Geo-thermal Heat Exchange System

By

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Author’s Declaration

I hereby declare that I am the sole authors of this report.

Bahador Rafie Baharloo

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Abstract

Geo-exchange systems allow heat pumps to be operable in colder regions where the low efficiency of conventional heat pumps prohibit their usage. The barriers to the widespread usage of the geo-exchange systems are as following: 1) the high costs associated with the installation of the deep-well heat exchangers and horizontal-trench heat exchangers, 2) the high cost of real-estate in urban/suburban areas supporting the required footprint. The aims of this project (phases I-III) is to increase the energy density of geo-exchange (heat) systems resulting in reduced installation costs and land requirements.

Theoretically, by burying a fluid (water) filled tank, hosting the outdoor heat-exchanger, in the ground and below the frost line, a stable temperature could be achieved. This provides an optimal location for year-round heat transfer from the surrounding ground to the water within the tank and from the water to the heat-exchanger.

The project focused on the proper instrumentation of the system (using electronic sensors, a mini-computer, and the required coding/programming) as well as the ground-heat source (simulation) and aimed to build upon the phases I & II.

The instrumentation of the system was achieved using appropriate electronics. The installation of the heat belt and the insulation of the tank had no effect on the COP of the heat pump and/or the heat transfer rate as made possible to be evaluated by the instrumentation and the data analysis. However, the installation of the heat belt and the insulation of the tank increased the system lockout time by ~ 14 hours.

Improvements and iterations to this system are still required and include things such as further increasing heat transfer in the outdoor heat exchanger, multi-domain CFD analysis of the whole system including the ground heat as well as burying the tank and system physically into the ground to collect real life data.

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Chapter 1. Introduction

1.1 Introduction

Very low enthalpy geothermal energy (VLEGE) is heat transfer from the ground at low depth and low temperatures of less than 40°C [1]. The direct exchange system (also known as direct-expansion ground source heat pump) used in this project could be classified as a VLEGE system since it is embedded at low depth of about 3ft. The coefficient of performance (COP) of VLEGE systems is documented to be at around four [2]. In the case of the VLEGE systems, the temperature difference of the heat sources is not large and independent of the seasonal variations. Also, it is known that COP of the heat pump is inversely proportional to the temperature difference of the heat sources [3].

The purpose of this project is to investigate a geothermal heat exchange system of ~ two cubic meters dimension with small footprint requirements. Electronic sensors (temperature and pressure) in conjunction with a Raspberry-Pi will be used to further collect and investigate the operational parameters of the system. The operational steps to be carried by the Raspberry Pi are coded using Python language. The collected data will be analyzed using MATLAB code.

1.1.1 Project Objective

To investigate the effect of the ground temp profile on the performance of the geothermal heat exchange system based on the current setup.

1.1.2 Project Scope

This project will solely look at the initial start-up conditions focusing only on the heating mode of the system and will run for at least 10 consecutive hours to simulate the start-up and initial heating of a dwelling.

The prototype (including the instrumentation) will be in a lab setting rather than being installed underground. However, the system will be insulated on 5-sides except the top to separate the system from the lab environment. The initial/starting conditions will be of ~ 4.0°C and resemble that observed in the actual environment during the cold months in Vancouver.

1.2 Background

The following section covers the overall background of this report in the areas of ground heat, electronic instrumentation, and MATLAB data analysis.

1.2.1 Ground Heat

The typical operation of a geothermal exchange system with heat pump in heating mode is illustrated (***Figure-1.1***).

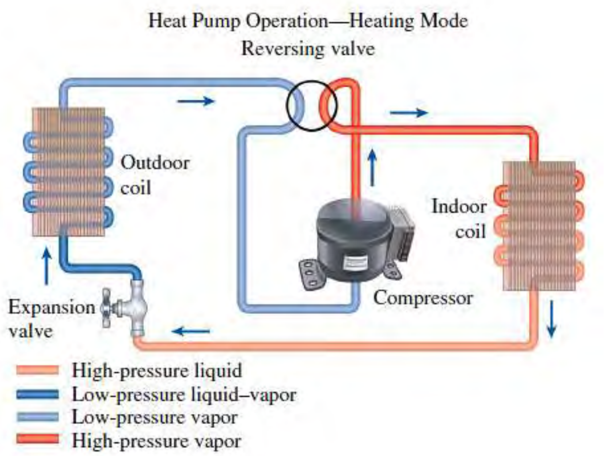

Figure 1.1- Direct Exchange Heat Pump Operation

In VLEGE system(s), the heat exchange takes place by internal fluid flowing through a collector system also known as the buried pipes. The collectors are placed horizontally taking on different shapes. The sizing of these collectors is based on the thermal performance of the soil (composition, density, water content, and the depth) in which the system is buried in. The two key soil parameters for designing a VLEGE system are the *soil temperature* at the collectors depth $T(z)$ and the *ground thermal diffusivity at the depth* (αz) [2].

Thermal diffusivity-α (m^2/s) is the ability of material to conduct thermal energy in relation to the material's capacity to store thermal energy. It is calculated through division of thermal conductivity by density and specific heat:

$$\alpha = \frac{k}{\rho C}$$

The ground thermal diffusivity values usually range from 1.72×10^{-6} m^2/s to 3.0×10^{-6} m^2/s based on the characteristics of the soil [4]. The search of the literature indicates that for a given soil type of constant composition with different densities and/or moisture degrees the α values range widely. Also, for a given soil and depth, depending on the rainfall α can vary throughout the year. Therefore, it makes sense to work with average values [2]. The α values could be estimated using tabulated data, experimentally in the laboratory setting using a test tube sample of the soil and/or through performing a thermal response test (TRT). TRT is the most reliable; however, most expensive method for analysis of soil thermal properties. [5] [6] [7] and not suitable for small/residential scale projects.

1.2.2 Numerical Simulation of Vertical Ground Heat

The annual cycles of the daily average soil temperature at the surface and at depth close to the surface follow a simple harmonic pattern that could be presented according to the following [8]:

$T_{soil(D,tyear)} = T_{mean} - T_{amp} * \exp(-\sqrt{(\pi /(365 * \alpha))} * \cos (2\pi/365 (t_{year} - t_{shift} - D/2\sqrt{365/(\pi * \alpha)})),$

where:

$T_{soil(D,tyear)}$ = Soil Temperature at depth D and Time of year

T_{mean} = Mean surface temperature (average air temperature). The temperature of the ground at an infinite depth will be this temperature

T_{amp} = Amplitude of surface temperature [(maximum air temperature - minimum air temperature)/2]

D = Depth below the surface (surface=0)

α = Thermal diffusivity of the ground (soil)

t_{year} = current time (day)

t_{shift} = day of the year of the minimum surface temperature

Generally, it is known that the earth temperature beyond a depth of 1 meter is usually insensitive to the diurnal cycle of air temperature and solar radiation. Also, annual fluctuation of the earth temperature extends to a depth of about 10 meters. For example, the temperature distribution with respect to time of the year for various depths is calculated and tabulated based on the Kasuda formula for Nicosia, Cyprus (***Figure-1.2***) [9].

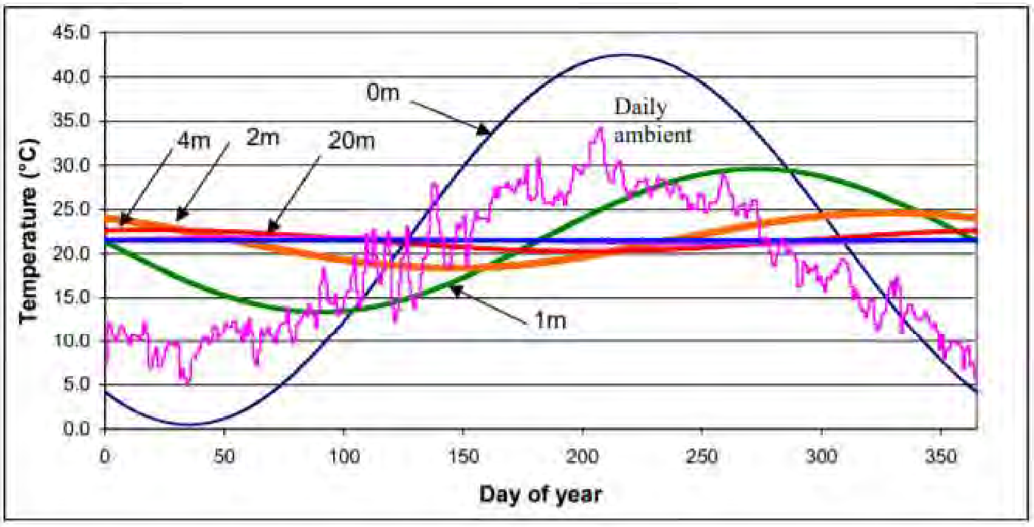

Figure 1.2 - Temperature variation at various depths as a function of time for Nicosia, Cyprus.

Florides and Kalogirou argue that the short-period temperature variations in winter are prominent to a depth of approximately 0.5 m. Because of the high thermal inertia of the soil, the temperature fluctuations at the surface of the ground are diminished as the depth of the ground increases and the temperature at 0.25 m depth gets its highest value of the day with a time lag of five hours compared to the maximum temperature at the depth of 0.1 m. The daily variation below the depth of 0.25 m is small and cannot be observed below the depth of one meter [9].

1.2.3 Raspberry Pi

The Raspberry Pi(s) are a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation. All Pi models feature a Broadcom system on a chip (SoC) with an integrated ARM-compatible central processing unit (CPU) and an on-chip graphics processing unit (GPU). Some of the related specifications can be summarized as following: processor speed ranging from 700 MHz to 1.4 GHz for the Pi 3 Model B+; on-board memory ranging from 256 MB to 1 GB RAM. Secure Digital (SD) cards in MicroSDHC form factor (SDHC on early models) are used to store the operating system and program memory. The Raspberry Pi can be accessed and operated with any other device/component with USB capabilities such as generic USB computer keyboard and mouse as well as USB storage, and USB to MIDI converters. The use of Raspberry Pi in both home, industrial, and commercial automation has gained traction in the recent years due to the low cost and relative simplicity of the system. The following is the complete list of various Raspberry Pi models:

Family	Model	Form Factor	Ethernet	Wireless	GPIO	Released	Discontinued
Raspberry Pi 1	B	Standard (85.60 × 56.5 mm)	Yes	No	26-pin	2012	Yes
	A		No			2013	Yes
	B+		Yes		40-pin	2014	
	A+	Compact (65 × 56.5 mm)	No			2014	
Raspberry Pi 2	B	Standard	Yes	No		2015	
Raspberry Pi Zero	Zero	Zero (65 × 30 mm)	No	No		2015	
	W/WH			Yes		2017	
Raspberry Pi 3	B	Standard	Yes	Yes		2016	
	A+	Compact	No			2018	
	B+	Standard	Yes			2018	

Table 1.1 - Various models of Raspberry Pi

The Raspberry Pi 3 B+ was used for this project. The following are the related specifications for the system:

- 1.4 GHz 64-bit Quad-Core Processor,
- 1 GB RAM
- Dual band 2.4HGz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN

The Raspberry Pi Foundation provides Raspbian, a Debian-based Linux distribution for download that was used in this project along with Python programming language that was used for coding.

1.2.4 Python (Programming Language)

Python was created by Guido van Rossum in 1991. Python is an interpreted language meaning that it is a type of programming language for which most of its implementations execute instructions directly and freely, without previously compiling a program into machine-language instructions. It is also a multi-paradigm programming language to allow programmers to use the most suitable programming style and associated constructs for a given job including object-oriented programming as well as structured programming. Furthermore, Python is highly extensible in which all its functionality is not built into its core. Its compact modularity has made it popular as a means of adding programmable interfaces to existing applications. Python is a high-level programming language. An interesting fact about the Python language is that it often uses English keywords where other languages use punctuation. The code looks close to the way human think. Additionally, the Python code is interpreted at runtime instead of being compiled to native code at compile time. Finally, Python is a dynamically typed language (meaning that one does not need to type variable type like string, Boolean or int) in contrast to the statically typed languages such as C, C++ or Java. The above advantages are at the cost of speed and performance. Regardless of the limitations of the Python, it is a highly productive, concise and expressive language that requires less time, effort, and lines of code to perform the same operations compared to the other programming languages. The above program attributes translate to shorter process development times and financial savings in the real world. Considering the above advantages, I chose Python as the coding language of choice to manage the electronic instrumentations for this project including the temperature and pressure sensors.

1.2.5 Electronic Instrumentations

Instrumentation is defined as the art and science of measurement and control of the process variables within a production or manufacturing area such as pressure, temperature, humidity, flow, pH, force, speed, etc. Instrumentation is an inter-disciplinary branch of engineering involved with development of new and intelligent sensors, smart transducers, microelectromechanical systems, and Bluetooth technology. Instrumentation and control engineering have routs in both electrical and electronics engineering and deal with measurement, automation, and control processes. Instrumentation and ultimately automation play an important role in reducing the involvement of manpower thus improving: the productivity, optimization, stability, reliability, safety, and continuity.

The applications of instrumentation and control engineering are vast including bio-med, chemical, oil & gas, power and many more. The application of building and airport automation is another area that instrumentation has a huge role in it. Also, Robotics is an interesting field that requires multidisciplinary skills including instrumentation and control. The temperature and pressure are the two types of sensors used in this project for the collection of data. The collected data was analyzed using MATLAB.

1.2.6 Data Analysis Using the MATLAB Code

MATLAB is a high-performance language that integrates computation, visualization, and programming in an easy-to-use environment developed by MathWorks. The typical uses of the MATLAB include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

Since the basic data element in MATLAB is an array that does not require dimensioning, the program is able to solve many technical computing problems in a fraction of time compared to scalar noninteractive languages such as C or Fortran. The MATLAB system consists of five main parts including:

- The MATLAB language
- The MATLAB working environment
- The MATLAB graphics handling
- The MATLAB mathematical function library
- The MATLAB Application Program Interface (API)

Furthermore, MATLAB is a multi-paradigm numerical computing environment that allows matrix manipulations, plotting of functions/data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages including C, C++, C#, Java, Fortran and Python. In addition, it can support object-oriented programing including classes, inheritance, visual dispatch, packages, pass-by-value semantics and pass-by-reference semantics. The collected data from the various experimental runs in this project are saved in the from of *.CSV files and consequently imported to MATLAB for analysis taking advantage of MATLAB's inherent and powerful analysis capabilities outlined above.

