	11949.99	0.1175	
$T_{water,out}$ (˚C)	16.02	16.09	16.04	16.03	4.27	11850.28	0.1168	
m_{water} (kg/s)	0.32	0.32	0.32	0.32	3.83	11590.49	0.1160	
		Pre-boiler			3.39	11127.46	0.1152	
$T_{water,in}$ (˚C)		22.84			2.98	9960.47	0.1144	
$T_{water,out}$ (˚C)		21.60						
m_{water} (kg/s)		2.16						
$T_{ref,in}$ (˚C)		-6.48						
$P_{ref,in}$ (kPa)		82.80						
$P_{ref,out}$ (kPa)		78.82						

Point ID	R-123, P/D 1.33, 20 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m²·s)**
T_{in} (˚C)	17.81	15.78	15.01	14.78	48.40	20118.99	0.2803	
T_1 (˚C)	17.42	15.62	14.98	14.78	43.89	21309.35	0.2761	
T_2 (˚C)	16.99	15.45	14.93	14.78	39.10	22505.06	0.2721	
T_3 (˚C)	16.58	15.30	14.88	14.78	34.30	22529.74	0.2683	
T_4 (˚C)	16.28	15.21	14.85	14.78	29.79	22319.75	0.2651	
T_5 (˚C)	16.00	15.09	14.83	14.78	18.99	19168.56	0.1672	
T_{out} (˚C)	15.77	15.02	14.80	14.78	16.95	19817.68	0.1671	
m_{water} (kg/s)		0.27			14.79	19682.65	0.1671	
$P_{water,in}$ (kPa)	736.01	N/A	N/A	338.61	12.62	18125.19	0.1673	
$P_{water,out}$ (kPa)	601.67	N/A	N/A	190.33	10.58	17115.22	0.1676	19.96
P_{sat} (kPa)	61.03	60.64	60.27	59.89	5.30	11575.41	0.1099	
$P_{bundle,in}$ (kPa)		60.50			4.83	11523.15	0.1092	
$P_{bundle,out}$ (kPa)		60.13			4.32	11373.42	0.1085	
m_{ref} (kg/s)		0.38			3.82	10658.16	0.1078	
	Path B	**Path C**	**Path D**	**Path E**	3.34	9555.20	0.1072	
$T_{water,in}$ (˚C)	17.85	17.83	17.91	17.85	0.00	0.00	0.1027	
$T_{water,out}$ (˚C)	15.16	15.23	15.20	15.16	0.00	0.00	0.1027	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	0.00	0.00	0.1027	
		Pre-boiler			0.00	0.00	0.1027	
$T_{water,in}$ (˚C)		29.96			0.00	0.00	0.1027	
$T_{water,out}$ (˚C)		21.56						
m_{water} (kg/s)		0.43						
$T_{ref,in}$ (˚C)		-7.48						
$P_{ref,in}$ (kPa)		89.29						
$P_{ref,out}$ (kPa)		83.60						

Point ID	R-123, P/D 1.33, 20 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	17.83	15.85	15.09	14.82	47.02	19736.18	0.5264	
T_1 (˚C)	17.46	15.70	15.05	14.82	42.74	20969.53	0.5224	
T_2 (˚C)	17.03	15.52	14.99	14.81	38.20	22072.77	0.5185	
T_3 (˚C)	16.64	15.38	14.94	14.80	33.65	22086.57	0.5149	
T_4 (˚C)	16.35	15.29	14.90	14.79	29.37	22193.08	0.5120	
T_5 (˚C)	16.07	15.17	14.88	14.80	18.74	18564.91	0.4131	
T_{out} (˚C)	15.84	15.10	14.85	14.78	16.75	19242.36	0.4131	
m_{water} (kg/s)	0.27				14.63	19093.32	0.4132	
$P_{water,in}$ (kPa)	738.40	N/A	N/A	340.24	12.51	17532.62	0.4135	
$P_{water,out}$ (kPa)	602.89	N/A	N/A	193.34	10.51	16502.17	0.4139	
P_{sat} (kPa)	60.98	60.72	60.44	60.09	6.19	12707.24	0.3555	19.81
$P_{bundle,in}$ (kPa)	60.34				5.64	12781.26	0.3547	
$P_{bundle,out}$ (kPa)	60.39				5.06	12688.09	0.3539	
m_{ref} (kg/s)	0.37				4.47	11991.36	0.3531	
	Path B	Path C	Path D	Path E	3.92	10925.83	0.3524	
$T_{water,in}$ (˚C)	17.86	17.84	17.92	17.85	0.00	0.00	0.3470	
$T_{water,out}$ (˚C)	15.17	15.23	15.20	15.18	0.00	0.00	0.3470	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	0.00	0.00	0.3470	
	Pre-boiler				0.00	0.00	0.3470	
$T_{water,in}$ (˚C)	37.75				0.00	0.00	0.3470	
$T_{water,out}$ (˚C)	33.57							
m_{water} (kg/s)	1.74							
$T_{ref,in}$ (˚C)	-6.23							
$P_{ref,in}$ (kPa)	121.99							
$P_{ref,out}$ (kPa)	109.24							