Chapter 2. Detailed Description of the Current Status

The ground and water-source heat pump geo-exchange systems aim to improve the limitations of the current air-source geo-exchange systems related to a drop in the efficiency (when the ambient temperatures fluctuate around and below freezing) by removing heat from quasi-constant temperature heat sources via ground or large bodies of water. The high cost related to the installation and land/real estate values in high density urban areas are the two main inhibiting factors for the wide adaptation and installation of the ground and water-source heat pump geo-exchange systems with horizontal loop collectors.

The focus of this project is to build on the previous years' projects through the design of the electronic instrumentation to simulate ground heat profile, data collection and analysis.

2.1 Problem Statement

The previous attempt at designing a multi-source system resulted in a working prototype that does not lock out before the desired runtime and has a comparable COP to current standard systems while simultaneously removing the need for expensive external heat exchanger loops. However, the system lacks proper instrumentation for the collection of key data points for the purpose of analysis and optimization.

2.2 Project Hypothesis

It is expected that by using a mini computer and programming/coding in conjunction with the usage of temperature and pressure sensors one should be able to achieve complete instrumentation of the system. Furthermore, by using the MATLAB code the collected data could be analyzed.

Chapter 3. Theoretical Background

The complete theoretical background for this project could be found and is covered in depth in the previous years' reports namely phases I & II.

Chapter 4. Detailed Project Activities and Equipment

4.1 List of Equipment

The following electronic components were used for the design and assembly of this project:

- Breadboard
- ADC – MCP3008

The MCP3008 is a low cost 8-channel 10-bit analog to digital converter. The MCP3008 is programmable to provide four pseudo-differential input pairs or eight single-ended inputs. Differential Nonlinearity (DNL) and Integral Nonlinearity (INL) are specified at ±1 LSB. Communication with the devices is accomplished using a simple serial interface compatible with the SPI protocol. The devices are capable of conversion rates of up to 200 ksps. The MCP3004/3008 devices operate over a broad voltage range (2.7V - 5.5V). Low-current design permits operation with typical standby currents of only 5 nA and typical active currents of 320 µA. The MCP3008 is offered in 16- pin PDIP and SOIC packages. The functional block diagram of the MCP3008 is presented in ***Figure 4.1***.

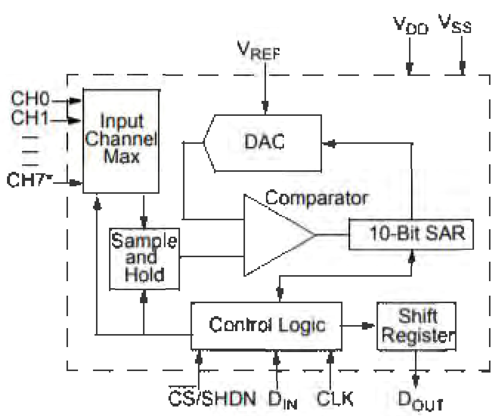

Figure 4.1 - Functional block diagram for MCP3008

This chip is a great option for reading simple analog signals, like from a temperature or pressure sensor. Having 8 channels one can read quite a few analog signals from the Pi.

- DS18B20 temperature sensor(s)

DS18B20 is a digital temperature sensor. Digital temperature sensors are typically silicon based integrated circuits. Most contain the temperature sensor, an analog to digital converter (ADC), memory to temporarily store the temperature readings, and an interface that allows communication between the sensor and a microcontroller. Unlike analog temperature sensors, calculations are performed by the sensor, and the output is an actual temperature value. The digital sensors differ from analog thermistors in several important ways. In thermistors, changes in the temperature cause changes in the resistance of a ceramic or polymer semiconducting material. Usually, the thermistor is set up in a voltage divider, and the voltage is measured between the thermistor and a known resistor. The voltage measurement is converted to resistance and then converted to a temperature value by the microcontroller [10]. Moreover, DS18B20 communicates with the "one-wire" communication protocol. This is a serial communication protocol that uses only one wire to transmit the temperature readings to the microcontroller. Under normal operations the DS18B20 requires 3 wires for proper operation: the Vcc, ground, and data wires. (In the parasite power mode, only the ground and data lines are used, and power is supplied through the data line). Additionally, A 64-bit ROM stores the device's unique serial code. This 64-bit address allows a microcontroller to receive temperature data from a virtually unlimited number of sensors at the same pin. The address tells the microcontroller which sensor a temperature value is coming from. Finally, this sensor is waterproof, has a wide working range of -55°C to 125°C relevant to this project, and cheap.

- Pressure transducer sender sensor for oil fuel air water,1/8"NPT thread stainless steel (500PSI)

A linearity curve was established according to the following series of equations and using laboratory experimental setup in which the out put was measured using a gauge:

Pressure (psi)	**Voltage (V)**
0	0.5
500	4.5

$$V = (P - 0)\left(\frac{4V}{500psi}\right) + 0.5V$$

Voltage (V)	ADC (bits)
0	0
5	1023

$$ADC = (V - 0)\left(\frac{1023bits}{5V}\right) + 0bits$$

$$ADC\ (V@0.5V) = (V - 0)\left(\frac{1023bits}{5V}\right) + 0bits$$

$ADC\ (V@0.5V) =\ 102.3\ bits$ = 102 bits

$ADC\ (V@4.5V) =\ 920.7\ bits$ = 921 bits

ADC (bits)	Pressure (psi)
102	0
921	500

$$P = (ADC - 102)\left(\frac{500psi}{819bits}\right) + 0psi$$

- CanaKit Raspberry Pi 3 B+ (B Plus) Ultimate Starter Kit - 32 GB
- 15mm X 4200mm 400W 120V KEENOVO Silicone Heater, Flexible Pipe Heating Strip/Belt

4.2 Design Approach

The following section covers the steps that were taken to create the end design.

4.2.1 The Current Design

The following electrical drawing (***Figure 4.2***) describes the complete instrumentation of the system.

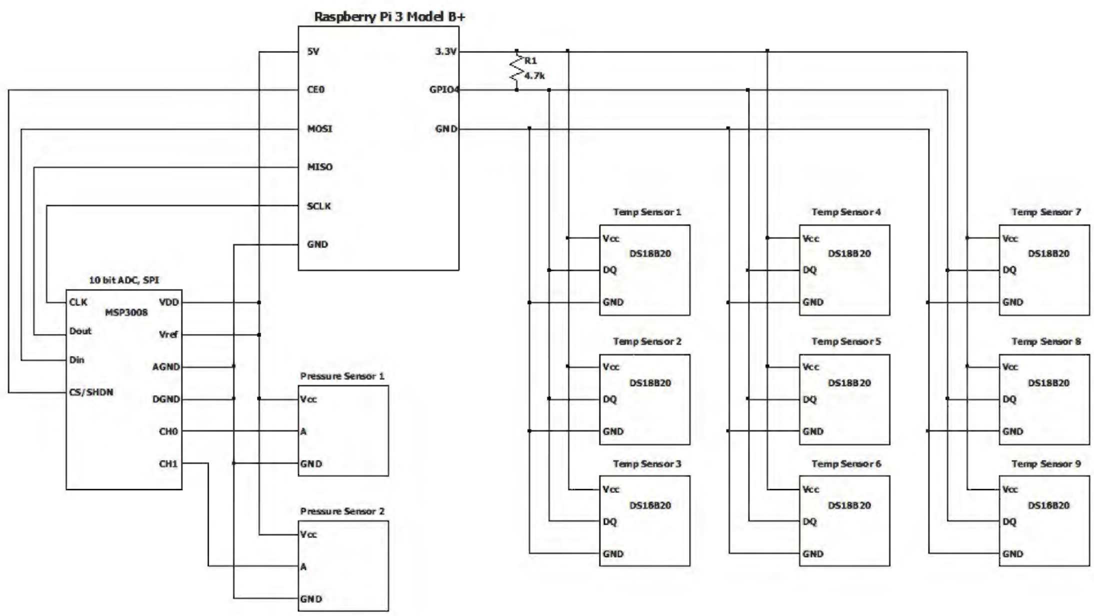

Figure 2.2 - Electrical instrumentation of the device.

The following steps were taken in brief to achieve the above:

Step-1: The Pi was connected to the breadboard via the ribbon cable and the GPIO to breadboard interface board as presented here (***Figure 4.3***).

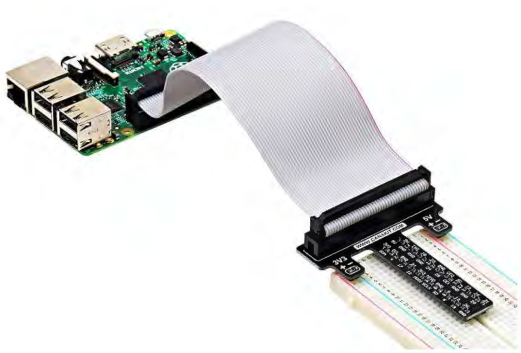

Figure 4.3 - Pi to breadboard connection

Step-2: The multiple temperature sensors were connected in parallel in the "normal power mode" (using a 4.7k resistor) from here-on known as "sensor-assembly".

Step-3: The sensor-assembly was then connected to the Pi (in this case the GPIO to breadboard interface board).

Step-4: The pressure transducers were connected through the ADC-MCP3008 to the Pi.

Step-5: Python was used to program/code the system and collect data (***Appendix-A***)

Step-6**:** The temperature sensors are/were distributed according to the following:

Sensor	**Location**	**Sensor**	**Location**
#03159779f45a	fin	#03159779328b	Tank wall 2
#0315977917a8	water	#031197791b8b	insulation
#03149779373a	suction line	#031197792d0b	return air
#031597790418	supply line	#03149779a32a	supply air
#03159779f876	Tank wall 1		

Table 4.1 - Location/distribution of the temperature sensors

Step-7**:** The pressure sensors are/were distributed according to the following:

Sensor	**Location**
p0	Low Pressure Side
p1	High Pressure Side

Table 4.2 - Location of the pressure sensors

Step-8: Heat belt and ground heat source simulation: The 400W heat belt was wrapped around the tank at the height of 12" from the bottom of the tank as shown in ***Figure 4.4***.

Figure 4.4 - Ground heat simulation using a 400W heat belt.

Step-9: 1.5" thick insulation panels (***Table 4.3***) were placed around the tank in order to separate the tank physically from the laboratory environment at the 4-sides and the bottom (***Figure 4.5***).

Material Property[1]	Units	Values
Thermal Resistance *Minimum per 25 mm (1 inch)* ASTM C518	m^2•°C/W (ft^2•h•°F/BTU)	0.65 (3.75)
Compressive Resistance *Minimum @ 10% Strain* ASTM D1621	kPa (psi)	70 (10)
Flexural Strength *Minimum* ASTM C203	kPa (psi)	170 (25)
Water Vapour Permeance[2] *Maximum* ASTM E96	ng/(Pa·s·m^2) (Perms)	300 (5.2)
Water Absorption[3] *Maximum* ASTM D2842	% By volume	6.0
Dimensional Stability *Maximum* ASTM D2126	% Linear Change	1.5
Limiting Oxygen Index *Minimum* ASTM D2863	%	24
Surface Burning Characteristics *Rating or Classification* CAN/ULC S102.2	Flame Spread Smoke Developed	290 Over 500

Table 2.3 - Material properties of the insulation boards.


Figure 4.5 - Insulated tank

Step-10: The system was started and allowed to operate till the temperature of the water in the tank was at about 4°C at which time the data collection and analysis were started either with the heat belt "off" or the heat belt "on" to simulate the ground thermal energy until the complete system lockout.

Step-11: The collected data was analyzed using the developed MATLAB code (***Appendix-B***)

Chapter 5. Discussion of results

5.1 Heat Pump COP vs. Time (Heat Belt Off & Heat Belt On)

The installation of the heat belt and the insulation of the tank had no effect on the COP of the heat pump as evidence by the instrumentation. This COP value is an acceptable value compared to what the heat pump was rated prior to incorporation into the system.