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	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	20.80	17.11	15.50	14.86	85.46	18734.21	0.5014	
T_1 (˚C)	20.12	16.77	15.40	14.83	78.27	19888.43	0.4986	
T_2 (˚C)	19.37	16.43	15.26	14.80	70.63	21225.57	0.4967	
T_3 (˚C)	18.62	16.12	15.13	14.77	63.00	21797.08	0.4959	
T_4 (˚C)	18.04	15.91	15.03	14.74	55.81	22107.99	0.4961	
T_5 (˚C)	17.55	15.67	14.95	14.72	39.01	20587.44	0.3041	
T_{out} (˚C)	17.10	15.51	14.88	14.70	34.90	21447.40	0.3003	
m_{water} (kg/s)	0.27				30.54	21721.49	0.2968	
$P_{water,in}$ (kPa)	738.66	N/A	N/A	341.14	26.17	20503.30	0.2938	
$P_{water,out}$ (kPa)	604.90	N/A	N/A	193.34	22.06	19884.17	0.2916	
P_{sat} (kPa)	60.58	60.25	59.97	59.67	15.28	18082.61	0.1780	19.89
$P_{bundle,in}$ (kPa)	59.91				13.84	18704.78	0.1794	
$P_{bundle,out}$ (kPa)	59.98				12.31	19399.41	0.1812	
m_{ref} (kg/s)	0.38				10.79	19176.35	0.1831	
	Path B	Path C	Path D	Path E	9.35	18047.27	0.1852	
$T_{water,in}$ (˚C)	20.84	20.84	20.91	20.84	4.21	11570.58	0.1131	
$T_{water,out}$ (˚C)	15.57	15.64	15.59	15.58	3.82	11365.13	0.1126	
m_{water} (kg/s)	0.32	0.32	0.32	0.32	3.41	10986.31	0.1120	
	Pre-boiler				3.00	10405.34	0.1114	
$T_{water,in}$ (˚C)	26.10				2.62	9168.20	0.1109	
$T_{water,out}$ (˚C)	22.56							
m_{water} (kg/s)	0.99							
$T_{ref,in}$ (˚C)	-6.11							
$P_{ref,in}$ (kPa)	88.47							
$P_{ref,out}$ (kPa)	82.84							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.81	17.77	15.91	15.13	91.54	17388.12	0.7791	
T_1 (˚C)	21.12	17.38	15.78	15.08	84.84	18604.53	0.7780	
T_2 (˚C)	20.29	16.98	15.61	15.03	77.71	20093.81	0.7781	
T_3 (˚C)	19.47	16.63	15.45	14.97	70.59	21049.28	0.7794	
T_4 (˚C)	18.83	16.38	15.33	14.92	63.88	21993.18	0.7817	
T_5 (˚C)	18.26	16.10	15.24	14.90	44.91	20380.29	0.5661	
T_{out} (˚C)	17.76	15.92	15.15	14.87	40.26	21287.16	0.5616	
m_{water} (kg/s)	0.27				35.32	21610.34	0.5575	
$P_{water,in}$ (kPa)	740.29	N/A	N/A	343.22	30.37	20666.72	0.5540	
$P_{water,out}$ (kPa)	606.00	N/A	N/A	195.24	25.72	20131.06	0.5514	
P_{sat} (kPa)	60.88	60.68	60.45	60.17	18.53	18772.13	0.4240	19.99
$P_{bundle,in}$ (kPa)	60.18				16.80	19618.23	0.4257	
$P_{bundle,out}$ (kPa)	60.55				14.96	20481.12	0.4277	
m_{ref} (kg/s)	0.38				13.12	20357.76	0.4300	
	Path B	**Path C**	**Path D**	**Path E**	11.39	19432.72	0.4325	
$T_{water,in}$ (˚C)	21.87	21.86	21.93	21.86	6.91	15786.87	0.3520	
$T_{water,out}$ (˚C)	15.94	15.94	15.90	15.97	6.21	15754.18	0.3511	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	5.46	15442.57	0.3501	
	Pre-boiler				4.71	14843.07	0.3490	
$T_{water,in}$ (˚C)	48.23				4.01	12948.11	0.3481	
$T_{water,out}$ (˚C)	31.21							
m_{water} (kg/s)	0.42							
$T_{ref,in}$ (˚C)	-5.64							
$P_{ref,in}$ (kPa)	123.48							
$P_{ref,out}$ (kPa)	110.32							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	22.85	19.47	16.90	15.72	72.00	11053.88	0.8082	
T_1 (˚C)	22.33	18.93	16.69	15.64	68.74	11645.72	0.8129	
T_2 (˚C)	21.67	18.40	16.45	15.54	65.28	12337.19	0.8191	
T_3 (˚C)	20.99	17.92	16.21	15.45	61.81	12838.90	0.8263	
T_4 (˚C)	20.46	17.55	16.02	15.37	58.55	13535.13	0.8343	
T_5 (˚C)	19.91	17.16	15.88	15.33	61.22	19554.30	0.6266	
T_{out} (˚C)	19.47	16.91	15.75	15.29	55.17	20362.59	0.6203	
m_{water} (kg/s)	0.27				48.74	20780.91	0.6143	
$P_{water,in}$ (kPa)	740.38	N/A	N/A	343.93	42.31	20129.95	0.6089	
$P_{water,out}$ (kPa)	606.33	N/A	N/A	195.09	36.25	19947.64	0.6043	
P_{sat} (kPa)	61.67	61.51	61.28	61.03	27.58	19722.65	0.4595	19.92
$P_{bundle,in}$ (kPa)	60.96				25.10	20854.52	0.4608	
$P_{bundle,out}$ (kPa)	61.45				22.47	22218.76	0.4626	
m_{ref} (kg/s)	0.38				19.85	22707.97	0.4645	
	Path B	**Path C**	**Path D**	**Path E**	17.37	22354.24	0.4667	
$T_{water,in}$ (˚C)	22.93	22.93	22.99	22.93	11.48	19534.62	0.3736	
$T_{water,out}$ (˚C)	16.90	16.50	16.46	16.86	10.19	19814.49	0.3718	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	8.82	19605.75	0.3699	
	Pre-boiler				7.45	18736.13	0.3681	
$T_{water,in}$ (˚C)	47.48				6.17	16183.05	0.3663	
$T_{water,out}$ (˚C)	31.96							
m_{water} (kg/s)	0.48							
$T_{ref,in}$ (˚C)	-5.59							
$P_{ref,in}$ (kPa)	125.33							
$P_{ref,out}$ (kPa)	112.11							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	24.49	19.06	16.47	15.32	122.13	16667.48	0.6780	
T_1 (˚C)	23.59	18.52	16.26	15.26	113.47	17770.95	0.6771	
T_2 (˚C)	22.50	17.98	16.03	15.17	104.27	19305.81	0.6778	
T_3 (˚C)	21.35	17.49	15.79	15.09	95.07	20216.76	0.6802	
T_4 (˚C)	20.50	17.12	15.61	15.02	86.42	21080.00	0.6840	
T_5 (˚C)	19.75	16.73	15.47	14.99	62.30	20209.72	0.3943	
T_{out} (˚C)	19.06	16.47	15.35	14.95	56.01	21110.98	0.3884	
m_{water} (kg/s)	0.27				49.32	21592.87	0.3831	
$P_{water,in}$ (kPa)	739.48	N/A	N/A	341.41	42.63	20861.54	0.3786	
$P_{water,out}$ (kPa)	605.68	N/A	N/A	194.54	36.33	20572.38	0.3752	
P_{sat} (kPa)	60.86	60.60	60.33	60.03	26.97	20012.37	0.2025	20.27
$P_{bundle,in}$ (kPa)	60.24				24.49	21118.65	0.2046	
$P_{bundle,out}$ (kPa)	60.41				21.86	22426.72	0.2072	
m_{ref} (kg/s)	0.38				19.22	22830.91	0.2101	
	Path B	**Path C**	**Path D**	**Path E**	16.74	22273.49	0.2133	
$T_{water,in}$ (˚C)	24.57	24.58	24.63	24.57	9.73	17251.51	0.1031	
$T_{water,out}$ (˚C)	16.40	16.44	16.40	16.49	8.75	17475.89	0.1018	
m_{water} (kg/s)	0.31	0.31	0.32	0.33	7.71	17508.32	0.1004	
	Pre-boiler				6.67	17054.85	0.0990	
$T_{water,in}$ (˚C)	23.74				5.68	15252.31	0.0977	
$T_{water,out}$ (˚C)	22.50							
m_{water} (kg/s)	2.63							
$T_{ref,in}$ (˚C)	-5.71							
$P_{ref,in}$ (kPa)	87.06							
$P_{ref,out}$ (kPa)	81.76							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	25.97	20.42	17.43	16.07	116.80	13840.03	0.7158	
T_1 (˚C)	25.17	19.80	17.20	15.99	112.27	15038.72	0.7215	
T_2 (˚C)	24.12	19.18	16.92	15.88	107.46	16841.54	0.7293	
T_3 (˚C)	22.96	18.61	16.63	15.78	102.66	18606.77	0.7390	
T_4 (˚C)	22.01	18.19	16.41	15.69	98.13	20633.67	0.7498	
T_5 (˚C)	21.18	17.73	16.24	15.64	71.48	19802.04	0.4351	
T_{out} (˚C)	20.43	17.44	16.09	15.59	64.32	20655.25	0.4281	
m_{water} (kg/s)	0.27				56.71	21107.44	0.4217	
$P_{water,in}$ (kPa)	738.23	N/A	N/A	342.05	49.10	20425.08	0.4163	
$P_{water,out}$ (kPa)	604.97	N/A	N/A	193.62	41.94	20183.14	0.4121	
P_{sat} (kPa)	62.32	62.09	61.84	61.55	32.01	20107.60	0.2245	20.35
$P_{bundle,in}$ (kPa)	61.68				29.18	21331.88	0.2268	
$P_{bundle,out}$ (kPa)	61.92				26.17	22910.05	0.2296	
m_{ref} (kg/s)	0.38				23.16	23732.51	0.2328	
	Path B	**Path C**	**Path D**	**Path E**	20.33	23601.71	0.2362	
$T_{water,in}$ (˚C)	26.06	26.07	26.12	26.06	12.27	18586.35	0.1159	
$T_{water,out}$ (˚C)	17.39	17.23	17.19	17.40	11.00	18974.38	0.1142	
m_{water} (kg/s)	0.31	0.31	0.32	0.33	9.64	19116.06	0.1124	
	Pre-boiler				8.29	18671.97	0.1106	
$T_{water,in}$ (˚C)	25.19				7.02	16740.92	0.1089	
$T_{water,out}$ (˚C)	22.99							
m_{water} (kg/s)	1.58							
$T_{ref,in}$ (˚C)	-5.57							
$P_{ref,in}$ (kPa)	89.35							
$P_{ref,out}$ (kPa)	83.78							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.72	14.92	14.70	14.70	19.41	17845.92	0.1442	
T_1 (˚C)	15.56	14.89	14.72	14.71	17.56	18584.96	0.1432	
T_2 (˚C)	15.38	14.83	14.72	14.72	15.60	18927.15	0.1422	
T_3 (˚C)	15.22	14.79	14.72	14.72	13.64	17921.19	0.1412	
T_4 (˚C)	15.12	14.77	14.72	14.73	11.79	17513.05	0.1403	
T_5 (˚C)	15.00	14.74	14.73	14.74	5.36	10849.02	0.1134	
T_{out} (˚C)	14.91	14.71	14.73	14.74	4.91	11123.08	0.1129	
m_{water} (kg/s)	0.27				4.43	10846.94	0.1124	
$P_{water,in}$ (kPa)	740.61	N/A	N/A	340.82	3.95	9928.29	0.1119	
$P_{water,out}$ (kPa)	605.30	N/A	N/A	193.46	3.50	9439.82	0.1114	
P_{sat} (kPa)	61.28	60.78	60.35	59.87	0.00	0.00	0.1076	25.11
$P_{bundle,in}$ (kPa)	60.87				0.00	0.00	0.1076	
$P_{bundle,out}$ (kPa)	60.09				0.00	0.00	0.1076	
m_{ref} (kg/s)	0.47				0.00	0.00	0.1076	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.1076	
$T_{water,in}$ (˚C)	15.74	15.73	15.81	15.74	0.00	0.00	0.1076	
$T_{water,out}$ (˚C)	14.83	14.90	14.89	14.83	0.00	0.00	0.1076	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	0.00	0.00	0.1076	
	Pre-boiler				0.00	0.00	0.1076	
$T_{water,in}$ (˚C)	29.35				0.00	0.00	0.1076	
$T_{water,out}$ (˚C)	26.11							
m_{water} (kg/s)	1.44							
$T_{ref,in}$ (˚C)	-7.98							
$P_{ref,in}$ (kPa)	95.38							
$P_{ref,out}$ (kPa)	89.26							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.82	15.80	15.04	14.81	48.20	20178.18	0.2326	
T_1 (˚C)	17.44	15.65	15.01	14.82	43.69	21373.82	0.2292	
T_2 (˚C)	17.01	15.48	14.97	14.82	38.91	22565.45	0.2260	
T_3 (˚C)	16.60	15.33	14.92	14.82	34.12	22589.94	0.2231	
T_4 (˚C)	16.30	15.24	14.89	14.81	29.61	22365.94	0.2205	
T_5 (˚C)	16.03	15.12	14.87	14.82	18.79	19231.73	0.1435	
T_{out} (˚C)	15.80	15.05	14.84	14.81	16.76	19802.72	0.1435	
m_{water} (kg/s)	0.27				14.61	19641.36	0.1435	
$P_{water,in}$ (kPa)	736.06	N/A	N/A	338.21	12.45	18054.33	0.1437	
$P_{water,out}$ (kPa)	602.40	N/A	N/A	190.23	10.42	17010.33	0.1439	
P_{sat} (kPa)	61.15	60.78	60.39	59.99	5.23	11756.87	0.0990	25.15
$P_{bundle,in}$ (kPa)	60.62				4.77	11722.06	0.0985	
$P_{bundle,out}$ (kPa)	60.20				4.27	11599.47	0.0979	
m_{ref} (kg/s)	0.47				3.77	10883.18	0.0974	
	Path B	**Path C**	**Path D**	**Path E**	3.30	9759.10	0.0969	
$T_{water,in}$ (˚C)	17.86	17.85	17.93	17.86	0.00	0.00	0.0933	
$T_{water,out}$ (˚C)	15.19	15.26	15.23	15.20	0.00	0.00	0.0933	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	0.00	0.00	0.0933	
	Pre-boiler				0.00	0.00	0.0933	
$T_{water,in}$ (˚C)	26.43				0.00	0.00	0.0933	
$T_{water,out}$ (˚C)	24.14							
m_{water} (kg/s)	1.87							
$T_{ref,in}$ (˚C)	-7.25							
$P_{ref,in}$ (kPa)	94.04							
$P_{ref,out}$ (kPa)	87.49							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	18.78	16.63	15.79	15.48	50.93	19822.23	0.5069	
T_1 (˚C)	18.37	16.46	15.75	15.48	46.34	21098.85	0.5036	
T_2 (˚C)	17.92	16.27	15.68	15.46	41.46	22351.07	0.5004	
T_3 (˚C)	17.48	16.11	15.62	15.45	36.58	22464.46	0.4975	
T_4 (˚C)	17.17	16.01	15.57	15.44	31.98	22723.57	0.4951	
T_5 (˚C)	16.86	15.88	15.54	15.44	20.54	18884.94	0.4091	
T_{out} (˚C)	16.62	15.80	15.51	15.43	18.34	19553.75	0.4091	
m_{water} (kg/s)	0.27				16.01	19399.91	0.4093	
$P_{water,in}$ (kPa)	738.33	N/A	N/A	339.31	13.68	17902.82	0.4095	
$P_{water,out}$ (kPa)	603.68	N/A	N/A	191.58	11.48	16924.57	0.4099	
P_{sat} (kPa)	62.58	62.34	62.04	61.75	7.22	14159.46	0.3597	24.96
$P_{bundle,in}$ (kPa)	61.88				6.59	14464.11	0.3590	
$P_{bundle,out}$ (kPa)	62.07				5.91	14601.97	0.3582	
m_{ref} (kg/s)	0.47				5.23	14009.71	0.3575	
	Path B	**Path C**	**Path D**	**Path E**	4.59	12960.58	0.3568	
$T_{water,in}$ (˚C)	18.81	18.80	18.88	18.80	0.00	0.00	0.3518	
$T_{water,out}$ (˚C)	15.86	15.92	15.89	15.88	0.00	0.00	0.3518	
m_{water} (kg/s)	0.31	0.31	0.32	0.33	0.00	0.00	0.3518	
	Pre-boiler				0.00	0.00	0.3518	
$T_{water,in}$ (˚C)	42.97				0.00	0.00	0.3518	
$T_{water,out}$ (˚C)	39.50							
m_{water} (kg/s)	2.68							
$T_{ref,in}$ (˚C)	-6.01							
$P_{ref,in}$ (kPa)	130.72							
$P_{ref,out}$ (kPa)	129.95							

Point ID	R-123, P/D 1.33, 25 25 0.30							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m²·˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.32	17.23	15.94	15.43	72.41	19387.80	0.5651	
T_1 (˚C)	19.75	16.97	15.85	15.41	66.05	20604.18	0.5629	
T_2 (˚C)	19.10	16.68	15.75	15.38	59.29	22024.22	0.5613	
T_3 (˚C)	18.47	16.43	15.65	15.35	52.54	22310.79	0.5605	
T_4 (˚C)	18.01	16.26	15.57	15.32	46.18	22576.79	0.5604	
T_5 (˚C)	17.58	16.07	15.51	15.32	31.75	20619.11	0.4350	
T_{out} (˚C)	17.22	15.95	15.45	15.30	28.34	21512.69	0.4323	
m_{water} (kg/s)	0.27				24.71	21687.33	0.4298	
$P_{water,in}$ (kPa)	739.81	N/A	N/A	343.27	21.08	20357.76	0.4277	
$P_{water,out}$ (kPa)	605.32	N/A	N/A	193.21	17.67	19482.02	0.4262	
P_{sat} (kPa)	62.14	61.90	61.65	61.34	11.88	17041.51	0.3526	25.12
$P_{bundle,in}$ (kPa)	61.45				10.81	17672.19	0.3537	
$P_{bundle,out}$ (kPa)	61.66				9.68	18224.74	0.3551	
m_{ref} (kg/s)	0.47				8.54	17944.28	0.3566	
	Path B	**Path C**	**Path D**	**Path E**	7.47	17028.22	0.3582	
$T_{water,in}$ (˚C)	20.36	20.35	20.43	20.36	3.66	11565.48	0.3119	
$T_{water,out}$ (˚C)	15.99	16.04	16.01	16.02	3.32	11327.32	0.3116	
m_{water} (kg/s)	0.31	0.31	0.32	0.33	2.96	10898.02	0.3112	
	Pre-boiler				2.60	10351.91	0.3108	
$T_{water,in}$ (˚C)	44.11				2.27	9026.76	0.3104	
$T_{water,out}$ (˚C)	35.75							
m_{water} (kg/s)	1.01							
$T_{ref,in}$ (˚C)	-5.83							
$P_{ref,in}$ (kPa)	130.67							
$P_{ref,out}$ (kPa)	123.02							

Point ID	R-123, P/D 1.33, 25 30 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.29	17.58	15.97	15.32	85.74	18658.51	0.4022	
T_1 (˚C)	20.61	17.25	15.86	15.30	78.54	19796.55	0.4001	
T_2 (˚C)	19.85	16.90	15.73	15.26	70.89	21127.41	0.3985	
T_3 (˚C)	19.10	16.59	15.59	15.23	63.24	21708.00	0.3979	
T_4 (˚C)	18.52	16.38	15.49	15.20	56.05	22010.21	0.3981	
T_5 (˚C)	18.03	16.13	15.41	15.19	39.21	20613.14	0.2463	
T_{out} (˚C)	17.58	15.98	15.35	15.17	35.09	21495.83	0.2433	
m_{water} (kg/s)	0.27				30.72	21792.32	0.2405	
$P_{water,in}$ (kPa)	737.71	N/A	N/A	340.80	26.34	20623.77	0.2383	
$P_{water,out}$ (kPa)	603.96	N/A	N/A	193.06	22.23	20055.26	0.2365	
P_{sat} (kPa)	61.74	61.40	61.11	60.79	15.44	18336.18	0.1466	25.30
$P_{bundle,in}$ (kPa)	61.07				13.96	18939.43	0.1477	
$P_{bundle,out}$ (kPa)	61.10				12.38	19613.73	0.1491	
m_{ref} (kg/s)	0.48				10.80	19324.51	0.1506	
	Path B	**Path C**	**Path D**	**Path E**	9.32	18077.58	0.1522	
$T_{water,in}$ (˚C)	21.34	21.33	21.40	21.33	4.15	11477.41	0.0954	
$T_{water,out}$ (˚C)	16.04	16.11	16.05	16.05	3.79	11353.94	0.0950	
m_{water} (kg/s)	0.32	0.32	0.32	0.32	3.41	11066.33	0.0946	
	Pre-boiler				3.03	10631.26	0.0941	
$T_{water,in}$ (˚C)	27.31				2.66	9497.08	0.0938	
$T_{water,out}$ (˚C)	24.08							
m_{water} (kg/s)	1.29							
$T_{ref,in}$ (˚C)	-6.07							
$P_{ref,in}$ (kPa)	94.40							
$P_{ref,out}$ (kPa)	88.00							

Point ID	R-123, P/D 1.33, 25 45 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	24.44	19.06	16.57	15.47	123.42	17558.63	0.5708	
T_1 (˚C)	23.48	18.54	16.37	15.41	113.45	18563.88	0.5685	
T_2 (˚C)	22.39	18.02	16.15	15.33	102.85	19863.27	0.5674	
T_3 (˚C)	21.27	17.54	15.92	15.25	92.26	20373.41	0.5677	
T_4 (˚C)	20.44	17.19	15.74	15.19	82.28	20713.98	0.5691	
T_5 (˚C)	19.71	16.82	15.61	15.15	59.83	20104.25	0.3420	
T_{out} (˚C)	19.06	16.58	15.49	15.11	53.77	20930.62	0.3375	
m_{water} (kg/s)	0.27				47.34	21437.03	0.3333	
$P_{water,in}$ (kPa)	739.55	N/A	N/A	342.40	40.90	20660.09	0.3299	
$P_{water,out}$ (kPa)	606.43	N/A	N/A	194.68	34.84	20319.52	0.3273	
P_{sat} (kPa)	61.28	61.03	60.75	60.44	25.97	19882.97	0.1920	25.06
$P_{bundle,in}$ (kPa)	60.61				23.59	20951.79	0.1939	
$P_{bundle,out}$ (kPa)	60.80				21.07	22252.36	0.1961	
m_{ref} (kg/s)	0.47				18.54	22687.28	0.1985	
	Path B	**Path C**	**Path D**	**Path E**	16.16	22154.30	0.2012	
$T_{water,in}$ (˚C)	24.52	24.52	24.58	24.51	9.22	16651.34	0.1157	
$T_{water,out}$ (˚C)	16.51	16.58	16.54	16.60	8.28	16780.02	0.1146	
m_{water} (kg/s)	0.31	0.31	0.32	0.33	7.28	16688.99	0.1136	
	Pre-boiler				6.29	16114.24	0.1125	
$T_{water,in}$ (˚C)	28.48				5.35	14291.71	0.1115	
$T_{water,out}$ (˚C)	24.09							
m_{water} (kg/s)	0.99							
$T_{ref,in}$ (˚C)	-5.64							
$P_{ref,in}$ (kPa)	95.44							
$P_{ref,out}$ (kPa)	88.58							

Point ID	**R-123, P/D 1.33, 35 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.52	14.70	14.47	14.46	19.94	18031.76	0.1291	
T_1 (˚C)	15.36	14.67	14.49	14.47	18.02	18760.82	0.1284	
T_2 (˚C)	15.18	14.61	14.48	14.48	15.97	19065.10	0.1276	
T_3 (˚C)	15.01	14.57	14.48	14.49	13.93	18022.42	0.1268	
T_4 (˚C)	14.91	14.55	14.49	14.49	12.01	17552.23	0.1261	
T_5 (˚C)	14.78	14.51	14.50	14.51	5.60	11228.50	0.1059	
T_{out} (˚C)	14.69	14.48	14.49	14.50	5.12	11449.92	0.1055	
m_{water} (kg/s)	0.27				4.60	11159.84	0.1051	
$P_{water,in}$ (kPa)	741.42	N/A	N/A	342.86	4.09	10181.31	0.1047	
$P_{water,out}$ (kPa)	606.80	N/A	N/A	196.20	3.61	9655.14	0.1044	
P_{sat} (kPa)	60.67	60.19	59.80	59.32	0.00	0.00	0.1016	35.23
$P_{bundle,in}$ (kPa)	60.15				0.00	0.00	0.1016	
$P_{bundle,out}$ (kPa)	59.51				0.00	0.00	0.1016	
m_{ref} (kg/s)	0.66				0.00	0.00	0.1016	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.1016	
$T_{water,in}$ (˚C)	15.54	15.51	15.59	15.53	0.00	0.00	0.1016	
$T_{water,out}$ (˚C)	14.60	14.66	14.65	14.60	0.00	0.00	0.1016	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	0.00	0.00	0.1016	
	Pre-boiler				0.00	0.00	0.1016	
$T_{water,in}$ (˚C)	31.13				0.00	0.00	0.1016	
$T_{water,out}$ (˚C)	28.75							
m_{water} (kg/s)	2.65							
$T_{ref,in}$ (˚C)	-7.68							
$P_{ref,in}$ (kPa)	107.64							
$P_{ref,out}$ (kPa)	99.93							

Point ID	**R-123, P/D 1.33, 35 15 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.71	15.75	15.01	14.79	46.81	20264.77	0.1917	
T_1 (˚C)	17.34	15.60	14.99	14.80	42.42	21469.21	0.1894	
T_2 (˚C)	16.92	15.43	14.94	14.80	37.75	22659.16	0.1871	
T_3 (˚C)	16.52	15.29	14.89	14.80	33.09	22671.67	0.1850	
T_4 (˚C)	16.23	15.20	14.86	14.79	28.70	22448.27	0.1833	
T_5 (˚C)	15.96	15.09	14.85	14.80	18.20	19271.81	0.1293	
T_{out} (˚C)	15.74	15.02	14.82	14.79	16.22	19917.87	0.1291	
m_{water} (kg/s)	0.27				14.12	19738.94	0.1291	
$P_{water,in}$ (kPa)	737.44	N/A	N/A	338.87	12.03	18102.68	0.1291	
$P_{water,out}$ (kPa)	602.36	N/A	N/A	191.04	10.05	17021.15	0.1291	
P_{sat} (kPa)	61.11	60.74	60.37	59.98	5.04	11644.62	0.0968	35.26
$P_{bundle,in}$ (kPa)	60.52				4.61	11682.80	0.0964	
$P_{bundle,out}$ (kPa)	60.18				4.16	11655.18	0.0961	
m_{ref} (kg/s)	0.67				3.70	11031.49	0.0957	
	Path B	**Path C**	**Path D**	**Path E**	3.28	10027.10	0.0954	
$T_{water,in}$ (˚C)	17.75	17.73	17.81	17.74	0.00	0.00	0.0929	
$T_{water,out}$ (˚C)	15.16	15.22	15.20	15.16	0.00	0.00	0.0929	
m_{water} (kg/s)	0.32	0.31	0.32	0.32	0.00	0.00	0.0929	
	Pre-boiler				0.00	0.00	0.0929	
$T_{water,in}$ (˚C)	29.89				0.00	0.00	0.0929	
$T_{water,out}$ (˚C)	27.63							
m_{water} (kg/s)	2.64							
$T_{ref,in}$ (˚C)	-6.83							
$P_{ref,in}$ (kPa)	107.69							
$P_{ref,out}$ (kPa)	99.32							

Point ID	R-123, P/D 1.33, 35 30 0.08							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	22.41	18.68	17.05	16.39	86.52	18587.62	0.3093	
T_1 (˚C)	21.73	18.34	16.94	16.37	79.24	19702.66	0.3079	
T_2 (˚C)	20.97	17.99	16.80	16.33	71.51	21014.82	0.3069	
T_3 (˚C)	20.21	17.68	16.67	16.29	63.77	21598.24	0.3066	
T_4 (˚C)	19.62	17.46	16.56	16.26	56.49	21873.68	0.3070	
T_5 (˚C)	19.13	17.21	16.49	16.25	39.70	20720.63	0.1960	
T_{out} (˚C)	18.68	17.06	16.42	16.23	35.52	21638.12	0.1937	
m_{water} (kg/s)	0.27				31.07	21958.07	0.1917	
$P_{water,in}$ (kPa)	737.82	N/A	N/A	340.62	26.63	20820.49	0.1899	
$P_{water,out}$ (kPa)	604.11	N/A	N/A	192.77	22.45	20279.67	0.1886	
P_{sat} (kPa)	64.47	64.14	63.83	63.49	15.54	18650.01	0.1234	35.03
$P_{bundle,in}$ (kPa)	63.77				14.11	19410.91	0.1243	
$P_{bundle,out}$ (kPa)	63.81				12.58	20331.24	0.1254	
m_{ref} (kg/s)	0.66				11.05	20335.92	0.1266	
	Path B	Path C	Path D	Path E	9.61	19404.19	0.1279	
$T_{water,in}$ (˚C)	22.47	22.47	22.55	22.47	4.43	12831.34	0.0869	
$T_{water,out}$ (˚C)	17.11	17.18	17.12	17.12	3.99	12564.80	0.0865	
m_{water} (kg/s)	0.32	0.32	0.32	0.32	3.52	12071.75	0.0862	
	Pre-boiler				3.05	11338.38	0.0858	
$T_{water,in}$ (˚C)	29.78				2.61	9793.29	0.0855	
$T_{water,out}$ (˚C)	27.63							
m_{water} (kg/s)	2.65							
$T_{ref,in}$ (˚C)	-5.86							
$P_{ref,in}$ (kPa)	107.54							
$P_{ref,out}$ (kPa)	99.73							