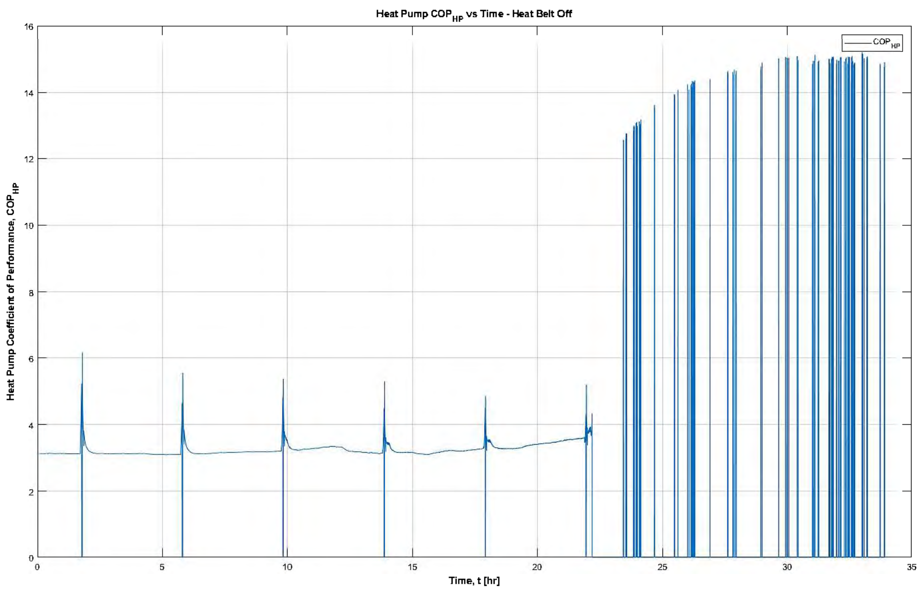

Figure 5.1 - Heat Pump COP vs. Time (Heat Belt Off)

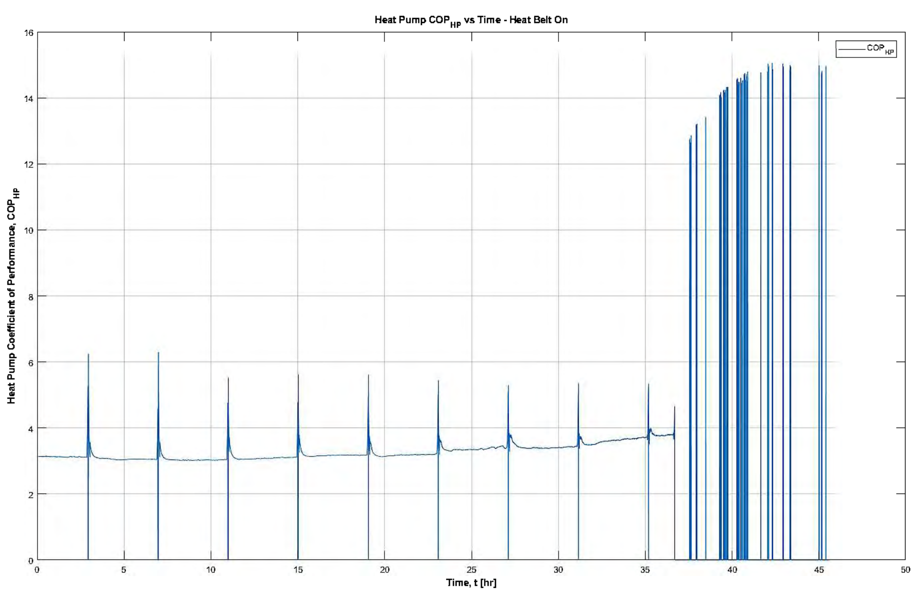

Figure 5.2 - Heat Pump COP vs. Time (Heat Belt On)

5.2 Heat Transfer Rate vs. Time (Heat Belt Off & Heat Belt On)

The installation of the heat belt and the insulation of the tank had no effect on the heat transfer rate as evidence by the instrumentation. Moreover, the results indicate that the compressor efficiency is quite low. There is a much higher amount of electrical power put into the system compared to the mechanical power.

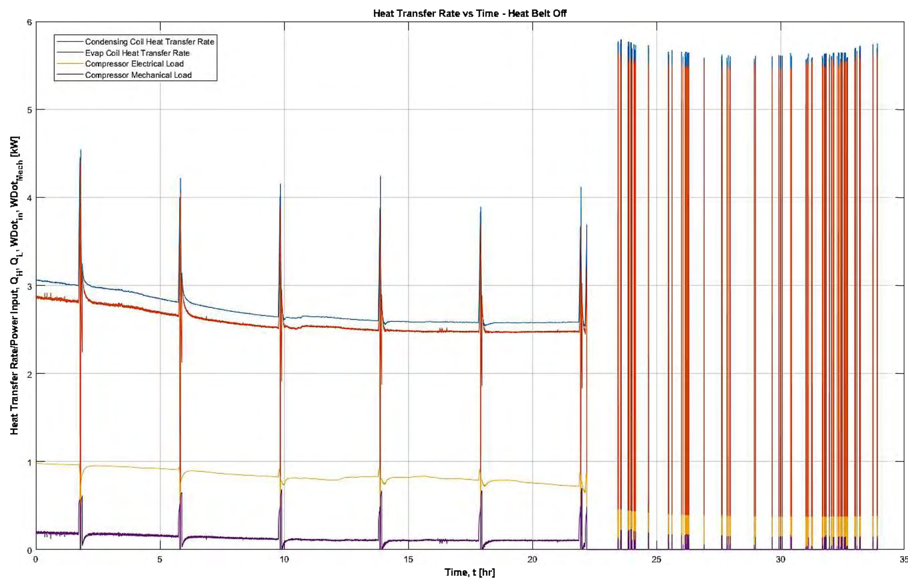

Figure 5.3 - Heat Transfer Rate vs. Time (Heat Belt Off)

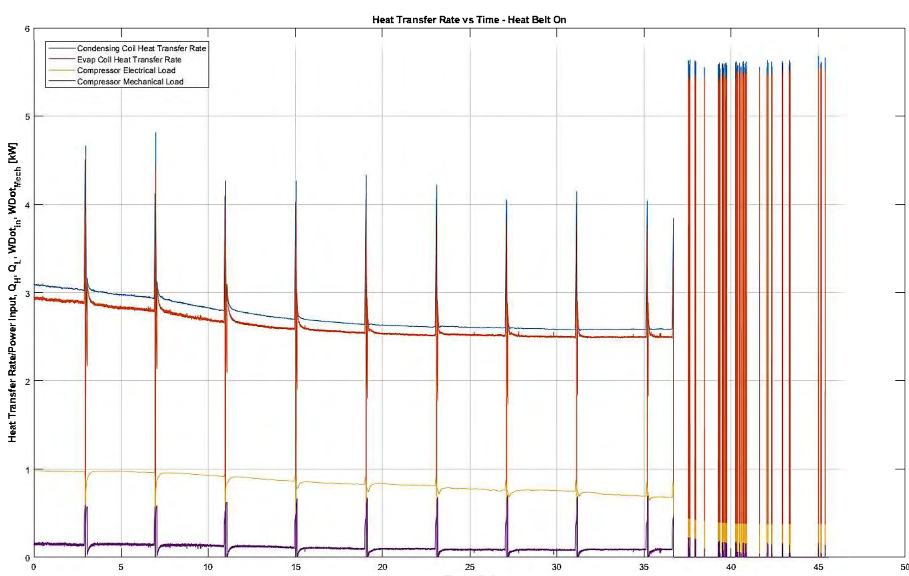

Figure 5.4 - Heat Transfer Rate vs. Time (Heat Belt On)

5.3 Temperature vs. Time (Heat Belt Off & Heat Belt On)

The installation of the heat belt and the insulation of the tank for the purpose of ground heat simulation increased the lockout time from ~22.5 hours to ~36.5 (14-hours increase) indicating that the sensors that were installed are functioning correctly with acceptable degree of accuracy.

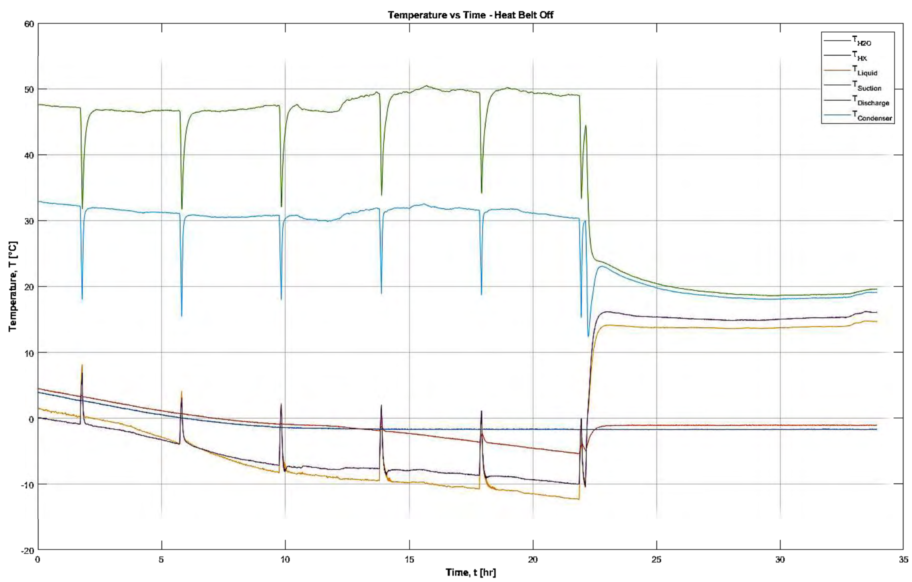

Figure 5.5 - Temperature vs. Time (Heat Belt off)

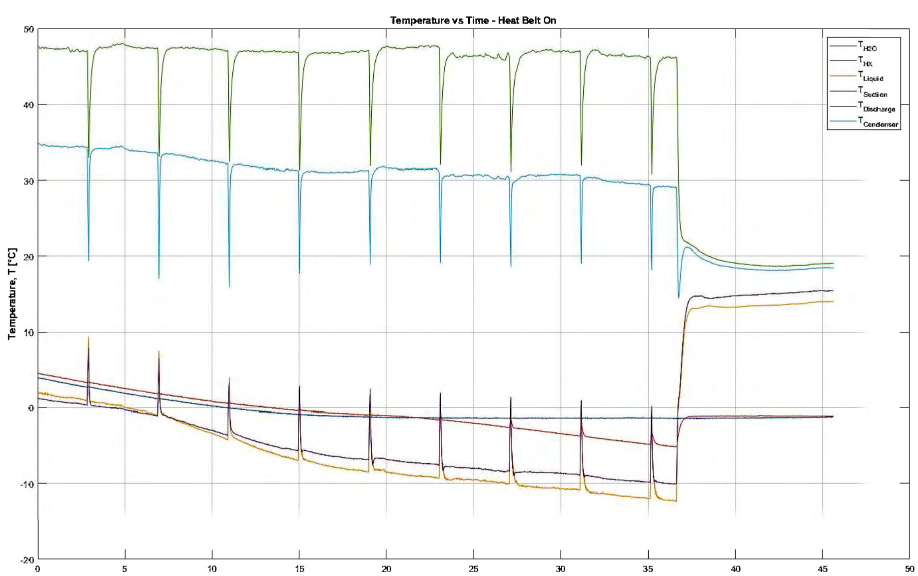

Figure 5.6 - Temperature vs. Time (Heat Belt On)

Chapter 6. Conclusion

The successful instrumentation of the device was achieved allowing for sensitively analysis and additional data collection. This in turn allows for investigation and the optimization of system parameters in the next phase of this project.

Additionally, the installation and insulation of a heat belt around the tank was completed. The instrumentation and data analysis established that once the heat belt is on, the amount of time required for the system to reach the lockout was extended. The governing mathematical equation [8] for the simulation of the ground heat was established through the literature search. It is now possible to proceed and simulate the ground heat for e.g. in Vancouver B.C. and the system response.

For these reasons mentioned above, the project was a success. The project has room for improvement and investigation specifically in the areas of optimization by using the established instrumentation (phase-III) and CFD simulations (phase-IV to be conducted).

Chapter 7. Lessons Learned

The main take home message from this project is that this is an interesting multidisciplinary project where one can learn and expand on the basic knowledge of electronics, instrumentation, programming, and thermodynamics among others. This is a perfect opportunity for a group of students who would like to expand on their basic knowledge of mechanical engineering and establish collaborative work possibly with students and faculty at other institutions with strong research funding and capabilities.

During the phase-III of this project, I focused on the instrumentation and data analysis of the system including the design, selection, programming, data collection, and finally the analysis. While some time was dedicated to learning the ANSYS program (Discovery Live), the recommendation would be to learn and use the ANSYS Fluent (student version) where the software can be successfully installed without the need for a dedicated graphics card or PC tower; therefore, allowing for more flexibility of resources and time.

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Appendix A – Programming Python Code

```
"""
Get the readings from the
   - temperature sensors via one-wire protocol
   - pressure sensors via spi protocol and ADC
   - save that data into a CSV file with a timestamp
"""

import time;
from w1thermsensor import W1ThermSensor;

# Import SPI library (for hardware SPI) and MCP3008 library.
import Adafruit_GPIO.SPI as SPI
import Adafruit_MCP3008

ERROR_CODE = -999;

# Hardware SPI configuration:
SPI_PORT   = 0;
SPI_DEVICE = 0;
adc = Adafruit_MCP3008.MCP3008(spi=SPI.SpiDev(SPI_PORT, SPI_DEVICE));

# List of all temperature sensors' ids
temp_ids =
('031197791b8b','0315977917a8','03149779373a','03159779f876','031597790418','031
59779f45a','031197792d0b','03159779328b','03149779a32a');
#03159779f45a fin
#0315977917a8 water
#03149779373a suction line
#031597790418 supply line
#03159779f876 Tank wall 1
#03159779328b Tank wall 2
#031197791b8b insulation
#031197792d0b return air
#03149779a32a supply air

# Init the temperature sensors objects
def GetTempSensors(sensor_ids):
   tempSensors = [];

   # 1-Wire Temperature Sensor Config
   for sensor_id_ in sensor_ids:
      tempSensor = W1ThermSensor(sensor_id=sensor_id_);
      tempSensors.append(tempSensor);
   return tempSensors;
```

```
# Get the ADC values from the converter (from 0 to 1023)
def GetADC(adc):
   # Read all 8 ADC channels and put values in a list.
   values = [0]*8;
   for i in range(8):
      # Make sure the SPI connection is established
      try:
         # The read_adc function will get the value of the specified channel (0-7).
         values[i] = adc.read_adc(i);

         if values[i] == 0: raise; # If reading zero, that is also a problem in our application
      except:
         values[i] = ERROR_CODE;
         pass;
   return values;


# Get the pressure in PSI readings from the adc sensors
def GetPressure(adc_v0, adc_v1):
   # Scaling linearly the ADC values to Pressure values
   p0 = round((adc_v0 - 102) * (500/819) + 0);
   p1 = round((adc_v1 - 102) * (500/819) + 0);

   # Check for errors
   if adc_v0 == ERROR_CODE: p0 = ERROR_CODE;
   if adc_v1 == ERROR_CODE: p1 = ERROR_CODE;

   return p0, p1;

# Get the temperature readings in deg C from all the sensors
def GetTemperature(tempSensors):
   temperatures = [];
   for tempSensor in tempSensors:
      # Get the readings and make sure the sensor is working properly
      try:
         t = tempSensor.get_temperature();
         t = round(t,3);
         pass;

      # Otherwise the reading is -999
      except:
         t = ERROR_CODE;
         pass;

      temperatures.append(t);
```

```
        pass;
    return temperatures

# Init the temperature sensors
tempSensors = GetTempSensors(temp_ids);

while 1:
            # Get adc Values from adc from the ADC Pressure sensor
            adc_values = GetADC(adc);

            # Get the Pressure values from the adcCode
            p0, p1 = GetPressure(adc_values[0],adc_values[1]);

            # Get the Temperature values in deg C
            t0, t1, t2, t3, t4, t5, t6, t7, t8 = GetTemperature(tempSensors);

            # Get the time stamp
            time_stamp = time.strftime("%x") +',' + time.strftime("%X")

            # combine the readings into single line of CSV
            line = time_stamp + ","  + str(p0) + "," + str(p1) +"," + str(t0) + "," + str(t1) + "," +
str(t2) + "," + str(t3) + "," + str(t4) + "," + str(t5) + "," + str(t6) + "," + str(t7) +"," + str(t8) +
'\n';


            # Output the readings to the CSV file in append mode
            with open('/home/pi/Desktop/Readings.csv', 'a') as file1:
           file1.write(line);


            print(line, end='');
            pass;
```