Point ID	R-123, P/D 1.33, 45 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	15.86	15.06	14.83	14.82	19.57	18025.42	0.1180	
T_1 (˚C)	15.71	15.03	14.85	14.83	17.70	18788.32	0.1173	
T_2 (˚C)	15.53	14.97	14.84	14.84	15.71	19116.36	0.1167	
T_3 (˚C)	15.37	14.93	14.84	14.84	13.72	18073.91	0.1161	
T_4 (˚C)	15.27	14.91	14.85	14.85	11.84	17715.96	0.1155	
T_5 (˚C)	15.14	14.87	14.85	14.86	5.54	11394.42	0.0996	
T_{out} (˚C)	15.05	14.84	14.85	14.86	5.07	11707.53	0.0993	
m_{water} (kg/s)	0.27				4.56	11437.33	0.0990	
$P_{water,in}$ (kPa)	741.02	N/A	N/A	341.69	4.06	10463.34	0.0987	
$P_{water,out}$ (kPa)	606.10	N/A	N/A	194.51	3.59	9954.31	0.0985	
P_{sat} (kPa)	61.53	61.08	60.70	60.22	0.00	0.00	0.0963	45.20
$P_{bundle,in}$ (kPa)	60.96				0.00	0.00	0.0963	
$P_{bundle,out}$ (kPa)	60.41				0.00	0.00	0.0963	
m_{ref} (kg/s)	0.85				0.00	0.00	0.0963	
	Path B	Path C	Path D	Path E	0.00	0.00	0.0963	
$T_{water,in}$ (˚C)	15.89	15.87	15.95	15.88	0.00	0.00	0.0963	
$T_{water,out}$ (˚C)	14.95	15.02	15.01	14.95	0.00	0.00	0.0963	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	0.00	0.00	0.0963	
	Pre-boiler				0.00	0.00	0.0963	
$T_{water,in}$ (˚C)	33.07				0.00	0.00	0.0963	
$T_{water,out}$ (˚C)	30.11							
m_{water} (kg/s)	2.65							
$T_{ref,in}$ (˚C)	-7.20							
$P_{ref,in}$ (kPa)	119.36							
$P_{ref,out}$ (kPa)	110.89							

Point ID	R-123, P/D 1.33, 55 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	16.15	15.37	15.15	15.13	19.22	17870.99	0.1095	
T_1 (˚C)	16.00	15.34	15.16	15.14	17.38	18601.42	0.1090	
T_2 (˚C)	15.82	15.28	15.16	15.15	15.43	18902.50	0.1085	
T_3 (˚C)	15.67	15.24	15.16	15.16	13.47	17886.20	0.1080	
T_4 (˚C)	15.57	15.22	15.16	15.16	11.64	17491.52	0.1076	
T_5 (˚C)	15.44	15.18	15.17	15.17	5.34	11077.94	0.0949	
T_{out} (˚C)	15.36	15.16	15.16	15.17	4.90	11398.91	0.0947	
m_{water} (kg/s)	0.27				4.43	11156.98	0.0945	
$P_{water,in}$ (kPa)	739.94	N/A	N/A	339.87	3.96	10245.29	0.0942	
$P_{water,out}$ (kPa)	604.91	N/A	N/A	192.45	3.52	9806.12	0.0940	
P_{sat} (kPa)	62.29	61.85	61.49	61.00	0.00	0.00	0.0922	54.02
$P_{bundle,in}$ (kPa)	61.72				0.00	0.00	0.0922	
$P_{bundle,out}$ (kPa)	61.21				0.00	0.00	0.0922	
m_{ref} (kg/s)	1.02				0.00	0.00	0.0922	
	Path B	Path C	Path D	Path E	0.00	0.00	0.0922	
$T_{water,in}$ (˚C)	16.18	16.16	16.24	16.18	0.00	0.00	0.0922	
$T_{water,out}$ (˚C)	15.26	15.33	15.32	15.26	0.00	0.00	0.0922	
m_{water} (kg/s)	0.31	0.32	0.32	0.33	0.00	0.00	0.0922	
	Pre-boiler				0.00	0.00	0.0922	
$T_{water,in}$ (˚C)	39.08				0.00	0.00	0.0922	
$T_{water,out}$ (˚C)	26.17							
m_{water} (kg/s)	0.71							
$T_{ref,in}$ (˚C)	-6.84							
$P_{ref,in}$ (kPa)	125.31							
$P_{ref,out}$ (kPa)	120.78							

Point ID	R-123, P/D 1.5, 10 5 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	15.88	15.03	14.78	14.78	20.31	19700.15	0.4145	
T_1 (˚C)	15.72	15.00	14.78	14.79	18.29	21030.12	0.4126	
T_2 (˚C)	15.52	14.94	14.79	14.80	16.14	21545.96	0.4108	
T_3 (˚C)	15.36	14.88	14.80	14.80	13.99	21150.72	0.4089	
T_4 (˚C)	15.22	14.85	14.80	14.81	11.97	20616.84	0.4072	
T_5 (˚C)	15.10	14.83	14.81	14.83	5.89	12426.66	0.3612	
T_{out} (˚C)	15.02	14.80	14.80	14.83	5.28	12415.77	0.3601	
m_{water} (kg/s)	0.26				4.64	12027.38	0.3589	
$P_{water,in}$ (kPa)	692.42	N/A	N/A	336.56	4.00	10964.63	0.3578	
$P_{water,out}$ (kPa)	568.95	N/A	N/A	191.76	3.39	9571.16	0.3567	
P_{sat} (kPa)	61.53	60.73	60.61	60.31	0.00	0.00	0.3506	9.96
$P_{bundle,in}$ (kPa)	60.86				0.00	0.00	0.3506	
$P_{bundle,out}$ (kPa)	60.28				0.00	0.00	0.3506	
m_{ref} (kg/s)	0.28				0.00	0.00	0.3506	
	Path B	Path C	Path D	Path E	0.00	0.00	0.3506	
$T_{water,in}$ (˚C)	15.87	15.85	15.88	15.87	0.00	0.00	0.3506	
$T_{water,out}$ (˚C)	14.92	14.97	14.97	14.94	0.00	0.00	0.3506	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.3506	
	Pre-boiler				0.00	0.00	0.3506	
$T_{water,in}$ (˚C)	39.03				0.00	0.00	0.3506	
$T_{water,out}$ (˚C)	27.90							
m_{water} (kg/s)	0.51							
$T_{ref,in}$ (˚C)	-7.90							
$P_{ref,in}$ (kPa)	104.43							
$P_{ref,out}$ (kPa)	94.92							

Point ID	R-123, P/D 1.5, 10 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	18.08	15.92	15.13	14.89	52.09	20847.00	0.3513	
T_1 (˚C)	17.70	15.78	15.10	14.90	47.42	22702.19	0.3456	
T_2 (˚C)	17.20	15.59	15.03	14.90	42.46	23942.46	0.3400	
T_3 (˚C)	16.79	15.42	14.99	14.90	37.50	24723.49	0.3349	
T_4 (˚C)	16.45	15.29	14.96	14.90	32.83	25485.76	0.3305	
T_5 (˚C)	16.13	15.20	14.95	14.91	20.50	18958.39	0.1965	
T_{out} (˚C)	15.91	15.13	14.92	14.91	18.26	19464.88	0.1961	
m_{water} (kg/s)	0.27				15.88	19528.15	0.1958	
$P_{water,in}$ (kPa)	749.80	N/A	N/A	355.86	13.50	18475.55	0.1957	
$P_{water,out}$ (kPa)	613.31	N/A	N/A	195.40	11.26	16456.94	0.1957	
P_{sat} (kPa)	61.31	60.56	60.37	60.18	5.84	9587.12	0.1170	10.10
$P_{bundle,in}$ (kPa)	60.78				5.20	9466.78	0.1158	
$P_{bundle,out}$ (kPa)	60.15				4.52	8647.64	0.1146	
m_{ref} (kg/s)	0.29				3.84	7569.95	0.1134	
	Path B	Path C	Path D	Path E	3.19	6380.48	0.1123	
$T_{water,in}$ (˚C)	18.11	18.09	18.11	18.09	0.00	0.00	0.1066	
$T_{water,out}$ (˚C)	15.28	15.34	15.31	15.28	0.00	0.00	0.1066	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1066	
	Pre-boiler				0.00	0.00	0.1066	
$T_{water,in}$ (˚C)	32.91				0.00	0.00	0.1066	
$T_{water,out}$ (˚C)	20.55							
m_{water} (kg/s)	0.22							
$T_{ref,in}$ (˚C)	-7.70							
$P_{ref,in}$ (kPa)	83.77							
$P_{ref,out}$ (kPa)	79.56							

Point ID	R-123, P/D 1.5, 10 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	18.01	15.87	15.07	14.85	49.49	20956.15	0.5842	
T_1 (˚C)	17.62	15.73	15.03	14.85	44.81	22845.66	0.5785	
T_2 (˚C)	17.13	15.55	14.99	14.85	39.83	24205.65	0.5729	
T_3 (˚C)	16.72	15.39	14.95	14.85	34.86	24663.60	0.5679	
T_4 (˚C)	16.39	15.26	14.92	14.85	30.18	25260.04	0.5635	
T_5 (˚C)	16.08	15.17	14.90	14.86	19.03	18783.96	0.4325	
T_{out} (˚C)	15.86	15.09	14.87	14.85	16.95	19438.54	0.4321	
m_{water} (kg/s)	0.26				14.74	19595.13	0.4318	
$P_{water,in}$ (kPa)	691.72	N/A	N/A	335.76	12.52	18660.42	0.4317	
$P_{water,out}$ (kPa)	568.66	N/A	N/A	190.11	10.44	16665.15	0.4318	
P_{sat} (kPa)	61.19	60.53	60.45	60.35	4.77	8362.10	0.3541	9.95
$P_{bundle,in}$ (kPa)	60.55				4.35	8077.92	0.3533	
$P_{bundle,out}$ (kPa)	60.34				3.90	7721.40	0.3525	
m_{ref} (kg/s)	0.28				3.46	7161.40	0.3517	
	Path B	Path C	Path D	Path E	3.04	6387.60	0.3510	
$T_{water,in}$ (˚C)	18.00	17.98	18.00	17.99	0.00	0.00	0.3455	
$T_{water,out}$ (˚C)	15.23	15.26	15.24	15.22	0.00	0.00	0.3455	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.3455	
	Pre-boiler				0.00	0.00	0.3455	
$T_{water,in}$ (˚C)	40.62				0.00	0.00	0.3455	
$T_{water,out}$ (˚C)	27.72							
m_{water} (kg/s)	0.43							
$T_{ref,in}$ (˚C)	-7.40							
$P_{ref,in}$ (kPa)	104.18							
$P_{ref,out}$ (kPa)	94.76							

Point ID	R-123, P/D 1.5, 10 27 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	20.49	16.96	15.46	14.92	78.78	18892.02	0.8178	
T_1 (˚C)	19.91	16.68	15.36	14.90	72.52	20787.71	0.8150	
T_2 (˚C)	19.11	16.35	15.25	14.88	65.87	22485.71	0.8132	
T_3 (˚C)	18.43	16.04	15.15	14.85	59.22	23781.49	0.8127	
T_4 (˚C)	17.86	15.80	15.06	14.83	52.96	25551.63	0.8134	
T_5 (˚C)	17.33	15.63	15.01	14.82	35.44	20603.12	0.5820	
T_{out} (˚C)	16.95	15.48	14.95	14.80	31.62	21619.40	0.5772	
m_{water} (kg/s)	0.26				27.56	22298.43	0.5728	
$P_{water,in}$ (kPa)	691.80	N/A	N/A	336.29	23.50	21846.86	0.5690	
$P_{water,out}$ (kPa)	568.80	N/A	N/A	190.51	19.68	20015.30	0.5661	
P_{sat} (kPa)	60.87	60.29	60.28	60.26	12.25	14445.70	0.4321	9.88
$P_{bundle,in}$ (kPa)	60.17				11.00	14427.98	0.4339	
$P_{bundle,out}$ (kPa)	60.34				9.67	14085.81	0.4361	
m_{ref} (kg/s)	0.28				8.34	13246.03	0.4385	
	Path B	**Path C**	**Path D**	**Path E**	7.09	11767.34	0.4410	
$T_{water,in}$ (˚C)	20.50	20.50	20.51	20.51	3.12	9271.79	0.3593	
$T_{water,out}$ (˚C)	15.67	15.62	15.57	15.64	2.85	9034.32	0.3588	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	2.57	8611.94	0.3583	
	Pre-boiler				2.28	8179.25	0.3578	
$T_{water,in}$ (˚C)	40.75				2.01	7228.85	0.3573	
$T_{water,out}$ (˚C)	27.73							
m_{water} (kg/s)	0.43							
$T_{ref,in}$ (˚C)	-7.46							
$P_{ref,in}$ (kPa)	104.23							
$P_{ref,out}$ (kPa)	94.77							

Point ID	R-123, P/D 1.5, 10 30 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.13	17.41	15.79	15.20	86.35	18938.90	0.6027	
T_1 (˚C)	20.49	17.12	15.69	15.18	79.62	20671.31	0.5997	
T_2 (˚C)	19.66	16.76	15.56	15.16	72.47	22141.18	0.5978	
T_3 (˚C)	18.96	16.43	15.45	15.13	65.32	22925.76	0.5973	
T_4 (˚C)	18.41	16.16	15.36	15.11	58.58	24772.71	0.5981	
T_5 (˚C)	17.80	15.98	15.30	15.10	40.06	20700.26	0.3523	
T_{out} (˚C)	17.40	15.81	15.23	15.08	35.91	21713.38	0.3473	
m_{water} (kg/s)	0.27				31.50	22461.28	0.3426	
$P_{water,in}$ (kPa)	750.63	N/A	N/A	355.27	27.08	22160.32	0.3387	
$P_{water,out}$ (kPa)	614.17	N/A	N/A	196.31	22.93	20597.75	0.3357	
P_{sat} (kPa)	61.47	60.78	60.70	60.60	14.08	14744.11	0.1916	10.12
$P_{bundle,in}$ (kPa)	60.85				12.71	14902.75	0.1934	
$P_{bundle,out}$ (kPa)	60.63				11.26	14638.32	0.1954	
m_{ref} (kg/s)	0.29				9.81	13916.27	0.1978	
	Path B	**Path C**	**Path D**	**Path E**	8.44	12610.63	0.2003	
$T_{water,in}$ (˚C)	21.18	21.17	21.19	21.17	3.23	8661.30	0.1119	
$T_{water,out}$ (˚C)	15.91	15.93	15.87	15.88	2.98	8438.48	0.1115	
m_{water} (kg/s)	0.31	0.31	0.29	0.31	2.71	8083.04	0.1110	
	Pre-boiler				2.43	7687.33	0.1105	
$T_{water,in}$ (˚C)	30.53				2.18	6916.16	0.1101	
$T_{water,out}$ (˚C)	20.31							
m_{water} (kg/s)	0.27							
$T_{ref,in}$ (˚C)	-7.44							
$P_{ref,in}$ (kPa)	83.78							
$P_{ref,out}$ (kPa)	79.50							

Point ID	**R-123, P/D 1.5, 15 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.56	14.72	14.48	14.49	21.04	19452.64	0.1436	
T_1 (˚C)	15.41	14.69	14.52	14.50	19.07	20741.59	0.1426	
T_2 (˚C)	15.21	14.63	14.50	14.51	16.99	21244.42	0.1415	
T_3 (˚C)	15.05	14.58	14.51	14.52	14.90	21160.24	0.1405	
T_4 (˚C)	14.91	14.55	14.52	14.52	12.93	20875.49	0.1395	
T_5 (˚C)	14.79	14.53	14.53	14.54	6.14	11608.20	0.1087	
T_{out} (˚C)	14.71	14.52	14.52	14.54	5.30	10832.84	0.1078	
m_{water} (kg/s)	0.27				4.40	9708.95	0.1067	
$P_{water,in}$ (kPa)	749.69	N/A	N/A	356.46	3.51	7953.82	0.1057	
$P_{water,out}$ (kPa)	613.61	N/A	N/A	195.38	2.67	6118.06	0.1047	
P_{sat} (kPa)	60.81	60.00	59.73	59.45	0.00	0.00	0.1015	22.98
$P_{bundle,in}$ (kPa)	60.37				0.00	0.00	0.1015	
$P_{bundle,out}$ (kPa)	59.38				0.00	0.00	0.1015	
m_{ref} (kg/s)	0.43				0.00	0.00	0.1015	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.1015	
$T_{water,in}$ (˚C)	15.58	15.55	15.58	15.57	0.00	0.00	0.1015	
$T_{water,out}$ (˚C)	14.63	14.69	14.68	14.66	0.00	0.00	0.1015	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1015	
	Pre-boiler				0.00	0.00	0.1015	
$T_{water,in}$ (˚C)	27.48				0.00	0.00	0.1015	
$T_{water,out}$ (˚C)	25.92							
m_{water} (kg/s)	2.65							
$T_{ref,in}$ (˚C)	-7.89							
$P_{ref,in}$ (kPa)	92.12							
$P_{ref,out}$ (kPa)	86.43							

Point ID	**R-123, P/D 1.5, 15 5 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.60	14.77	14.51	14.50	19.81	19764.04	0.3902	
T_1 (˚C)	15.44	14.74	14.52	14.51	17.81	21044.13	0.3890	
T_2 (˚C)	15.24	14.68	14.53	14.51	15.68	21433.23	0.3877	
T_3 (˚C)	15.09	14.62	14.53	14.52	13.56	20939.59	0.3865	
T_4 (˚C)	14.96	14.59	14.53	14.52	11.56	20263.01	0.3853	
T_5 (˚C)	14.84	14.57	14.53	14.54	5.94	11745.74	0.3550	
T_{out} (˚C)	14.76	14.54	14.52	14.54	5.31	11591.64	0.3542	
m_{water} (kg/s)	0.26				4.64	11094.99	0.3535	
$P_{water,in}$ (kPa)	692.02	N/A	N/A	333.27	3.97	9983.20	0.3527	
$P_{water,out}$ (kPa)	567.64	N/A	N/A	191.27	3.34	8608.23	0.3519	
P_{sat} (kPa)	60.64	59.99	59.89	59.72	0.00	0.00	0.3480	15.21
$P_{bundle,in}$ (kPa)	59.95				0.00	0.00	0.3480	
$P_{bundle,out}$ (kPa)	59.68				0.00	0.00	0.3480	
m_{ref} (kg/s)	0.43				0.00	0.00	0.3480	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.3480	
$T_{water,in}$ (˚C)	15.58	15.56	15.59	15.58	0.00	0.00	0.3480	
$T_{water,out}$ (˚C)	14.63	14.67	14.66	14.63	0.00	0.00	0.3480	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.3480	
	Pre-boiler				0.00	0.00	0.3480	
$T_{water,in}$ (˚C)	50.40				0.00	0.00	0.3480	
$T_{water,out}$ (˚C)	34.22							
m_{water} (kg/s)	0.53							
$T_{ref,in}$ (˚C)	-7.22							
$P_{ref,in}$ (kPa)	129.74							
$P_{ref,out}$ (kPa)	121.32							

Point ID	R-123, P/D 1.5, 15 15 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	17.79	15.62	14.82	14.58	52.39	20904.22	0.2665	
T_1 (˚C)	17.41	15.48	14.80	14.59	47.68	22766.58	0.2626	
T_2 (˚C)	16.91	15.29	14.73	14.59	42.67	24028.02	0.2587	
T_3 (˚C)	16.50	15.12	14.69	14.60	37.67	24774.26	0.2552	
T_4 (˚C)	16.15	14.99	14.66	14.60	32.96	25527.36	0.2522	
T_5 (˚C)	15.83	14.90	14.64	14.61	20.63	19013.99	0.1610	
T_{out} (˚C)	15.61	14.82	14.61	14.60	18.35	19481.50	0.1607	
m_{water} (kg/s)		0.27			15.93	19503.28	0.1605	
$P_{water,in}$ (kPa)	749.38	N/A	N/A	355.61	13.50	18366.72	0.1605	
$P_{water,out}$ (kPa)	613.74	N/A	N/A	194.41	11.22	16261.36	0.1605	
P_{sat} (kPa)	60.55	59.82	59.63	59.45	6.01	9838.16	0.1073	14.87
$P_{bundle,in}$ (kPa)		59.99			5.33	9694.88	0.1064	
$P_{bundle,out}$ (kPa)		59.40			4.61	8813.89	0.1056	
m_{ref} (kg/s)		0.42			3.90	7674.08	0.1047	
	Path B	Path C	Path D	Path E	3.22	6415.07	0.1039	
$T_{water,in}$ (˚C)	17.81	17.79	17.82	17.82	0.00	0.00	0.1000	
$T_{water,out}$ (˚C)	14.98	15.02	15.00	14.98	0.00	0.00	0.1000	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1000	
		Pre-boiler			0.00	0.00	0.1000	
$T_{water,in}$ (˚C)		27.53			0.00	0.00	0.1000	
$T_{water,out}$ (˚C)		23.20						
m_{water} (kg/s)		0.91						
$T_{ref,in}$ (˚C)		-7.29						
$P_{ref,in}$ (kPa)		90.76						
$P_{ref,out}$ (kPa)		84.87						