Appendix B – Programming MATLAB Code

```
%%%%%%%%%%%%%% Capstone Project - Heat Transfer Calculations
%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Background
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Using data collected from sensors connected to a retrofitted heat pump,
% Climate Master model number TCH012AGD40CLSS,the heat transfer rates of
% the indoor and outdoor coils will be calculated as well as the COP of the
% the heat pump.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% A := Total area of flat panel heat exchanger [m^2]
% COP_HP := Coefficient of performance of the heat pump in heating mode
% Cp := Average specific heat of dry air between -10C to 50C [J/kg*K]
% dt := Timestep [s]
% E := Voltage potential accross compressor windings [V]
% H := Height of flat panel heat exchanger [m]
% h_H20 := Heat transfer coefficient for flat panel heat exchanger [W/(m^2*K]
% I := Current draw from compressor [A]
% mDotAir := Mass flow rate of air [kg/s]
% pLow := Recorded absolute pressure on the low side of the heat pump [kPa]
% pHigh := Recorded absolute pressure on the high side of the heat pump [kPa]
% rhoAir := Density of air at Standard Air Condiditions [kg/m^3]
% S := Entropy of refrigerant at a given point [kJ/(kg*K)]
% T_H2O := Recorded temperature of the water in the tank [K]
% T_HX := Recorded temperature of the heat exchanger [K]
% T_Liquid := Recorded temperature of refrigerant on the liquid line [K]
% T_Suction := Recorded temperature of refrigerant on the suction line [K]
% T_Tank1 := Recorded temperature of tank wall at location 1 [K]
% T_Tank2 := Recorded temperature of tank wall at location 2 [K]
% T_Ins := Recorded temperature at midpoint of insulation [K]
% T_ReturnAir := Recorded temperature of return air [K]
% T_SupplyAir := Recorded temperature of supply air [K]
% VDot := SCFM of measurement from balometer converted to metric [m^3/s]
% W := Width of flat panel heat exchanger [m]
% WDotIn:= Power draw from the compressor [kW]
% X := Quality of the refrigerant at a given point
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Declarations
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clear;          % Clears workspace
clc;            % Clears command window
format long
```

```
CpAvg = 1005;
dt = 8;
E = 240;
I = 6.04;
H = 26*0.0254;
rhoAir = 1.225;
S = 0;
W = 25*0.0254;
X = 0;

A = 2*H*W;
VDot = 590*0.0283168/60;
WDotIn = E*I/1000;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Retrieve collected data from CSV file and assign to variables
[m,pLow,pHigh,T_H2O,T_HX,T_Ins,T_Liquid,T_Discharge,T_Suction,T_c,T_Tank1,T_Tank2] =
getData('HeatBeltOff.csv');

% Retrieve data from spreadsheet containing saturated thermodynamic
% properties of Suva R410A refrigerant throughout its working pressure
[mTDPSat,nTDPSat,TDPSat] = getTable('Thermodynamic Table for Saturated
R410A.xlsx',1);

% Retrieve data from spreadsheet containing superheated thermodynamic
% properties of Suva R410A refrigerant throughout its working pressure
[mTDPSup,nTDPSup,TDPSup] = getTable('Thermodynamic Table for Superheated
R410A.xlsx',2);

tMax = m*dt-1;
t = (0:dt/3600:tMax/3600)';

% Calculate the enthalpy of the refrigerant at four points of interest
[h1,h2,h3,h4,mDot,WDot] =
calculateParameters(m,mTDPSat,mTDPSup,nTDPSup,pLow,pHigh,TDPSat,TDPSup,T_Liqui
d,T_Discharge,T_Suction,T_c);

% Calculate the COP, mass flow rate, and heat transfer rate across both
% heat exchangers of the heat pump
[COP_HP,h_H2O,QDotL,QDotH,WDotM] =
calculatePerformance(A,h1,h2,h3,h4,m,mDot,pLow,pHigh,T_HX,T_H2O,WDot);

% Plot graphs of heat pump heat transfer rate, compressor power input,
% coefficient of performance, and heat transfer coefficient for flat panel
% heat exchanger
```

```
plotResults(COP_HP,h_H2O,QDotL,QDotH,t,WDot,WDotM);

function [h1,h2,h3,h4,mDot,WDot] =
calculateParameters(m,mTDPSat,mTDPSup,nTDPSup,pLow,pHigh,TDPSat,TDPSup,T_Liqui
d,T_Discharge,T_Suction,T_c)
%calculateParameters finds and returns the parameters of interest for
%analyzing the performance of a heat pump
%   Uses the saturated and superheated thermodynamic properties tables for
%   R410 refrigerant to find the enthalpies of the refrigerant at four
%   different locations on the heat pump
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   h1 := Enthalpy of refrigerant at the suction line
%   h2 := Enthalpy of refrigerant at the discharge line
%   h3 := Enthalpy of refrigerant at indoor HX coil outlet
%   h4 := Enthalpy of refrigerant at the liquid line
%   m := Number of rows in the data collection file for the heat pump
%   mTDPSat := Number of rows in the saturated thermodynamic properties table
%   mTDPSup := Number of rows in the superheated thermodynamic properties table
%   nTDPSup := Number of columns in the superheated thermodynamic properties table
%   TDP := Array of saturated thermodynamic properties for R410A
%   pLow := Recorded absolute pressure on the low side of the heat pump [kPa]
%   pHigh := Recorded absolute pressure on the high side of the heat pump [kPa]
%   S := Entropy of refrigerant at a given point [kJ/(kg*K)]
%   T_Liquid := Recorded temperature of refrigerant on the liquid line [K]
%   T_Suction := Recorded temperature of refrigerant on the suction line [K]
%   T_ReturnAir := Recorded temperature of return air [K]
%   T_SupplyAir := Recorded temperature of supply air [K]
%   WDot:= Vector of size m of power draw from compressor [kW]
%   WDotIn:= Power draw from compressor [kW]
%   X := Quality of refrigerant at a given point
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    h1 = zeros(m,1);
    h2 = zeros(m,1);
    h3 = zeros(m,1);
    h4 = zeros(m,1);
    mDot = zeros(m,1);
    WDot = zeros(m,1);

    for i=1:m
        if(isSystemRunning(pLow(i),pHigh(i))) % Determine if compressor is ON
            % Determine if refrigerant is saturated or superheated
            if(isSaturatedVapour(pHigh(i),T_Discharge(i),TDPSat,mTDPSat))
```

```
        h2(i) = getSaturatedVapourEnthalpy(T_Discharge(i),TDPSat,mTDPSat);
        S = getSaturatedVapourEntropy(T_Discharge(i),TDPSat,mTDPSat);
        X = getQuality(S,T_Suction(i),TDPSat,mTDPSat);
        h1(i) = getSaturatedEnthalpy(T_Suction(i),TDPSat,mTDPSat,X);
      else % Refrigerant is superheated
        h2(i) = getVapourEnthalpy(pHigh(i),T_Discharge(i),TDPSup,mTDPSup,nTDPSup);
        S = getVapourEntropy(pHigh(i),T_Discharge(i),TDPSup,mTDPSup,nTDPSup);
        % Determine if refrigerant on low pressure side is saturated or superheated
        if(isSaturatedVapour(pHigh(i),T_Discharge(i),TDPSat,mTDPSat))
          X = getQuality(S,T_Suction(i),TDPSat,mTDPSat);
          h1(i) = getSaturatedEnthalpy(T_Suction(i),TDPSat,mTDPSat,X);
        else % Refrigerant on low pressure side is superheated
          h1(i) = getVapourEnthalpy(pLow(i),T_Suction(i),TDPSup,mTDPSup,nTDPSup);
        end
      end
      h3(i) = getSaturatedLiquidEnthalpy(T_c(i),TDPSat,mTDPSat);
      S = getSaturatedLiquidEntropy(T_c(i),TDPSat,mTDPSat);
      X = getQuality(S,T_Liquid(i),TDPSat,mTDPSat);
      h4(i) = getSaturatedEnthalpy(T_Liquid(i),TDPSat,mTDPSat,X);
      % Finds the mass flow rate of the refrigerant
      mDot(i) = getMassFlowRate(T_Discharge(i)-273.15,T_Suction(i)-273.15);
      WDot(i) = getCompressorPower(T_Discharge(i)-273.15,T_Suction(i)-273.15);
    end
  end
end

function [COP_HP,h_H2O,QDotL,QDotH,WDotM] =
calculatePerformance(A,h1,h2,h3,h4,m,mDot,pLow,pHigh,T_HX,T_H2O,WDot)
%calculatePerformance finds and returns the parameters of the performance
%of a heat pump
%   Uses the the calculated enthalpies of the refrigerant at four
%   different locations on the heat pump to calculate the COP,the mass flow
%   rate,and heat transfer rate across both heat exchangers of the heat
%   pump
%
%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   A := Total area of flat panel heat exchanger [m^2]
%   COP_HP := Coefficient of Performance of the heat pump in heating mode
%   h1 := Enthalpy of refrigerant at the suction line
%   h2 := Enthalpy of refrigerant at the discharge line
%   h3 := Enthalpy of refrigerant at indoor HX coil outlet
%   h4 := Enthalpy of refrigerant at the liquid line
%   h_H2O := Heat transfer coefficient for flat panel heat exchanger [W/(m^2*K]
%   QDotL := Heat transfer rate across outdoor coil [kW]
%   QDotH := Heat transfer rate across indoor coil [kW]
```

```
%   T_H2O := Recorded temperature of the water in the tank [K]
%   T_HX := Recorded temperature of the heat exchanger [K]
%   WDot := Vector of size m of power draw from compressor [kW]
%   WDotIn := Power draw from compressor [kW]
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  COP_HP = zeros(m,1);
  h_H2O = zeros(m,1);
  QDotL = zeros(m,1);
  QDotH = zeros(m,1);
  WDotM = zeros(m,1);

  for i=1:m
     if(isSystemRunning(pLow(i),pHigh(i))) % Determine if compressor is ON
       QDotL(i) = mDot(i).*(h1(i)-h4(i));  % Find heat transfer rate for outdoor coil
       QDotH(i) = mDot(i).*(h2(i)-h3(i));  % Find heat transfer rate for indoor coil
       WDotM(i) = QDotH(i)-QDotL(i);
       if (WDotM(i) < 0)
          WDotM(i) = 0;
       end
       h_H2O(i) = QDotL(i)./(A*(T_HX(i)-T_H2O(i)));
       COP_HP(i) = QDotH(i)/WDot(i);   % Find COP of heat pump
     end
  end
end

function [WDot] = getCompressorPower(Tc,Te)
%getCompressorPower returns the compressor power draw for the heat pump
%   Uses manufacturer's specification sheet to calculate the compressor
%   power draw for a Tecumseh OEM model No. HG143AR-502-A4
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   C1-C10 := Compressor constants for calculations
%   m := Number of rows in the data collection file for the heat pump
%   Tc := Recorded temperature of refrigerant at the condensing coil [K]
%   Te := Recorded temperature of refrigerant at the evaporator coil [K]
%   WDot := Power draw from the compressor [kW]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  C1 = 1.706937E+02;
  C2 = -1.120174E+01;
  C3 = 2.713094E+01;
```

```
  C4 = -1.577200E+00;
  C5 = 4.790266E-01;
  C6 = -3.773444E-01;
  C7 = 5.309486E-02;
  C8 = 5.289560E-03;
  C9 = -1.120708E-03;
  C10 = 3.439925E-03;

  WDot =
C1+C2*Te+C4*Te^2+C7*Te^3+(C3+C5*Te+C8*Te^2)*Tc+(C6+C9*Te)*Tc^2+C10*Tc^3;
  WDot = WDot/1000; % Converts to kW
End

function
[m,pLow,pHigh,T_H2O,T_HX,T_Ins,T_Liquid,T_Discharge,T_Suction,T_c,T_Tank1,T_Tank2] =
getData(FileName)
%getData returns data from a CSV file
%   Uses the given file name to retrieve and format a CSV file and return
%   it with the specific columns of interest as variables
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   FileName := The name under which the file of interest is saved under
%   m := Number of rows of the given m x n matrix
%   pLow := Pressure of refrigerant on low side [kPaA]
%   pHigh := Pressure of refrigerant on high side [kPaA];
%   T_H2O := Recorded temperature of water in tank [K]
%   T_HX := Recorded temperature of heat exchanger [K]
%   T_Ins := Recorded temperature at midpoint of insulation [K]
%   T_Liquid := Recorded temperature of refrigerant on liquid line [K]
%   T_ReturnAir := Recorded temperature of return air [K]
%   T_Suction := Recorded temperature of refrigerant on suction line [K]
%   T_SupplyAir := Recorded temperature of supply air [K]
%   T_Tank1 := Recorded temperature of tank wall at location 1 [K]
%   T_Tank2 := Recorded temperature of tank wall at location 2 [K]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  Table = readtable(FileName);
  [m,~] = size(table2array(Table(:,1)));
  pLow = table2array(Table(:,3))*6.89476+101.325;
  pHigh = table2array(Table(:,4))*6.89476+101.325;
  T_Ins = table2array(Table(:,5))+273.15;
  T_H2O = table2array(Table(:,6))+273.15;
  T_Suction = table2array(Table(:,7))+273.15;
```

```
   T_Tank1 = table2array(Table(:,8))+273.15;
   T_Liquid = table2array(Table(:,9))+273.15;
   T_HX = table2array(Table(:,10))+273.15;
   T_Discharge = table2array(Table(:,11))+273.15;
   T_Tank2 = table2array(Table(:,12))+273.15;
   T_c = table2array(Table(:,13))+273.15;
End

function [mDot] = getMassFlowRate(Tc,Te)
%getMassFlowRate returns the refrigerant mass flow rate of the heat pump
%   Uses manufacturer's specification sheet to calculate the refrigerant
%   mass flow rate for a Tecumseh OEM model No. HG143AR-502-A4
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   m := Number of rows in the data collection file for the heat pump
%   mDot := Mass flow rate of refrigerant [kg/s]
%   Tc := Recorded temperature of refrigerant at the condensing coil [K]
%   Te := Recorded temperature of refrigerant at the evaporator coil [K]
%   C1-C10 := Compressor constants for calculations
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

   C1 = 1.734147E+02;
   C2 = -8.440538E-01;
   C3 = -1.018925E+00;
   C4 = -7.335037E-02;
   C5 = 2.260299E-01;
   C6 = -1.363841E-02;
   C7 = 5.538000E-04;
   C8 = 4.559198E-03;
   C9 = -2.795898E-03;
   C10 = 2.005282E-04;

   mDot =
C1+C2*Te+C4*Te^2+C7*Te^3+(C3+C5*Te+C8*Te^2)*Tc+(C6+C9*Te)*Tc^2+C10*Tc^3;
   mDot = mDot/(2.20462*3600); % Convert to kg/s from lb/hr
end

function [X] = getQuality(S,T,TDP,m)
%getQuality returns the quality of the refrigerant in the saturated region
%   Uses thermodynamic tabular data for Saturated R410A to find the quality