Point ID	R-123, P/D 1.5, 15 15 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	18.03	15.88	15.08	14.83	49.56	20940.98	0.5061	
T_1 (˚C)	17.64	15.75	15.04	14.84	44.88	22857.06	0.5022	
T_2 (˚C)	17.15	15.56	14.99	14.83	39.90	24201.58	0.4985	
T_3 (˚C)	16.74	15.39	14.95	14.83	34.93	24722.61	0.4950	
T_4 (˚C)	16.40	15.27	14.91	14.82	30.24	25351.22	0.4921	
T_5 (˚C)	16.09	15.18	14.89	14.83	19.21	19102.62	0.4043	
T_{out} (˚C)	15.87	15.10	14.86	14.82	17.12	19844.40	0.4042	
m_{water} (kg/s)		0.26			14.89	20090.31	0.4042	
$P_{water,in}$ (kPa)	692.83	N/A	N/A	334.94	12.66	19188.52	0.4043	
$P_{water,out}$ (kPa)	569.51	N/A	N/A	190.50	10.56	17204.58	0.4046	
P_{sat} (kPa)	61.11	60.51	60.49	60.38	5.17	9066.25	0.3534	14.89
$P_{bundle,in}$ (kPa)		60.35			4.72	8833.12	0.3528	
$P_{bundle,out}$ (kPa)		60.39			4.24	8498.71	0.3522	
m_{ref} (kg/s)		0.43			3.77	7952.69	0.3517	
	Path B	Path C	Path D	Path E	3.32	7151.36	0.3511	
$T_{water,in}$ (˚C)	18.04	18.02	18.04	18.03	0.00	0.00	0.3471	
$T_{water,out}$ (˚C)	15.24	15.26	15.23	15.23	0.00	0.00	0.3471	
m_{water} (kg/s)	0.31	0.31	0.29	0.31	0.00	0.00	0.3471	
		Pre-boiler			0.00	0.00	0.3471	
$T_{water,in}$ (˚C)		41.31			0.00	0.00	0.3471	
$T_{water,out}$ (˚C)		36.90						
m_{water} (kg/s)		1.91						
$T_{ref,in}$ (˚C)		-7.57						
$P_{ref,in}$ (kPa)		129.05						
$P_{ref,out}$ (kPa)		120.21						

Point ID	R-123, P/D 1.5, 15 30 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	21.10	17.36	15.73	15.14	86.75	18908.77	0.4422	
T_1 (˚C)	20.46	17.07	15.63	15.12	80.00	20641.97	0.4402	
T_2 (˚C)	19.63	16.71	15.50	15.09	72.83	22113.80	0.4390	
T_3 (˚C)	18.92	16.37	15.39	15.07	65.65	22899.29	0.4386	
T_4 (˚C)	18.36	16.11	15.30	15.05	58.90	24741.18	0.4392	
T_5 (˚C)	17.76	15.92	15.24	15.04	40.28	20793.36	0.2707	
T_{out} (˚C)	17.35	15.75	15.17	15.02	36.09	21820.22	0.2672	
m_{water} (kg/s)		0.27			31.64	22577.25	0.2639	
$P_{water,in}$ (kPa)	750.13	N/A	N/A	355.91	27.19	22276.54	0.2612	
$P_{water,out}$ (kPa)	613.25	N/A	N/A	196.21	23.01	20689.05	0.2591	
P_{sat} (kPa)	61.33	60.65	60.56	60.43	14.21	14991.64	0.1598	14.90
$P_{bundle,in}$ (kPa)		60.66			12.82	15170.90	0.1610	
$P_{bundle,out}$ (kPa)		60.45			11.34	14900.68	0.1624	
m_{ref} (kg/s)		0.43			9.87	14156.62	0.1640	
	Path B	**Path C**	**Path D**	**Path E**	8.48	12822.02	0.1658	
$T_{water,in}$ (˚C)	21.14	21.13	21.15	21.14	3.38	9219.93	0.1044	
$T_{water,out}$ (˚C)	15.85	15.88	15.81	15.82	3.09	8938.84	0.1041	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	2.79	8510.38	0.1037	
		Pre-boiler			2.49	8036.80	0.1033	
$T_{water,in}$ (˚C)		29.02			2.20	7126.79	0.1030	
$T_{water,out}$ (˚C)		22.51						
m_{water} (kg/s)		0.62						
$T_{ref,in}$ (˚C)		-7.60						
$P_{ref,in}$ (kPa)		91.11						
$P_{ref,out}$ (kPa)		85.31						

Point ID	R-123, P/D 1.5, 15 30 0.35							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m².˚C)	x	G (kg/m².s)
T_{in} (˚C)	20.83	17.26	15.69	15.09	83.27	19195.35	0.6718	
T_1 (˚C)	20.22	16.98	15.59	15.06	76.65	20957.79	0.6698	
T_2 (˚C)	19.42	16.63	15.46	15.03	69.62	22521.76	0.6685	
T_3 (˚C)	18.73	16.31	15.34	14.99	62.59	23127.45	0.6682	
T_4 (˚C)	18.22	16.06	15.25	14.96	55.97	25016.24	0.6687	
T_5 (˚C)	17.63	15.88	15.19	14.95	38.59	20931.14	0.5094	
T_{out} (˚C)	17.25	15.71	15.12	14.93	34.63	22064.41	0.5062	
m_{water} (kg/s)		0.27			30.43	22899.09	0.5033	
$P_{water,in}$ (kPa)	748.19	N/A	N/A	353.59	26.23	22733.80	0.5008	
$P_{water,out}$ (kPa)	611.82	N/A	N/A	195.79	22.27	21273.37	0.4990	
P_{sat} (kPa)	61.12	60.58	60.62	60.57	14.45	15759.88	0.4059	15.10
$P_{bundle,in}$ (kPa)		60.33			13.00	15999.48	0.4070	
$P_{bundle,out}$ (kPa)		60.63			11.47	15696.74	0.4084	
m_{ref} (kg/s)		0.43			9.93	14878.63	0.4099	
	Path B	**Path C**	**Path D**	**Path E**	8.48	13414.41	0.4115	
$T_{water,in}$ (˚C)	20.86	20.86	20.88	20.87	4.49	12344.63	0.3547	
$T_{water,out}$ (˚C)	15.78	15.77	15.72	15.74	4.03	11993.62	0.3542	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	3.55	11316.42	0.3536	
		Pre-boiler			3.08	10575.37	0.3531	
$T_{water,in}$ (˚C)		41.77			2.62	9071.58	0.3525	
$T_{water,out}$ (˚C)		37.31						
m_{water} (kg/s)		1.91						
$T_{ref,in}$ (˚C)		-7.03						
$P_{ref,in}$ (kPa)		129.78						
$P_{ref,out}$ (kPa)		121.56						

Point ID	R-123, P/D 1.5, 15 42 0.24							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	24.33	18.77	16.26	15.25	118.23	17083.07	0.7293	
T_1 (˚C)	23.42	18.31	16.07	15.19	109.64	18746.35	0.7280	
T_2 (˚C)	22.19	17.76	15.84	15.12	100.52	20320.39	0.7279	
T_3 (˚C)	21.12	17.24	15.65	15.06	91.40	21416.72	0.7293	
T_4 (˚C)	20.28	16.83	15.49	15.01	82.81	23455.58	0.7320	
T_5 (˚C)	19.38	16.53	15.38	14.98	57.80	20496.64	0.4863	
T_{out} (˚C)	18.77	16.27	15.27	14.94	51.78	21708.15	0.4815	
m_{water} (kg/s)		0.25			45.39	22712.35	0.4772	
$P_{water,in}$ (kPa)	664.62	N/A	N/A	325.33	39.00	22827.89	0.4736	
$P_{water,out}$ (kPa)	547.27	N/A	N/A	185.17	32.99	21485.08	0.4709	
P_{sat} (kPa)	60.97	60.44	60.47	60.45	23.08	18201.17	0.3264	15.05
$P_{bundle,in}$ (kPa)		60.20			20.62	18892.55	0.3279	
$P_{bundle,out}$ (kPa)		60.52			18.00	18898.01	0.3298	
m_{ref} (kg/s)		0.43			15.39	18189.66	0.3320	
	Path B	**Path C**	**Path D**	**Path E**	12.93	16453.24	0.3344	
$T_{water,in}$ (˚C)	24.37	24.38	24.38	24.37	7.38	15254.70	0.2449	
$T_{water,out}$ (˚C)	16.45	16.39	16.30	16.39	6.61	15180.88	0.2439	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	5.78	14707.98	0.2429	
		Pre-boiler			4.96	13987.43	0.2420	
$T_{water,in}$ (˚C)		36.18			4.18	12239.61	0.2410	
$T_{water,out}$ (˚C)		31.37						
m_{water} (kg/s)		1.31						
$T_{ref,in}$ (˚C)		-5.58						
$P_{ref,in}$ (kPa)		115.66						
$P_{ref,out}$ (kPa)		104.85						

Point ID	R-123, P/D 1.5, 15 42 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	24.76	21.21	17.98	16.43	74.43	9306.52	0.7998	
T_1 (˚C)	24.39	20.62	17.71	16.31	73.00	10052.91	0.8074	
T_2 (˚C)	23.63	19.93	17.36	16.18	71.49	10949.58	0.8166	
T_3 (˚C)	22.88	19.28	17.07	16.07	69.98	11712.38	0.8270	
T_4 (˚C)	22.30	18.74	16.81	15.97	68.55	12930.99	0.8377	
T_5 (˚C)	21.60	18.35	16.63	15.90	78.15	19135.19	0.6325	
T_{out} (˚C)	21.21	17.99	16.45	15.84	70.69	20050.76	0.6261	
m_{water} (kg/s)		0.27			62.75	20804.91	0.6198	
$P_{water,in}$ (kPa)	747.17	N/A	N/A	354.71	54.82	20926.53	0.6141	
$P_{water,out}$ (kPa)	611.61	N/A	N/A	198.15	47.35	20092.05	0.6094	15.01
P_{sat} (kPa)	62.87	62.39	62.47	62.48	37.19	19598.23	0.4617	
$P_{bundle,in}$ (kPa)		62.02			33.65	20780.18	0.4624	
$P_{bundle,out}$ (kPa)		62.58			29.90	21445.33	0.4634	
m_{ref} (kg/s)		0.43			26.14	21568.21	0.4648	
	Path B	**Path C**	**Path D**	**Path E**	22.60	20636.55	0.4662	
$T_{water,in}$ (˚C)	24.85	24.87	24.87	24.86	15.12	21072.01	0.3729	
$T_{water,out}$ (˚C)	17.75	17.22	17.18	17.72	13.53	21737.23	0.3710	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	11.83	21921.48	0.3689	
		Pre-boiler			10.13	21527.49	0.3669	
$T_{water,in}$ (˚C)		41.68			8.53	19707.05	0.3650	
$T_{water,out}$ (˚C)		37.63						
m_{water} (kg/s)		2.12						
$T_{ref,in}$ (˚C)		-6.55						
$P_{ref,in}$ (kPa)		130.00						
$P_{ref,out}$ (kPa)		122.71						

Point ID	**R-123, P/D 1.5, 15 45 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	25.37	19.48	16.80	15.71	128.94	17462.84	0.6284	
T_1 (˚C)	24.36	18.99	16.60	15.64	119.05	18998.20	0.6261	
T_2 (˚C)	23.06	18.40	16.36	15.57	108.55	20329.27	0.6251	
T_3 (˚C)	21.95	17.85	16.15	15.50	98.05	21157.74	0.6258	
T_4 (˚C)	21.06	17.41	15.97	15.45	88.16	22771.75	0.6279	
T_5 (˚C)	20.12	17.09	15.85	15.41	62.65	20410.56	0.3662	
T_{out} (˚C)	19.47	16.81	15.73	15.38	56.26	21594.74	0.3611	
m_{water} (kg/s)	0.26				49.46	22611.57	0.3565	
$P_{water,in}$ (kPa)	690.78	N/A	N/A	334.91	42.67	22765.74	0.3528	
$P_{water,out}$ (kPa)	568.13	N/A	N/A	190.58	36.28	21567.30	0.3501	
P_{sat} (kPa)	61.97	61.37	61.37	61.32	25.40	18422.74	0.1953	15.07
$P_{bundle,in}$ (kPa)	61.26				22.77	19200.12	0.1969	
$P_{bundle,out}$ (kPa)	61.37				19.99	19349.20	0.1989	
m_{ref} (kg/s)	0.43				17.20	18847.58	0.2013	
	Path B	**Path C**	**Path D**	**Path E**	14.58	17301.55	0.2038	
$T_{water,in}$ (˚C)	25.43	25.43	25.44	25.43	8.13	15756.34	0.1077	
$T_{water,out}$ (˚C)	16.95	16.93	16.82	16.87	7.28	15718.45	0.1067	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	6.38	15336.34	0.1056	
	Pre-boiler				5.49	14600.36	0.1046	
$T_{water,in}$ (˚C)	35.80				4.64	12880.13	0.1035	
$T_{water,out}$ (˚C)	22.56							
m_{water} (kg/s)	0.28							
$T_{ref,in}$ (˚C)	-3.57							
$P_{ref,in}$ (kPa)	93.79							
$P_{ref,out}$ (kPa)	87.45							

Point ID	**R-123, P/D 1.5, 20 5 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.50	14.64	14.40	14.41	21.45	19931.50	0.1357	
T_1 (˚C)	15.35	14.61	14.44	14.42	19.44	21317.58	0.1349	
T_2 (˚C)	15.14	14.55	14.42	14.43	17.30	21909.85	0.1341	
T_3 (˚C)	14.98	14.50	14.42	14.43	15.16	21894.91	0.1333	
T_4 (˚C)	14.84	14.47	14.43	14.44	13.15	21688.13	0.1326	
T_5 (˚C)	14.72	14.45	14.44	14.46	6.37	12262.14	0.1087	
T_{out} (˚C)	14.63	14.44	14.44	14.46	5.50	11473.11	0.1079	
m_{water} (kg/s)	0.27				4.57	10338.16	0.1071	
$P_{water,in}$ (kPa)	750.34	N/A	N/A	355.50	3.64	8491.63	0.1063	
$P_{water,out}$ (kPa)	613.92	N/A	N/A	195.57	2.77	6535.89	0.1055	
P_{sat} (kPa)	60.58	59.79	59.55	59.28	0.00	0.00	0.1030	30.13
$P_{bundle,in}$ (kPa)	60.09				0.00	0.00	0.1030	
$P_{bundle,out}$ (kPa)	59.18				0.00	0.00	0.1030	
m_{ref} (kg/s)	0.57				0.00	0.00	0.1030	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.1030	
$T_{water,in}$ (˚C)	15.51	15.48	15.52	15.51	0.00	0.00	0.1030	
$T_{water,out}$ (˚C)	14.55	14.61	14.60	14.58	0.00	0.00	0.1030	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1030	
	Pre-boiler				0.00	0.00	0.1030	
$T_{water,in}$ (˚C)	30.28				0.00	0.00	0.1030	
$T_{water,out}$ (˚C)	27.80							
m_{water} (kg/s)	2.19							
$T_{ref,in}$ (˚C)	-7.79							
$P_{ref,in}$ (kPa)	101.69							
$P_{ref,out}$ (kPa)	94.67							

Point ID	R-123, P/D 1.5, 20 5 0.35							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	15.71	14.90	14.65	14.62	19.24	19522.14	0.3764	
T_1 (˚C)	15.56	14.87	14.65	14.63	17.34	20792.50	0.3756	
T_2 (˚C)	15.37	14.81	14.66	14.64	15.32	21215.64	0.3747	
T_3 (˚C)	15.22	14.76	14.65	14.64	13.30	20837.81	0.3739	
T_4 (˚C)	15.09	14.73	14.66	14.65	11.39	20311.58	0.3731	
T_5 (˚C)	14.98	14.70	14.66	14.66	5.79	11501.26	0.3505	
T_{out} (˚C)	14.89	14.68	14.65	14.66	5.21	11457.68	0.3500	
m_{water} (kg/s)		0.26			4.59	11020.08	0.3494	
$P_{water,in}$ (kPa)	686.17	N/A	N/A	333.19	3.97	10034.64	0.3489	
$P_{water,out}$ (kPa)	563.66	N/A	N/A	191.32	3.38	8805.79	0.3484	
P_{sat} (kPa)	60.87	60.32	60.25	60.08	0.00	0.00	0.3453	20.02
$P_{bundle,in}$ (kPa)		60.16			0.00	0.00	0.3453	
$P_{bundle,out}$ (kPa)		60.07			0.00	0.00	0.3453	
m_{ref} (kg/s)		0.57			0.00	0.00	0.3453	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.3453	
$T_{water,in}$ (˚C)	15.70	15.69	15.71	15.70	0.00	0.00	0.3453	
$T_{water,out}$ (˚C)	14.76	14.79	14.79	14.76	0.00	0.00	0.3453	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.3453	
		Pre-boiler			0.00	0.00	0.3453	
$T_{water,in}$ (˚C)		62.18			0.00	0.00	0.3453	
$T_{water,out}$ (˚C)		38.84						
m_{water} (kg/s)		0.48						
$T_{ref,in}$ (˚C)		-6.36						
$P_{ref,in}$ (kPa)		130.72						
$P_{ref,out}$ (kPa)		131.83						

Point ID	R-123, P/D 1.5, 20 15 0.10							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.90	15.66	14.83	14.57	54.00	20888.61	0.2318	
T_1 (˚C)	17.51	15.52	14.81	14.58	49.16	22763.83	0.2288	
T_2 (˚C)	17.00	15.32	14.73	14.58	44.02	24043.11	0.2259	
T_3 (˚C)	16.57	15.14	14.68	14.58	38.88	24819.41	0.2232	
T_4 (˚C)	16.21	15.01	14.65	14.58	34.05	25618.57	0.2209	
T_5 (˚C)	15.88	14.91	14.63	14.59	21.49	19317.44	0.1499	
T_{out} (˚C)	15.65	14.83	14.60	14.58	19.11	19848.83	0.1497	
m_{water} (kg/s)		0.27			16.59	19926.66	0.1495	
$P_{water,in}$ (kPa)	749.72	N/A	N/A	353.91	14.07	18819.44	0.1495	
$P_{water,out}$ (kPa)	613.99	N/A	N/A	195.27	11.69	16685.73	0.1495	
P_{sat} (kPa)	60.46	59.77	59.61	59.43	6.49	10422.47	0.1076	19.90
$P_{bundle,in}$ (kPa)		59.86			5.77	10334.46	0.1070	
$P_{bundle,out}$ (kPa)		59.38			5.01	9472.61	0.1063	
m_{ref} (kg/s)		0.57			4.24	8320.45	0.1056	
	Path B	**Path C**	**Path D**	**Path E**	3.53	7012.46	0.1050	
$T_{water,in}$ (˚C)	17.92	17.90	17.92	17.91	0.00	0.00	0.1018	
$T_{water,out}$ (˚C)	14.98	15.02	14.99	14.98	0.00	0.00	0.1018	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1018	
		Pre-boiler			0.00	0.00	0.1018	
$T_{water,in}$ (˚C)		29.16			0.00	0.00	0.1018	
$T_{water,out}$ (˚C)		27.17						
m_{water} (kg/s)		2.65						
$T_{ref,in}$ (˚C)		-6.85						
$P_{ref,in}$ (kPa)		101.73						
$P_{ref,out}$ (kPa)		94.34						

Point ID	**R-123, P/D 1.5, 20 15 0.35**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	18.29	16.16	15.35	15.10	49.40	21023.07	0.4660	
T_1 (˚C)	17.90	16.02	15.31	15.10	44.70	22924.75	0.4631	
T_2 (˚C)	17.41	15.84	15.26	15.09	39.70	24267.76	0.4604	
T_3 (˚C)	17.00	15.67	15.22	15.09	34.71	24767.82	0.4578	
T_4 (˚C)	16.67	15.54	15.18	15.08	30.01	25353.25	0.4557	
T_5 (˚C)	16.36	15.46	15.16	15.09	18.98	18827.40	0.3908	
T_{out} (˚C)	16.15	15.38	15.13	15.08	16.94	19553.08	0.3907	
m_{water} (kg/s)	0.26				14.77	19798.88	0.3907	
$P_{water,in}$ (kPa)	690.70	N/A	N/A	335.47	12.60	18992.74	0.3908	
$P_{water,out}$ (kPa)	567.73	N/A	N/A	190.96	10.55	17108.15	0.3910	
P_{sat} (kPa)	61.72	61.16	61.16	61.07	5.34	9328.25	0.3530	20.23
$P_{bundle,in}$ (kPa)	60.93				4.88	9100.30	0.3526	
$P_{bundle,out}$ (kPa)	61.09				4.38	8741.56	0.3521	
m_{ref} (kg/s)	0.58				3.88	8175.95	0.3517	
	Path B	**Path C**	**Path D**	**Path E**	3.42	7360.77	0.3513	
$T_{water,in}$ (˚C)	18.30	18.28	18.30	18.29	0.00	0.00	0.3482	
$T_{water,out}$ (˚C)	15.49	15.51	15.48	15.47	0.00	0.00	0.3482	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.3482	
	Pre-boiler				0.00	0.00	0.3482	
$T_{water,in}$ (˚C)	48.32				0.00	0.00	0.3482	
$T_{water,out}$ (˚C)	44.10							
m_{water} (kg/s)	2.71							
$T_{ref,in}$ (˚C)	-7.30							
$P_{ref,in}$ (kPa)	130.70							
$P_{ref,out}$ (kPa)	131.84							

Point ID	**R-123, P/D 1.5, 20 30 0.10**							
	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	21.29	17.38	15.67	15.04	90.48	18854.65	0.3651	
T_1 (˚C)	20.63	17.07	15.56	15.01	83.52	20603.87	0.3636	
T_2 (˚C)	19.76	16.69	15.42	14.98	76.12	22106.40	0.3627	
T_3 (˚C)	19.01	16.34	15.30	14.95	68.72	22948.75	0.3626	
T_4 (˚C)	18.43	16.06	15.20	14.92	61.75	24864.87	0.3633	
T_5 (˚C)	17.80	15.86	15.13	14.91	42.33	21033.94	0.2313	
T_{out} (˚C)	17.37	15.69	15.06	14.89	37.95	22123.68	0.2286	
m_{water} (kg/s)	0.27				33.30	22971.35	0.2261	
$P_{water,in}$ (kPa)	747.69	N/A	N/A	354.32	28.65	22764.69	0.2240	
$P_{water,out}$ (kPa)	611.51	N/A	N/A	196.15	24.27	21236.96	0.2224	
P_{sat} (kPa)	60.98	60.33	60.26	60.13	15.17	15620.21	0.1450	19.95
$P_{bundle,in}$ (kPa)	60.31				13.70	15893.85	0.1459	
$P_{bundle,out}$ (kPa)	60.12				12.13	15700.84	0.1470	
m_{ref} (kg/s)	0.57				10.56	15017.54	0.1482	
	Path B	**Path C**	**Path D**	**Path E**	9.08	13679.83	0.1495	
$T_{water,in}$ (˚C)	21.34	21.33	21.34	21.34	3.89	10415.26	0.1016	
$T_{water,out}$ (˚C)	15.78	15.80	15.74	15.74	3.53	10097.46	0.1013	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	3.15	9575.16	0.1010	
	Pre-boiler				2.78	8987.55	0.1006	
$T_{water,in}$ (˚C)	31.49				2.42	7872.20	0.1003	
$T_{water,out}$ (˚C)	24.59							
m_{water} (kg/s)	0.77							
$T_{ref,in}$ (˚C)	-7.50							
$P_{ref,in}$ (kPa)	100.07							
$P_{ref,out}$ (kPa)	93.10							