%   of the saturated refrigerant for a given temperature and entropy equal
%   to that of the high pressure side of the regfrigeration cycle
%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   m := Number of rows in TDP
%   T := Temperature of refrigerant [K]
%   TDP := Array of saturated thermodynamic properties for R410A
%   S := Entropy of higher pressure refrigerant [kJ/(kg*K)]
%   X := The quality of the refrigerant
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
  end
  i = i-1;

  % Single linear interpolations
  Sf = ((TDP(i+1,11)-TDP(i,11))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,11);
  Sg = ((TDP(i+1,12)-TDP(i,12))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,12);
  X = (S-Sf)/(Sg-Sf);
End

function [Hf] = getSaturatedLiquidEnthalpy(T,TDP,m)
%getSaturatedLiquidEnthalpy returns the enthalpy of the refrigerant at the
%saturated liquid state
%   Uses thermodynamic tabular data for Saturated R410A to find the value
%   of the liquid saturation enthalpy for a given temperature
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Hf := Enthalpy of saturated liquid refrigerant [kJ/kg]
%   m := Number of rows in TDP
%   T := Temperature of refrigerant [K]
%   TDP := Array of saturated thermodynamic properties for R410A
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
```

```
  end
  i = i-1;

  % Single linear interpolation
  Hf = ((TDP(i+1,8)-TDP(i,8))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,8);
end

function [Sf] = getSaturatedLiquidEntropy(T,TDP,m)
%getSaturatedLiquidEntropy returns the entropy of the refrigerant at the
%saturated liquid state
%   Uses thermodynamic tabular data for Saturated R410A to find the value
%   of the liquid saturation entropy for a given temperature
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   m := Number of rows in TDP
%   T := Temperature of refrigerant [K]
%   TDP := Array of saturated thermodynamic properties for R410A
%   Sf := Entropy of saturated liquid refrigerant [kJ/(kg*K)]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
  end
  i = i-1;

  % Single linear interpolation
  Sf = ((TDP(i+1,11)-TDP(i,11))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,11);
end

function [Hg] = getSaturatedVapourEnthalpy(T,TDP,m)
%getSaturatedVapourEnthalpy returns the enthalpy of the refrigerant at the
%saturated vapour state
%   Uses thermodynamic tabular data for Saturated R410A to find the value
%   of the vapour saturation enthalpy for a given temperature
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Hg := Enthalpy of saturated vapour refrigerant [kJ/kg]
%   m := Number of rows in TDP
%   T := Temperature of refrigerant [K]
```

```
%   TDP := Array of saturated thermodynamic properties for R410A
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
  end
  i = i-1;

  % Single linear interpolation
  Hg = ((TDP(i+1,10)-TDP(i,10))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,10);
end

function [Sg] = getSaturatedVapourEntropy(T,TDP,m)
%getSaturatedVapourEntropy returns the entropy of the refrigerant at the
%saturated vapour state
%   Uses thermodynamic tabular data for Saturated R410A to find the value
%   of the vapour saturation entropy for a given temperature
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   m := Number of rows in TDP
%   T := Temperature of refrigerant [K]
%   TDP := Array of saturated thermodynamic properties for R410A
%   Sg := Entropy of saturated vapour refrigerant [kJ/(kg*K)]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
  end
  i = i-1;

  % Single linear interpolation
  Sg = ((TDP(i+1,12)-TDP(i,12))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,12);
End

function [m,n,Table] = getTable(FileName,num)
```

```
%getTable returns data from a excel spreadsheet
%   Uses the given file name to retrieve and format an excel spreadsheet
%   file and returns it as an array of size m x n
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Data := A MatLab table file from the retrieved data
%   FileName := The name under which the file of interest is saved under
%   m := Number of rows of the given m x n matrix
%   n := Number of columns of the given m x n matrix
%   num := An integer used to determine what section of the file is of
%       interest and should be retrieved
%   Table := An m x n array containing the tabular data of interest
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  if(num == 1)
    Data = readtable(FileName,'Range','A3:L173','ReadVariableNames',false);
    [m,n] = size(table2array(Data(:,1))); % Number of rows of m x n matrix
    Table = table2array(Data(:,:));
  else
    Data = readtable(FileName,'ReadVariableNames',false);
    [m,n] = size(table2array(Data)); % Number of rows of m x n matrix
    Table = table2array(Data(:,:));
  end

end

function [Hv] = getVapourEnthalpy(P,T,TDP,m,n)
%getVapourEnthalpy - Returns vapour enthalpy of the refrigerant for a given
%temperature, and pressure
%   Uses thermodynamic tabular data for superheated R410A to find the value
%   of the vapour enthalpy for a given temperature and pressure
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Hv := Enthalpy of superheated vapour refrigerant [kJ/kg]
%   m := Number of rows in TDP
%   p := Pressure of refrigerant [kPaA]
%   T := Temperature of refrigerant [K]
%   TDP := Array of superheated thermodynamic properties for R410A
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
   Href = 141.1;
   i = 1;
   j = 2;

   P = P*0.14504;         % Convert to PSIA
   T = T*1.8+32-459.67;    % Convert to degrees Fahrenheit

   while(T >= TDP(i,1) && i <= m)
     i = i+1;
   end
   i = i-1;

function [Sv] = getVapourEntropy(p,T,TDP,m,n)
%getVapourEntropy - Returns vapour entropy of the refrigerant for a given
%temperature, and pressure
%   Uses thermodynamic tabular data for superheated R410A to find the value
%   of the vapour entropy for a given temperature and pressure
%
%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   m := Number of rows in TDP
%   p := Pressure of refrigerant [kPaA]
%   T := Temperature of refrigerant [K]
%   TDP := Array of superheated thermodynamic properties for R410A
%   Sv := Entropy of superheated vapour refrigerant [kJ/(kg*K)]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

   i = 1;
   j = 2;
   Sref = 0.7666;

   p = p*0.14504;         % Convert to PSIA
   T = T*1.8+32-459.67;    % Convert to degrees Fahrenheit


   while(T >= TDP(i,1) && i <= m)
     i = i+1;
   end
   i = i-1;

   while(p >= TDP(1,j) && j <= n)
      j = j+3;
   end
   j = j-3;
```

```
  % Double linear interpolation
  SvLow = ((TDP(i+1,j+2)-TDP(i,j+2))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,j+2);
  SvHigh = ((TDP(i+1,j+5)-TDP(i,j+5))/(TDP(i+1,1)-TDP(i,1)))*(T-TDP(i,1))+TDP(i,j+5);
  Sv = ((SvHigh-SvLow)/(TDP(1,j+5)-TDP(1,j+5))*(p-TDP(1,j+1))+SvLow)/0.23901+Sref;

End

function [bool] = isSaturatedVapour(p,T,TDP,m)
%isSaturatedVapour returns true if refrigerant is saturated and false
%otherwise
%   Uses thermodynamic tabular data for Saturated R410A to find out whether
%   the refrigerant is saturated or superheated fo a given temperature and
%   pressure
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   Hg := Enthalpy of saturated vapour refrigerant [kJ/kg]
%   m := Number of rows in TDP
%   p := Pressure of refrigerant [kPaA]
%   T := Temperature of refrigerant [K]
%   TDP := Array of saturated thermodynamic properties for R410A
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  TOL = 50;

  bool = false;
  i = 1;
  T = T-273.15;   % Convert to degrees Celsius

  while(T >= TDP(i,1) && i <= m)
    i = i+1;
  end
  i = i-1;

function [bool] = isSystemRunning(pLow,pHigh)
%isSystemRunning returns true if the heat pump is ON or false if OFF
%   Compares the refrigerant pressures on the low and high side of heat
%   pump and if they are within a certain tolerance, returns false
%   (compressor is OFF), otherwise returns true
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   pLow := Pressure of refrigerant on low side [kPaA]
```

```
%   pHigh := Pressure of refrigerant on high side [kPaA]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    TOL = 100;

    if(abs(pHigh - pLow) <= TOL)
        bool = false;
    else
        bool = true;
    end
end
 load('COPHPBeltOff.mat')
    load('COPHPBeltOn.mat')
    load('mDotBeltOff.mat')
    load('mDotBeltOn.mat')
    load('QDotHBeltOff.mat')
    load('QDotHBeltOn.mat')
    load('QDotLBeltOff.mat')
    load('QDotLBeltOn.mat')
    load('T_H2OBeltOff.mat')
    load('T_H2OBeltOn.mat')
    load('T_Tank1BeltOff.mat')
    load('T_Tank1BeltOn.mat')
    load('T_Tank1BeltOn.mat')

    C = 273.15;
%     beta = @(T) ((-32.74-(-68.5))/(275-273.15))*(T-273.15)-68.5;
    dt = 8;
%     g = 9.81;
%     TOL = 1e-4;
%     k2 = 14.9;
%     L2 = 3/16;
%     kf =@(T) ((574e-3-569e-3)/(275-273.15))*(T-273.15)+569e-3;
%     nu =@(T) (((1652e-6-1750e-6)/(275-273.15))*(T-273.15)+1750e-6)/1000;
%     Pr =@(T) ((12.22-12.99)/(275-273.15))*(T-273.15)+12.99;
    [m1,~] = size(COP_HP);
    [m2,~] = size(COP_HPOn);
    tMax1 = m1*dt-1;
    tMax2 = m2*dt-1;
    t1 = (0:dt/3600:tMax1/3600)';
    t2 = (0:dt/3600:tMax2/3600)';
    i1 = 2806;
    i2 = 530;
    t1 = t1(i1:m1)-t1(i1);
```

```
  t2 = t2(i2:m2)-t2(i2);
  COP_HP = COP_HP(i1:m1);
  COP_HPOn = COP_HPOn(i2:m2);
  mDot = mDot(i1:m1);
  mDotOn = mDotOn(i2:m2);
  QDotH = QDotH(i1:m1);
  QDotHOn = QDotHOn(i2:m2);
  QDotL = QDotL(i1:m1);
  QDotLOn = QDotLOn(i2:m2);
  T_H2O = T_H2O(i1:m1)-273.15;
  T_H2OOn = T_H2OOn(i2:m2)-273.15;
  T_Tank1 = T_Tank1(i1:m1)-273.15;
  T_Tank1On = T_Tank1On(i2:m2)-273.15;

%   Gr_L =@(beta,nu,T_s,T_inf) g*beta*(T_s-T_inf)/(nu^2);
%   gPr =@(Pr) 0.75*Pr^(1/2)/((0.609+1.221*Pr^(1/2)+1.238*Pr)^(1/4));
%   T_s = T_Tank1(1)+1;
%   T_S = 0;

%   for i=2:m
%     while( abs(T_S-T_s) > TOL)
%       T_S = T_Tank1-(4/3)*(L2/k2)*(T_s-
T_H2O(i))*(Gr_L(beta(T_H2O(i)),nu(T_H2O(i)),T_s,T_H2O(i))/4)^(1/4)*gPr(Pr(T_H2O(i)));
%     end
%   end

  figure
  plot(t1,T_H2O,t1,T_Tank1,t2,T_H2OOn,t2,T_Tank1On);
  title('Temperature vs Time');
  xlabel('Time, t [hr]','fontweight','bold');
  ylabel('Temperature, T [°C]','fontweight','bold');
  legend('T_H_2_O - Heat Belt Off','T_T_a_n_k - Heat Belt Off','T_H_2_O - Heat Belt
On','T_T_a_n_k - Heat Belt On');
  grid on;

  figure
  plot(t1,QDotL,t2,QDotLOn);
  title('Heat Transfer Rate vs Time - Heat Belt On');
  xlabel('Time, t [hr]','fontweight','bold');
  ylabel('Heat Transfer Rate, Q_L [kW]','fontweight','bold');
  legend('Evap Coil Heat Transfer Rate - Heat Belt Off','Evap Coil Heat Transfer Rate - Heat
Belt On');
  grid on;

  figure
  plot(t1,COP_HP,t2,COP_HPOn);
```

```
    title('Heat Pump COP_H_P vs Time - Heat Belt On');
    xlabel('Time, t [hr]','fontweight','bold');
    ylabel('Heat Pump Coefficient of Performance, COP_H_P','fontweight','bold');
    legend('COP_H_P - Heat Belt Off','COP_H_P - Heat Belt On');
    grid on;

function [] =
plotResults(COP_HP,h_H2O,m,QDotL,QDotH,t,T_H2O,T_HX,T_Liquid,T_Suction,T_Discharge,
T_c,WDot,WDotM)
%plotResults plots various parameters of interest
%   Plots heat pump performance parameters and formats plots
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%% Variable Definitions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%   COP_HP := Coefficient of Performance of the heat pump in heating mode
%   h_H2O := Heat transfer coefficient for flat panel heat exchanger [W/(m^2*K]
%   QDotL := Heat transfer rate across outdoor coil [kW]
%   QDotH := Heat transfer rate across indoor coil [kW]
%   t := Vector of timesteps [s]
%   WDot := Vector of size m of power draw from compressor [kW]
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Code
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    C = 273.15;
    i = 1;
    tCF = t(i);

    figure
    plot(t(i:m)-tCF,T_H2O(i:m)-C,t(i:m)-tCF,T_HX(i:m)-C,t(i:m)-tCF,T_Liquid(i:m)-C,t(i:m)-
tCF,T_Suction(i:m)-C,t(i:m)-tCF,T_Discharge(i:m)-C,t(i:m)-tCF,T_c(i:m)-C);
    title('Temperature vs Time - Heat Belt On');
    xlabel('Time, t [hr]','fontweight','bold');
    ylabel('Temperature, T [°C]','fontweight','bold');

legend('T_H_2_O','T_H_X','T_L_i_q_u_i_d','T_S_u_c_t_i_o_n','T_D_i_s_c_h_a_r_g_e','T_C_o_n_d_e_
n_s_e_r');
    grid on;

    figure
    plot(t(i:m)-tCF,QDotH(i:m),t(i:m)-tCF,QDotL(i:m),t(i:m)-tCF,WDot(i:m),t(i:m)-
tCF,WDotM(i:m));
    title('Heat Transfer Rate vs Time - Heat Belt On');
    xlabel('Time, t [hr]','fontweight','bold');
    ylabel('Heat Transfer Rate/Power Input, Q_H, Q_L, WDot_i_n, WDot_M_e_c_h
[kW]','fontweight','bold');
```

```
  legend('Condensing Coil Heat Transfer Rate','Evap Coil Heat Transfer Rate','Compressor
Electrical Load','Compressor Mechanical Load');
  grid on;

  figure
  plot(t(i:m)-tCF,COP_HP(i:m));
  title('Heat Pump COP_H_P vs Time - Heat Belt On');
  xlabel('Time, t [hr]','fontweight','bold');
  ylabel('Heat Pump Coefficient of Performance, COP_H_P','fontweight','bold');
  legend('COP_H_P');
  grid on;

  figure
  plot(t(i:m)-tCF,h_H2O(i:m));
  title('Heat Exchanger Convective Heat Transfer Coefficient vs Time - Heat Belt On');
  xlabel('Time, t [hr]','fontweight','bold');
  ylabel('Convective Heat Transfer Coefficient, h_H_2_O [kW/m^2K]','fontweight','bold');
  legend('h_H_2_O');
  grid on;
end
```