Point ID	R-123, P/D 1.5, 20 40 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	23.95	18.71	16.38	15.47	114.97	17856.07	0.4527	
T_1 (˚C)	23.04	18.29	16.21	15.42	106.03	19469.39	0.4510	
T_2 (˚C)	21.89	17.77	16.01	15.36	96.53	20849.75	0.4501	
T_3 (˚C)	20.90	17.29	15.84	15.31	87.03	21694.52	0.4503	
T_4 (˚C)	20.11	16.91	15.69	15.27	78.10	23399.86	0.4514	
T_5 (˚C)	19.28	16.64	15.59	15.24	54.74	20638.21	0.2793	
T_{out} (˚C)	18.70	16.39	15.49	15.21	49.11	21833.93	0.2760	
m_{water} (kg/s)	0.26				43.13	22867.98	0.2729	
$P_{water,in}$ (kPa)	689.15	N/A	N/A	332.86	37.14	22983.12	0.2703	
$P_{water,out}$ (kPa)	566.29	N/A	N/A	189.95	31.51	21672.04	0.2685	
P_{sat} (kPa)	61.67	61.05	61.03	60.93	21.07	17415.95	0.1667	20.15
$P_{bundle,in}$ (kPa)	60.95				18.89	17964.82	0.1679	
$P_{bundle,out}$ (kPa)	60.96				16.57	17897.03	0.1693	
m_{ref} (kg/s)	0.58				14.25	17216.89	0.1709	
	Path B	Path C	Path D	Path E	12.06	15634.35	0.1727	
$T_{water,in}$ (˚C)	23.99	23.99	24.00	23.99	6.34	13740.88	0.1100	
$T_{water,out}$ (˚C)	16.54	16.55	16.45	16.48	5.69	13538.83	0.1094	
m_{water} (kg/s)	0.31	0.31	0.29	0.31	5.00	13009.66	0.1088	
	Pre-boiler				4.31	12257.29	0.1082	
$T_{water,in}$ (˚C)	34.56				3.66	10690.61	0.1076	
$T_{water,out}$ (˚C)	24.92							
m_{water} (kg/s)	0.51							
$T_{ref,in}$ (˚C)	-2.82							
$P_{ref,in}$ (kPa)	103.23							
$P_{ref,out}$ (kPa)	95.67							

Point ID	R-123, P/D 1.5, 25 5 0.10							
	Tube A1	Tube A2	Tube A3	Tube A4	q" (kW/m)	h (W/m²·˚C)	x	G (kg/m².s)
T_{in} (˚C)	15.92	15.07	14.82	14.83	21.25	19985.15	0.1258	
T_1 (˚C)	15.77	15.04	14.87	14.84	19.25	21392.64	0.1251	
T_2 (˚C)	15.57	14.98	14.84	14.85	17.12	21999.73	0.1245	
T_3 (˚C)	15.41	14.93	14.85	14.86	14.99	21970.98	0.1238	
T_4 (˚C)	15.27	14.90	14.85	14.87	12.99	21732.92	0.1232	
T_5 (˚C)	15.15	14.87	14.87	14.89	6.30	12478.51	0.1043	
T_{out} (˚C)	15.06	14.86	14.86	14.88	5.49	11857.54	0.1037	
m_{water} (kg/s)	0.27				4.63	10905.53	0.1031	
$P_{water,in}$ (kPa)	750.58	N/A	N/A	355.55	3.77	9197.08	0.1025	
$P_{water,out}$ (kPa)	614.30	N/A	N/A	194.79	2.96	7351.20	0.1019	
P_{sat} (kPa)	61.63	60.85	60.64	60.35	0.00	0.00	0.0998	25.00
$P_{bundle,in}$ (kPa)	61.10				0.00	0.00	0.0998	
$P_{bundle,out}$ (kPa)	60.25				0.00	0.00	0.0998	
m_{ref} (kg/s)	0.71				0.00	0.00	0.0998	
	Path B	Path C	Path D	Path E	0.00	0.00	0.0998	
$T_{water,in}$ (˚C)	15.94	15.91	15.95	15.93	0.00	0.00	0.0998	
$T_{water,out}$ (˚C)	14.98	15.04	15.03	15.00	0.00	0.00	0.0998	
m_{water} (kg/s)	0.31	0.31	0.29	0.31	0.00	0.00	0.0998	
	Pre-boiler				0.00	0.00	0.0998	
$T_{water,in}$ (˚C)	32.49				0.00	0.00	0.0998	
$T_{water,out}$ (˚C)	29.93							
m_{water} (kg/s)	2.66							
$T_{ref,in}$ (˚C)	-7.95							
$P_{ref,in}$ (kPa)	112.03							
$P_{ref,out}$ (kPa)	104.40							

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	17.91	15.90	15.17	14.96	48.73	21241.99	0.1973	
T_1 (˚C)	17.55	15.77	15.15	14.96	44.27	23146.32	0.1951	
T_2 (˚C)	17.09	15.60	15.09	14.97	39.53	24406.91	0.1929	
T_3 (˚C)	16.71	15.44	15.05	14.97	34.79	25098.49	0.1909	
T_4 (˚C)	16.39	15.33	15.03	14.97	30.33	25764.13	0.1891	
T_5 (˚C)	16.09	15.25	15.01	14.99	18.86	19172.52	0.1393	
T_{out} (˚C)	15.89	15.17	14.98	14.98	16.79	19735.89	0.1392	
m_{water} (kg/s)		0.27			14.59	19822.16	0.1391	
$P_{water,in}$ (kPa)	750.49	N/A	N/A	356.43	12.40	18747.52	0.1391	
$P_{water,out}$ (kPa)	614.20	N/A	N/A	197.32	10.33	16644.55	0.1392	
P_{sat} (kPa)	61.51	60.82	60.67	60.48	5.31	9385.66	0.1103	25.03
$P_{bundle,in}$ (kPa)		60.88			4.74	9295.89	0.1099	
$P_{bundle,out}$ (kPa)		60.43			4.14	8514.74	0.1095	
m_{ref} (kg/s)		0.72			3.53	7501.60	0.1090	
	Path B	**Path C**	**Path D**	**Path E**	2.97	6364.31	0.1086	
$T_{water,in}$ (˚C)	17.93	17.91	17.94	17.92	0.00	0.00	0.1065	
$T_{water,out}$ (˚C)	15.33	15.37	15.34	15.33	0.00	0.00	0.1065	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.1065	
		Pre-boiler			0.00	0.00	0.1065	
$T_{water,in}$ (˚C)		32.81			0.00	0.00	0.1065	
$T_{water,out}$ (˚C)		29.74						
m_{water} (kg/s)		2.19						
$T_{ref,in}$ (˚C)		-6.19						
$P_{ref,in}$ (kPa)		113.90						
$P_{ref,out}$ (kPa)		105.41						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	16.14	15.31	15.06	15.06	20.95	20159.84	0.1140	
T_1 (˚C)	15.99	15.28	15.10	15.08	18.93	21538.98	0.1135	
T_2 (˚C)	15.79	15.22	15.08	15.09	16.78	22048.87	0.1130	
T_3 (˚C)	15.63	15.17	15.08	15.10	14.63	21864.96	0.1126	
T_4 (˚C)	15.50	15.14	15.09	15.10	12.60	21432.38	0.1122	
T_5 (˚C)	15.38	15.11	15.10	15.12	6.17	12415.82	0.0990	
T_{out} (˚C)	15.29	15.10	15.09	15.12	5.39	11794.30	0.0986	
m_{water} (kg/s)		0.27			4.55	10865.63	0.0982	
$P_{water,in}$ (kPa)	751.00	N/A	N/A	354.95	3.71	9170.19	0.0977	
$P_{water,out}$ (kPa)	613.80	N/A	N/A	194.63	2.92	7368.30	0.0973	
P_{sat} (kPa)	62.18	61.45	61.25	60.98	0.00	0.00	0.0958	35.04
$P_{bundle,in}$ (kPa)		61.58			0.00	0.00	0.0958	
$P_{bundle,out}$ (kPa)		60.86			0.00	0.00	0.0958	
m_{ref} (kg/s)		1.00			0.00	0.00	0.0958	
	Path B	**Path C**	**Path D**	**Path E**	0.00	0.00	0.0958	
$T_{water,in}$ (˚C)	16.16	16.13	16.16	16.15	0.00	0.00	0.0958	
$T_{water,out}$ (˚C)	15.21	15.27	15.26	15.23	0.00	0.00	0.0958	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.0958	
		Pre-boiler			0.00	0.00	0.0958	
$T_{water,in}$ (˚C)		35.02			0.00	0.00	0.0958	
$T_{water,out}$ (˚C)		31.61						
m_{water} (kg/s)		2.67						
$T_{ref,in}$ (˚C)		-6.44						
$P_{ref,in}$ (kPa)		120.97						
$P_{ref,out}$ (kPa)		124.76						

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	Tube A1	**Tube A2**	**Tube A3**	**Tube A4**	**q" (kW/m)**	**h (W/m².˚C)**	**x**	**G (kg/m².s)**
T_{in} (˚C)	18.18	16.21	15.50	15.30	47.71	21245.00	0.1620	
T_1 (˚C)	17.83	16.09	15.49	15.30	43.32	23128.05	0.1604	
T_2 (˚C)	17.38	15.92	15.42	15.31	38.66	24363.91	0.1589	
T_3 (˚C)	17.00	15.77	15.39	15.31	34.00	25043.91	0.1574	
T_4 (˚C)	16.69	15.66	15.36	15.31	29.62	25663.92	0.1562	
T_5 (˚C)	16.40	15.58	15.35	15.32	18.33	19110.88	0.1210	
T_{out} (˚C)	16.20	15.50	15.32	15.32	16.35	19718.63	0.1209	
m_{water} (kg/s)	0.27				14.24	19843.85	0.1209	
$P_{water,in}$ (kPa)	748.03	N/A	N/A	351.34	12.13	18859.65	0.1209	
$P_{water,out}$ (kPa)	612.03	N/A	N/A	194.57	10.15	16864.72	0.1210	
P_{sat} (kPa)	62.36	61.67	61.54	61.34	5.13	9268.63	0.1004	34.79
$P_{bundle,in}$ (kPa)	61.71				4.57	9139.83	0.1002	
$P_{bundle,out}$ (kPa)	61.28				3.98	8318.19	0.0999	
m_{ref} (kg/s)	0.99				3.38	7283.49	0.0995	
	Path B	**Path C**	**Path D**	**Path E**	2.82	6134.88	0.0993	
$T_{water,in}$ (˚C)	18.20	18.18	18.22	18.20	0.00	0.00	0.0978	
$T_{water,out}$ (˚C)	15.65	15.69	15.66	15.64	0.00	0.00	0.0978	
m_{water} (kg/s)	0.31	0.31	0.30	0.31	0.00	0.00	0.0978	
	Pre-boiler				0.00	0.00	0.0978	
$T_{water,in}$ (˚C)	35.50				0.00	0.00	0.0978	
$T_{water,out}$ (˚C)	31.51							
m_{water} (kg/s)	2.20							
$T_{ref,in}$ (˚C)	-4.89							
$P_{ref,in}$ (kPa)	126.82							
$P_{ref,out}$ (kPa)	127.60							