Tranquility® Compact (TC) Series

Models TCH/V006 -060 60Hz - HFC - 410A

The Tranquility® 16 Compact (TC) Series raises the bar for water-source heat pump application flexibility. Not only does the Tranquility® 16 Compact Series exceed ASHRAE 90.1 efficiencies, but with the new ECM fan motor option, it also delivers higher efficiencies up to 15.9 EER (Tower-Boiler) and 18.1 EER (Geothermal).

Advantages of the Compat TC Series:

- ECM fan motor option
- EarthPure® (HFC-410A) refrigerant
- Exceeds ASHRAE 90.1 efficiencies
- Galvanized steel construction with attractive matte black epoxy powder coat paint front access panel
- Epoxy powder painted galvanized steel drain pan
- Sound absorbing glass fiber insulation
- Unique double isolation compressor mounting for quiet operation
- Insulated divider and separate compressor/air handler compartments
- Copeland scroll compressors (size 024 and above)
- TXV metering device
- Microprocessor controls standard (optional DXM and/or DDC controls)
- Field convertible discharge air arrangement for horizontal units
- Optional water side economizer

Unit Size

Horizontal Model		W	D	H
006 - 012	in cm	19.1 48.5	34.1 86.6	11.1 28.2
015 - 018	in cm	20.1 51.1	43.1 109.5	17.0 43.2
024 - 030	in cm	20.1 51.1	43.1 109.5	18.3 46.5
036 - 042	in cm	20.1 51.1	47.1 119.6	21.0 53.3
048 - 060	in cm	24.1 61.2	54.1 137.4	21.0 53.3

Vertical Upflow Model		W	D	H
006 - 012	in cm	19.1 48.5	19.1 48.5	22.0 55.9
015 - 018	in cm	21.5 54.6	21.5 54.6	39.0 99.1
024 - 030, 041	in cm	21.5 54.6	21.5 54.6	40.0 101.6
036 - 042	in cm	21.5 54.6	26.0 66.0	45.0 114.3
048 - 060	in cm	24.0 61.0	32.5 82.6	46.0 116.8

Physical Data

TC Series	006	009	012	015	018	024	030	036	041	042	048	060
[illegible]			Rotary						Scroll			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ECM Fan Motor & Blower												
[illegible]	N/A	N/A	N/A	9x7	9x7	9x7	9x7	[illegible]	N/A	[illegible]	10x10	11x10
PSC Fan Motor & Blower												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6x5	9x7	9x7	9x7	9x7	[illegible]	[illegible]	[illegible]	10x10	11x10
Water Connection Size												
FPT	1/2"	1/2"	1/2"	1/2"	1/2"	3/4"	3/4"	3/4"	3/4"	3/4"	1"	1"
[illegible]	0.123	0.143	0.167	0.286	0.450	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vertical												
[illegible]	[illegible]	[illegible]	[illegible]	20x17.25	20x17.25	20x17.25	20x17.25	24x21.75	20x17.25	24x21.75	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	106	114	152	158	[illegible]	[illegible]	[illegible]	215	216	[illegible]	[illegible]
[illegible]	115	118	124	164	[illegible]	[illegible]	[illegible]	[illegible]	217	[illegible]	[illegible]	[illegible]
Horizontal												
[illegible]	[illegible]	[illegible]	[illegible]	16x22	16x22	16x22	16x22	20x25	N/A	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	106	114	152	158	174	[illegible]	[illegible]	N/A	218	[illegible]	[illegible]
[illegible]	115	118	124	164	[illegible]	[illegible]	[illegible]	[illegible]	N/A	[illegible]	[illegible]	[illegible]

Tested To ASHRAE/AHRI/ISO 13256-1 English (I-P)

Model	Fan Motor	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
		Cooling 86°F		Heating 68°F		Cooling 59°F		Heating 50°F		Cooling 77°F		Heating 32°F	
		Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP
TC-006	PSC	5,800	13.2	7,500	4.7	6,800	21.1	6,100	4.0	6,200	15.4	4,900	3.4
TC-009	PSC	8,900	14.4	11,600	4.3	10,100	21.0	9,400	3.9	9,500	15.7	7,400	3.4
TC-012	PSC	11,200	14.5	15,200	4.3	11,700	20.0	12,500	3.8	12,000	14.9	9,800	3.2
TC-015	PSC	14,500	15.4	17,300	5.0	16,800	24.5	14,400	4.4	15,000	17.2	11,100	3.6
	ECM	14,500	15.5	16,000	5.1	16,000	25.0	13,600	4.4	15,000	17.8	10,900	3.6
TC-018	PSC	17,300	16.3	21,500	5.0	20,600	23.6	17,300	4.2	18,400	16.3	13,900	3.4
	ECM	19,600	15.9	22,000	5.3	22,900	23.6	18,200	4.4	20,200	18.1	14,100	3.8
TC-024	PSC	23,700	13.4	28,500	4.7	26,700	20.9	24,000	4.1	24,900	15.4	18,500	3.3
	ECM	23,800	14.3	27,700	4.9	26,700	21.5	23,400	4.1	24,800	16.4	18,500	3.5
TC-030	PSC	28,100	13.4	35,100	4.6	31,700	20.1	29,600	4.1	28,800	15.1	22,400	3.4
	ECM	28,200	14.3	35,000	4.8	31,800	22.0	30,000	4.4	29,300	16.5	23,600	3.7
TC-036	PSC	34,500	13.5	45,200	4.4	36,700	20.2	37,500	4.0	35,300	14.9	29,600	3.3
	ECM	34,500	14.0	43,400	4.5	39,000	20.9	35,800	4.0	35,400	15.5	28,700	3.4
TCV-041	PSC	36,500	13.2	45,700	4.3	41,400	19.7	38,300	3.7	38,000	14.5	30,000	3.2
TC-042	PSC	40,100	13.2	52,700	4.3	45,900	19.6	44,000	3.8	40,500	14.4	34,300	3.2
	ECM	42,100	14.9	50,400	4.5	46,400	22.0	42,400	4.0	42,200	16.8	33,900	3.4
TC-048	PSC	47,700	13.3	55,900	4.7	54,300	20.5	46,500	4.1	49,000	14.7	36,400	3.4
	ECM	47,900	14.2	53,000	4.8	51,600	21.0	45,400	4.3	49,000	16.3	36,400	3.6
TC-060	PSC	59,400	13.4	72,000	4.3	66,600	19.9	60,000	3.9	60,100	14.9	47,500	3.3
	ECM	60,000	14.8	71,200	4.4	67,000	21.0	59,600	4.0	61,400	16.5	47,500	3.4

Cooling capacities based upon 80.6°F DB, 66.2°F WB entering air temperature
Heating capacities based upon 68°F DB, 59°F WB entering air temperature
All ratings based upon operation at lower voltage of dual voltage rated models

AHRI CERTIFIED

CLIMATEMASTER
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Oklahoma City, OK 73179
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climatemaster.com

Appendix D – R410A Thermodynamic Properties

Freon™ 410A

Refrigerant (R-410A)

Thermodynamic Properties (ENG Units)

New tables of the thermodynamic properties of Freon™ 410A refrigerant (ASHRAE designation: R-410A [50/50]) have been developed and are presented here. These tables are based on extensive experimental measurements. Equations have been developed, based on the Martin-Hou equation of state, which represent the data with accuracy and consistency throughout the entire range of temperature, pressure, and density. Vapor enthalpy and entropy are calculated from the standard Martin-Hou equations. Additional equations have been developed for the calculation of saturated liquid enthalpy, latent enthalpy, and saturated liquid entropy and are presented here.

Physical Properties

Chemical Formula	CH_2F_2/CHF_2CF_3 (50/50% by weight)
Molecular Weight	72.58
Boiling Point at One Atmosphere	-60.84 °F (-51.58 °C)
Critical Temperature	161.83 °F (72.13 °C) 621.50 °R (345.28 K)
Critical Pressure	714.50 psia (4926.1 kPa [abs])
Critical Density	30.52 lb/ft³ (488.90 kg/m³)
Critical Volume	0.0328 ft³/lb (0.00205 m³/kg)

Units and Factors

t = Temperature in °F

T = Temperature in °R = °F + 459.67

P = Pressure in lb/in² absolute (psia)

v_f = Volume of saturated liquid in ft³/lb

v_g = Volume of saturated vapor in ft³/lb

V = Volume of superheated vapor in ft³/lb

$d_f = 1/v_f$ = Density of saturated liquid in lb/ft³

$d_g = 1/v_g$ = Density of saturated vapor in lb/ft³

h_f = Enthalpy of saturated liquid in Btu/lb

h_{fg} = Enthalpy of vaporization in Btu/lb

h_g = Enthalpy of saturated vapor in Btu/lb

H = Enthalpy of superheated vapor in Btu/lb

s_f = Entropy of saturated liquid in Btu/(lb)(°R)

s_g = Entropy of saturated vapor in Btu/(lb)(°R)

S = Entropy of superheated vapor in Btu/(lb)(°R)

C_p = Heat capacity at constant pressure in Btu/(lb)(°F)

C_v = Heat capacity at constant volume in Btu/(lb)(°F)

v_s = Velocity of sound in ft/sec

The gas constant, R = 10.732 (psia)(ft³)/(°R) (lb-mole) for Freon™ 410A, R = 0.1479 (psia)(ft³)/lb·°R

One atmosphere = 14.696 psia

Conversion factor from work units to heat units:

J = 0.185053

Btu/lb = (psia·ft³)/lb·J

Reference point for enthalpy and entropy:

h_f = 0.0 Btu/lb at -40 °F (-40 °C)

s_f = 0.0 Btu/lb·°R at -40 °F (-40 °C)

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Equations

Conversion Factors—ENG Units to SI Units

Properties listed in the following thermodynamic tables in ENG units can be converted to SI units using the conversion factors shown below. Please note that in converting enthalpy and entropy from ENG to SI units, a change in reference states must be included (from H = 0 and S = 0 at -40 °F (-40 °C) for ENG units to H = 200 and S = 1 at 0 °C (32 °F) for SI units). In the conversion equation below, H (ref) and S (ref) are the saturated liquid enthalpy and entropy at -40 °C (-40 °F). For Freon™ 410A, H (ref) = 141.1 kJ/kg and S (ref) = 0.7666 kJ/kg·K.

P (kPa)	= P (psia) ÷ 0.14504
T (°C)	= (T[°F] - 32) ÷ 1.8
D (kg/m³)	= D (lb/ft³) ÷ 0.062428
V (m³/kg)	= V (ft³/lb) ÷ 16.018
H (kJ/kg)	= (H [Btu/lb] ÷ 0.43021) + H (ref)
S (kJ/kg)	= (S [Btu/lb·°R] ÷ 0.23901) + S (ref)
C_p (kJ/kg·K)	= C_p (Btu/lb·°F) ÷ 0.23901
C_v (kJ/kg·K)	= C_v (Btu/lb·°F) ÷ 0.23901
v_s (m/sec)	= v_s (ft/sec) ÷ 3.2808

Martin-Hou Equation of State

Coefficients for the Martin-Hou equation of state are presented below:

$$P = RT/(V-b) + \sum_{i=2}^{5}(A_i + B_iT + C_i\exp[-kT/T_c])/(V-b)^i$$

For SI units

T and T_c are in K = °C + 273.15 , V is in m³/kg, and P is in kPa (abs).

R = 0.11455 kJ/kg·K for Freon™ 410A

b, A_i, B_i, C_i, and k are constants:

A_2 = -1.721781 E-01	A_4 = -4.329207 E-07
B_2 = 1.646288 E-04	B_4 = 0.000000 E+00
C_2 = -6.293665 E+00	C_4 = 0.000000 E+00
A_3 = 2.381558 E-04	A_5 = -6.241072 E-10
B_3 = -1.462803 E-08	B_5 = 1.380469 E-12
C_3 = 1.532461 E-02	C_5 = 1.604125 E-07
b = 4.355134 E-04	k = 5.750000 E+00

X and Y are constants used in the vapor enthalpy and entropy equations for the Martin-Hou equation of state:

X = 2.987192 E+02 Y = 8.463990 E-01

For ENG units

T and T_c are in °R = °F + 459.67, V is in ft³/lb, and P is in psia.

R = 0.147852 (psia)(ft³)/lb·°R for Freon™ 410A

b, A_i, B_i, C_i, and k are constants:

A_2 = -6.407692 E+00	A_4 = -4.134026 E-03
B_2 = 3.403745 E-03	B_4 = 0.000000 E+00
C_2 = -2.342218 E+02	C_4 = 0.000000 E+00
A_3 = 1.419729 E-01	A_5 = -9.546510 E-05
B_3 = -4.844597 E-06	B_5 = 1.173112 E-07
C_3 = 9.135529 E+00	C_5 = 2.453712 E-02
b = 6.976251 E-03	k = 5.750000 E+00

X and Y are constants used in the vapor enthalpy and entropy equations for the Martin-Hou equation of state:

X = 6.779200 E+01 Y = -7.838900 E-02

Ideal Gas Heat Capacity (at constant pressure):

$$C_p^o = a + bT + cT^2 + dT^3$$

Ideal Gas Heat Capacity (at constant volume):

$$C_v^o = C_p^o - R$$

For SI units

C_p^o and C_v^o = kJ/kg·K

R = 0.114550 kJ/kg·K for Freon™ 410A

T is in K = °C + 273.15

a, b, c, and d are constants:

a = 2.676084 E-01	c = -9.848184 E-07
b = 2.115353 E-03	d = 6.493781 E-11

For ENG units

C_p^o and C_v^o = Btu/lb·°R

R = 0.02737815 Btu/lb·°R for Freon™ 410A

T is in °R = °F + 459.67

a, b, c, and d are constants:

a = 6.395995 E-02	c = -7.264730 E-08
b = 2.808787 E-04	d = 2.661267 E-12

Liquid Enthalpy, Latent Enthalpy, and Liquid Entropy Equations

Saturated Liquid Enthalpy:

$$h_f = A + BX + C(X)^2 + D(X)^3 + E(X)^4 + F(X)^5$$

where $X = (1 - T_r)^{1/3} - X_o$, and $T_r = T/T_c$

Latent Enthalpy:

$h_{fg} = h_g - h_f$

Saturated Liquid Entropy:

$s_f = s_g - ([h_g - h_f]/T)$

For SI units

h_f, h_g, and h_{fg} are in kJ/kg

s_f and s_g are in kJ/(kg)(K)

T and T_c are in K = °C + 273.15

A, B, C, D, E, F, and X_o are constants:

A = 2.211749 E+02 | E = 1.052000 E+03
B = -5.149668 E+02 | F = 1.596000 E+03
C = -6.316250 E+02 | X_o = 5.541498 E-01
D = -2.622749 E+02

For ENG units

h_f, h_g, and h_{fg} are in Btu/lb

s_f and s_g are in Btu/(lb)(°R)

T and T_c are in °R = °F + 459.67

A, B, C, D, E, F, and X_o are constants:

A = 3.442467 E+01 | E = 4.528092 E+02
B = -2.215447 E+02 | F = 6.866152 E+02
C = -2.717314 E+02 | X_o = 5.541498 E-01
D = -1.128898 E+02

Vapor Pressure

$\log_n (P_{sat}/P_c) = 1/T_r (A + BX + CX^2 + DX^3 + EX^4 + FX^5)$

where $X = (1 - T_r) - X_o$, and $T_r = T/T_c$

A, B, C, D, E, F, and X_o are constants:

Constants for vapor pressure of saturated liquid (bubble point), p_f:

A = -1.437600 E+00 | E = -4.068750 E+00
B = -6.871500 E+00 | F = -1.233300 E+00
C = -5.362300 E-01 | X_o = 2.086902 E-01
D = -3.826420 E+00

Constants for vapor pressure of saturated vapor (dew point), p_g:

A = -1.440004 E+00 | E = -3.521484 E+00
B = -6.865265 E+00 | F = -7.750000 E+00
C = -5.354309 E-01 | X_o = 2.086902 E-01
D = -3.749023 E+00

Because both pressure and temperature appear in the reduced form in the equation, the same constants can be used for either SI or ENG units.

For SI units

T and T_c are in K = °C + 273.15

P and P_c are in kPa (abs)

For ENG units

T and T_c are in °R = °F + 459.67

P and P_c are in psia

Density of the Saturated Liquid

$d_f/D_c = A_f + B_f(1-T_r)^{(1/3)} + C_f(1-T_r)^{(2/3)} + D_f(1-T_r) + E_f(1-T_r)^{(4/3)}$

A_f, B_f, C_f, D_f, and E_f are constants:

A_f = 1.000000 E+00 | D_f = 1.819972 E+00
B_f = 1.984734 E+00 | E_f = -7.171684 E-01
C_f = -1.767593 E-01

Because both density and temperature appear in the reduced form in the equation, the same constants can be used for either SI or ENG units.

For SI units

T_r and T/T_c both in K = °C + 273.15

d_f and D_c are in kg/m³

For ENG units

T_r and T/T_c both in °R = °F + 459.67

d_f and D_c are in lb/ft³

Table 1. Freon™ 410A Saturation Properties—Temperature Table

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_l	Vapor p_g	Liquid v_l	Vapor v_g	Liquid d_l	Vapor d_g	Liquid H_l	Latent H_{lg}	Vapor H_g	Liquid S_l	Vapor S_g	
−150	0.49	0.49	0.0106	94.0107	94.39	0.0106	−34.1	134.3	100.2	−0.0946	0.3390	−150
−149	0.52	0.51	0.0106	89.5452	94.30	0.0112	−33.8	134.1	100.3	−0.0937	0.3380	−149
−148	0.55	0.54	0.0106	85.3254	94.20	0.0117	−33.5	134.0	100.5	−0.0928	0.3371	−148
−147	0.58	0.57	0.0106	81.3361	94.10	0.0123	−33.2	133.9	100.6	−0.0919	0.3361	−147
−146	0.60	0.60	0.0106	77.5632	94.01	0.0129	−32.9	133.7	100.7	−0.0910	0.3352	−146
−145	0.64	0.63	0.0106	73.9935	93.91	0.0135	−32.6	133.5	100.9	−0.0900	0.3343	−145
−144	0.67	0.66	0.0107	70.6147	93.81	0.0142	−32.4	133.4	101.0	−0.0891	0.3334	−144
−143	0.70	0.69	0.0107	67.4151	93.72	0.0148	−32.1	133.2	101.2	−0.0882	0.3325	−143
−142	0.74	0.73	0.0107	64.3842	93.62	0.0155	−31.8	133.1	101.3	−0.0873	0.3316	−142
−141	0.77	0.76	0.0107	61.5119	93.52	0.0163	−31.5	132.9	101.4	−0.0864	0.3307	−141
−140	0.81	0.80	0.0107	58.7888	93.42	0.0170	−31.2	132.8	101.6	−0.0855	0.3298	−140
−139	0.85	0.84	0.0107	56.2061	93.33	0.0178	−30.9	132.6	101.7	−0.0846	0.3289	−139
−138	0.89	0.88	0.0107	53.7558	93.23	0.0186	−30.6	132.5	101.8	−0.0838	0.3281	−138
−137	0.93	0.92	0.0107	51.4301	93.13	0.0194	−30.3	132.3	102.0	−0.0829	0.3272	−137
−136	0.98	0.97	0.0107	49.2219	93.03	0.0203	−30.0	132.2	102.1	−0.0820	0.3264	−136
−135	1.02	1.01	0.0108	47.1244	92.93	0.0212	−29.7	132.0	102.3	−0.0811	0.3255	−135
−134	1.07	1.06	0.0108	45.1314	92.84	0.0222	−29.5	131.9	102.4	−0.0802	0.3247	−134
−133	1.12	1.11	0.0108	43.2370	92.74	0.0231	−29.2	131.7	102.5	−0.0793	0.3239	−133
−132	1.17	1.16	0.0108	41.4356	92.64	0.0241	−28.9	131.5	102.7	−0.0784	0.3231	−132
−131	1.23	1.21	0.0108	39.7222	92.54	0.0252	−28.6	131.4	102.8	−0.0775	0.3223	−131
−130	1.28	1.27	0.0108	38.0917	92.44	0.0263	−28.3	131.2	102.9	−0.0766	0.3215	−130
−129	1.34	1.33	0.0108	36.5397	92.34	0.0274	−28.0	131.1	103.1	−0.0757	0.3207	−129
−128	1.40	1.39	0.0108	35.0619	92.24	0.0285	−27.7	130.9	103.2	−0.0748	0.3199	−128
−127	1.46	1.45	0.0109	33.6542	92.14	0.0297	−27.4	130.8	103.4	−0.0739	0.3191	−127
−126	1.52	1.51	0.0109	32.3129	92.04	0.0309	−27.1	130.6	103.5	−0.0730	0.3184	−126
−125	1.59	1.58	0.0109	31.0344	91.94	0.0322	−26.8	130.4	103.6	−0.0721	0.3176	−125
−124	1.66	1.65	0.0109	29.8154	91.84	0.0335	−26.5	130.3	103.8	−0.0713	0.3169	−124
−123	1.73	1.72	0.0109	28.6527	91.74	0.0349	−26.2	130.1	103.9	−0.0704	0.3161	−123
−122	1.81	1.79	0.0109	27.5434	91.64	0.0363	−25.9	130.0	104.0	−0.0695	0.3154	−122
−121	1.88	1.87	0.0109	26.4846	91.54	0.0378	−25.6	129.8	104.2	−0.0686	0.3147	−121
−120	1.96	1.95	0.0109	25.4738	91.44	0.0393	−25.3	129.6	104.3	−0.0677	0.3139	−120
−119	2.04	2.03	0.0109	24.5085	91.34	0.0408	−25.0	129.5	104.5	−0.0668	0.3132	−119
−118	2.13	2.12	0.0110	23.5863	91.24	0.0424	−24.7	129.3	104.6	−0.0660	0.3125	−118
−117	2.22	2.20	0.0110	22.7051	91.14	0.0440	−24.4	129.1	104.7	−0.0651	0.3118	−117
−116	2.31	2.29	0.0110	21.8626	91.04	0.0457	−24.1	129.0	104.9	−0.0642	0.3111	−116
−115	2.40	2.39	0.0110	21.0573	90.93	0.0475	−23.8	128.8	105.0	−0.0633	0.3104	−115
−114	2.50	2.48	0.0110	20.2870	90.83	0.0493	−23.5	128.6	105.1	−0.0624	0.3097	−114
−113	2.60	2.59	0.0110	19.5499	90.73	0.0512	−23.2	128.5	105.3	−0.0616	0.3091	−113
−112	2.70	2.69	0.0110	18.8446	90.63	0.0531	−22.9	128.3	105.4	−0.0607	0.3084	−112
−111	2.81	2.79	0.0110	18.1694	90.53	0.0550	−22.6	128.1	105.5	−0.0598	0.3077	−111
−110	2.92	2.91	0.0111	17.5228	90.42	0.0571	−22.3	128.0	105.7	−0.0589	0.3071	−110
−109	3.03	3.02	0.0111	16.9035	90.32	0.0592	−22.0	127.8	105.8	−0.0580	0.3064	−109
−108	3.15	3.14	0.0111	16.3101	90.22	0.0613	−21.7	127.6	105.9	−0.0572	0.3058	−108
−107	3.27	3.26	0.0111	15.7415	90.11	0.0635	−21.4	127.5	106.1	−0.0563	0.3051	−107
−106	3.40	3.38	0.0111	15.1963	90.01	0.0658	−21.1	127.3	106.2	−0.0554	0.3045	−106
−105	3.53	3.51	0.0111	14.6736	89.91	0.0681	−20.8	127.1	106.3	−0.0546	0.3039	−105
−104	3.66	3.64	0.0111	14.1722	89.81	0.0706	−20.5	127.0	106.5	−0.0537	0.3033	−104
−103	3.80	3.78	0.0111	13.6912	89.70	0.0730	−20.2	126.8	106.6	−0.0528	0.3027	−103
−102	3.94	3.92	0.0112	13.2296	89.60	0.0756	−19.9	126.6	106.7	−0.0520	0.3020	−102
−101	4.08	4.07	0.0112	12.7865	89.49	0.0782	−19.6	126.4	106.9	−0.0511	0.3014	−101
−100	4.23	4.22	0.0112	12.3611	89.39	0.0809	−19.3	126.3	107.0	−0.0502	0.3008	−100
−99	4.39	4.37	0.0112	11.9525	89.29	0.0837	−19.0	126.1	107.1	−0.0494	0.3002	−99
−98	4.54	4.53	0.0112	11.5599	89.18	0.0865	−18.6	125.9	107.3	−0.0485	0.2997	−98
−97	4.71	4.69	0.0112	11.1828	89.08	0.0894	−18.3	125.7	107.4	−0.0476	0.2991	−97
−96	4.88	4.86	0.0112	10.8203	88.97	0.0924	−18.0	125.6	107.5	−0.0468	0.2985	−96
−95	5.05	5.03	0.0113	10.4718	88.87	0.0955	−17.7	125.4	107.7	−0.0459	0.2979	−95
−94	5.23	5.21	0.0113	10.1367	88.76	0.0987	−17.4	125.2	107.8	−0.0450	0.2974	−94
−93	5.41	5.39	0.0113	9.8144	88.66	0.1019	−17.1	125.0	107.9	−0.0442	0.2968	−93
−92	5.60	5.58	0.0113	9.5043	88.55	0.1052	−16.8	124.8	[illegible]	−0.0433	0.2962	−92
−91	5.79	5.77	0.0113	9.2059	88.44	0.1086	−16.5	124.7	108.2	−0.0425	0.2957	−91

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_f	Vapor p_g	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid H_f	Latent H_{fg}	Vapor H_g	Liquid S_f	Vapor S_g	
−90	5.99	5.97	0.0113	8.9187	88.34	0.1121	−16.2	124.5	108.3	−0.0416	0.2951	−90
−89	6.19	6.18	0.0113	8.6422	88.23	0.1157	−15.9	124.3	108.4	−0.0408	0.2946	−89
−88	6.40	6.39	0.0113	8.3760	88.12	0.1194	−15.5	124.1	108.6	−0.0399	0.2940	−88
−87	6.62	6.60	0.0114	8.1196	88.02	0.1232	−15.2	123.9	108.7	−0.0390	0.2935	−87
−86	6.84	6.82	0.0114	7.8725	87.91	0.1270	−14.9	123.7	108.8	−0.0382	0.2930	−86
−85	7.07	7.05	0.0114	7.6345	87.80	0.1310	−14.6	123.6	109.0	−0.0373	0.2925	−85
−84	7.30	7.28	0.0114	7.4050	87.70	0.1350	−14.3	123.4	109.1	−0.0365	0.2919	−84
−83	7.54	7.52	0.0114	7.1839	87.59	0.1392	−14.0	123.2	109.2	−0.0356	0.2914	−83
−82	7.79	7.77	0.0114	6.9706	87.48	0.1435	−13.7	123.0	109.4	−0.0348	0.2909	−82
−81	8.04	8.02	0.0114	6.7649	87.37	0.1478	−13.3	122.8	109.5	−0.0339	0.2904	−81
−80	8.30	8.28	0.0115	6.5665	87.27	0.1523	−13.0	122.6	109.6	−0.0331	0.2899	−80
−79	8.56	8.54	0.0115	6.3750	87.16	0.1569	−12.7	122.4	109.7	−0.0323	0.2894	−79
−78	8.84	8.82	0.0115	6.1903	87.05	0.1615	−12.4	122.2	109.9	−0.0314	0.2889	−78
−77	9.12	9.09	0.0115	6.0120	86.94	0.1663	−12.1	122.1	110.0	−0.0306	0.2884	−77
−76	9.40	9.38	0.0115	5.8398	86.83	0.1712	−11.8	121.9	110.1	−0.0297	0.2879	−76
−75	9.70	9.67	0.0115	5.6736	86.72	0.1763	−11.4	121.7	110.2	−0.0289	0.2874	−75
−74	10.00	9.97	0.0115	5.5130	86.61	0.1814	−11.1	121.5	110.4	−0.0280	0.2869	−74
−73	10.30	10.28	0.0116	5.3579	86.50	0.1866	−10.8	121.3	110.5	−0.0272	0.2865	−73
−72	10.62	10.60	0.0116	5.2080	86.39	0.1920	−10.5	121.1	110.6	−0.0264	0.2860	−72
−71	10.94	10.92	0.0116	5.0632	86.28	0.1975	−10.2	120.9	110.7	−0.0255	0.2855	−71
−70	11.28	11.25	0.0116	4.9232	86.17	0.2031	−9.8	120.7	110.9	−0.0247	0.2851	−70
−69	11.61	11.59	0.0116	4.7878	86.06	0.2089	−9.5	120.5	111.0	−0.0238	0.2846	−69
−68	11.96	11.93	0.0116	4.6570	85.95	0.2147	−9.2	120.3	111.1	−0.0230	0.2841	−68
−67	12.32	12.29	0.0116	4.5304	85.84	0.2207	−8.9	120.1	111.2	−0.0222	0.2837	−67
−66	12.68	12.65	0.0117	4.4080	85.73	0.2269	−8.5	119.9	111.4	−0.0213	0.2832	−66
−65	13.05	13.02	0.0117	4.2895	85.62	0.2331	−8.2	119.7	111.5	−0.0205	0.2828	−65
−64	13.43	13.40	0.0117	4.1749	85.51	0.2395	−7.9	119.5	111.6	−0.0197	0.2823	−64
−63	13.82	13.79	0.0117	4.0639	85.40	0.2461	−7.6	119.3	111.7	−0.0189	0.2819	−63
−62	14.22	14.19	0.0117	3.9565	85.29	0.2527	−7.3	119.1	111.8	−0.0180	0.2815	−62
−61	14.63	14.60	0.0117	3.8526	85.17	0.2596	−6.9	118.9	112.0	−0.0172	0.2810	−61
−60	15.05	15.01	0.0118	3.7519	85.06	0.2665	−6.6	118.7	112.1	−0.0164	0.2806	−60
−59	15.47	15.44	0.0118	3.6543	84.95	0.2736	−6.3	118.5	112.2	−0.0155	0.2802	−59
−58	15.91	15.87	0.0118	3.5599	84.84	0.2809	−6.0	118.3	112.3	−0.0147	0.2797	−58
−57	16.35	16.32	0.0118	3.4683	84.72	0.2883	−5.6	118.1	112.4	−0.0139	0.2793	−57
−56	16.81	16.77	0.0118	3.3796	84.61	0.2959	−5.3	117.9	112.6	−0.0131	0.2789	−56
−55	17.28	17.24	0.0118	3.2937	84.50	0.3036	−5.0	117.7	112.7	−0.0122	0.2785	−55
−54	17.75	17.71	0.0119	3.2103	84.38	0.3115	−4.6	117.4	112.8	−0.0114	0.2781	−54
−53	18.24	18.19	0.0119	3.1295	84.27	0.3195	−4.3	117.2	112.9	−0.0106	0.2777	−53
−52	18.73	18.69	0.0119	3.0512	84.15	0.3277	−4.0	117.0	113.0	−0.0098	0.2773	−52
−51	19.24	19.19	0.0119	2.9752	84.04	0.3361	−3.7	116.8	113.2	−0.0090	0.2768	−51
−50	19.76	19.71	0.0119	2.9015	83.92	0.3447	−3.3	116.6	113.3	−0.0082	0.2764	−50
−49	20.29	20.24	0.0119	2.8300	83.81	0.3534	−3.0	116.4	113.4	−0.0073	0.2761	−49
−48	20.82	20.78	0.0119	2.7606	83.69	0.3622	−2.7	116.2	113.5	−0.0065	0.2757	−48
−47	21.38	21.32	0.0120	2.6933	83.58	0.3713	−2.3	115.9	113.6	−0.0057	0.2753	−47
−46	21.94	21.88	0.0120	2.6279	83.46	0.3805	−2.0	115.7	113.7	−0.0049	0.2749	−46
−45	22.51	22.46	0.0120	2.5645	83.35	0.3899	−1.7	115.5	113.8	−0.0041	0.2745	−45
−44	23.10	23.04	0.0120	2.5029	83.23	0.3995	−1.3	115.3	114.0	−0.0033	0.2741	−44
−43	23.69	23.64	0.0120	2.4430	83.11	0.4093	−1.0	115.1	114.1	−0.0025	0.2737	−43
−42	24.30	24.24	0.0120	2.3849	83.00	0.4193	−0.7	114.9	114.2	−0.0017	0.2733	−42
−41	24.92	24.86	0.0121	2.3285	82.88	0.4295	−0.3	114.6	114.3	−0.0008	0.2730	−41
−40	25.56	25.49	0.0121	2.2737	82.76	0.4398	0.0	114.4	114.4	0.0000	0.2726	−40
−39	26.20	26.14	0.0121	2.2204	82.65	0.4504	0.3	114.2	114.5	0.0008	0.2722	−39
−38	26.86	26.80	0.0121	2.1687	82.53	0.4611	0.7	114.0	114.6	0.0016	0.2718	−38
−37	27.53	27.47	0.0121	2.1183	82.41	0.4721	1.0	113.7	114.7	0.0024	0.2715	−37
−36	28.22	28.15	0.0122	2.0694	82.29	0.4832	1.3	113.5	114.9	0.0032	0.2711	−36
−35	28.92	28.84	0.0122	2.0219	82.17	0.4946	1.7	113.3	115.0	0.0040	0.2708	−35
−34	29.63	29.55	0.0122	1.9757	82.05	0.5062	2.0	113.1	115.1	0.0048	0.2704	−34
−33	30.35	30.28	0.0122	1.9307	81.93	0.5179	2.3	112.8	115.2	0.0056	0.2700	−33
−32	31.09	31.01	0.0122	1.8870	81.81	0.5300	2.7	112.6	115.3	0.0064	0.2697	−32
−31	31.85	31.76	0.0122	1.8444	81.70	0.5422	3.0	112.4	115.4	0.0072	0.2693	−31

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_l	Vapor p_g	Liquid v_l	Vapor v_g	Liquid $1/v_l$	Vapor $1/v_g$	Liquid H_l	Latent H_{lg}	Vapor H_g	Liquid S_l	Vapor S_g	
−30	32.61	32.53	0.0123	1.8030	81.58	0.5546	3.4	112.1	115.5	0.0080	0.2690	−30
−29	33.39	33.31	0.0123	1.7628	81.45	0.5673	3.7	111.9	115.6	0.0088	0.2686	−29
−28	34.19	34.10	0.0123	1.7236	81.33	0.5802	4.0	111.7	115.7	0.0096	0.2683	−28
−27	35.00	34.91	0.0123	1.6854	81.21	0.5933	4.4	111.4	115.8	0.0104	0.2679	−27
−26	35.83	35.73	0.0123	1.6483	81.09	0.6067	4.7	111.2	115.9	0.0112	0.2676	−26
−25	36.67	36.57	0.0124	1.6122	80.97	0.6203	5.1	111.0	116.0	0.0120	0.2673	−25
−24	37.52	37.42	0.0124	1.5770	80.85	0.6341	5.4	110.7	116.1	0.0127	0.2669	−24
−23	38.39	38.29	0.0124	1.5427	80.73	0.6482	5.7	110.5	116.2	0.0135	0.2666	−23
−22	39.28	39.17	0.0124	1.5093	80.60	0.6625	6.1	110.3	116.3	0.0143	0.2663	−22
−21	40.18	40.07	0.0124	1.4768	80.48	0.6771	6.4	110.0	116.5	0.0151	0.2659	−21
−20	41.10	40.99	0.0124	1.4452	80.36	0.6920	6.8	109.8	116.6	0.0159	0.2656	−20
−19	42.03	41.92	0.0125	1.4143	80.23	0.7071	7.1	109.5	116.7	0.0167	0.2653	−19
−18	42.98	42.86	0.0125	1.3843	80.11	0.7224	7.5	109.3	116.8	0.0175	0.2649	−18
−17	43.95	43.83	0.0125	1.3550	79.99	0.7380	7.8	109.1	116.9	0.0183	0.2646	−17
−16	44.93	44.81	0.0125	1.3264	79.86	0.7539	8.2	108.8	117.0	0.0191	0.2643	−16
−15	45.94	45.81	0.0125	1.2986	79.74	0.7701	8.5	108.6	117.1	0.0198	0.2640	−15
−14	46.95	46.82	0.0126	1.2715	79.61	0.7865	8.8	108.3	117.2	0.0206	0.2637	−14
−13	47.99	47.85	0.0126	1.2450	79.49	0.8032	9.2	108.1	117.3	0.0214	0.2633	−13
−12	49.04	48.90	0.0126	1.2192	79.36	0.8202	9.5	107.8	117.4	0.0222	0.2630	−12
−11	50.11	49.97	0.0126	1.1941	79.24	0.8375	9.9	107.6	117.5	0.0230	0.2627	−11
−10	51.20	51.06	0.0126	1.1695	79.11	0.8551	10.2	107.3	117.6	0.0237	0.2624	−10
−9	52.31	52.16	0.0127	1.1456	78.99	0.8729	10.6	107.1	117.6	0.0245	0.2621	−9
−8	53.43	53.28	0.0127	1.1222	78.86	0.8911	10.9	106.8	117.7	0.0253	0.2618	−8
−7	54.57	54.42	0.0127	1.0995	78.73	0.9095	11.3	106.6	117.8	0.0261	0.2615	−7
−6	55.74	55.58	0.0127	1.0772	78.60	0.9283	11.6	106.3	117.9	0.0268	0.2612	−6
−5	56.92	56.75	0.0127	1.0555	78.47	0.9474	12.0	106.0	118.0	0.0276	0.2609	−5
−4	58.12	57.95	0.0128	1.0344	78.35	0.9668	12.3	105.8	118.1	0.0284	0.2606	−4
−3	59.34	59.16	0.0128	1.0137	78.22	0.9865	12.7	105.5	118.2	0.0292	0.2603	−3
−2	60.58	60.40	0.0128	0.9935	78.09	1.0065	13.0	105.3	118.3	0.0299	0.2600	−2
−1	61.83	61.65	0.0128	0.9738	77.96	1.0269	13.4	105.0	118.4	0.0307	0.2597	−1
0	63.11	62.93	0.0128	0.9546	77.83	1.0475	13.7	104.7	118.5	0.0315	0.2594	0
1	64.41	64.22	0.0129	0.9358	77.70	1.0686	14.1	104.5	118.6	0.0323	0.2591	1
2	65.73	65.54	0.0129	0.9175	77.57	1.0899	14.5	104.2	118.7	0.0330	0.2588	2
3	67.07	66.87	0.0129	0.8996	77.44	1.1116	14.8	104.0	118.8	0.0338	0.2585	3
4	68.43	68.23	0.0129	0.8821	77.31	1.1337	15.2	103.7	118.9	0.0346	0.2582	4
5	69.81	69.61	0.0130	0.8650	77.17	1.1561	15.5	103.4	118.9	0.0353	0.2579	5
6	71.22	71.00	0.0130	0.8483	77.04	1.1788	15.9	103.2	119.0	0.0361	0.2576	6
7	72.64	72.42	0.0130	0.8320	76.91	1.2020	16.2	102.9	119.1	0.0369	0.2573	7
8	74.09	73.86	0.0130	0.8160	76.78	1.2255	16.6	102.6	119.2	0.0376	0.2570	8
9	75.56	75.33	0.0130	0.8004	76.64	1.2493	16.9	102.3	119.3	0.0384	0.2568	9
10	77.05	76.81	0.0131	0.7852	76.51	1.2736	17.3	102.1	119.4	0.0392	0.2565	10
11	78.56	78.32	0.0131	0.7703	76.37	1.2982	17.7	101.8	119.5	0.0399	0.2562	11
12	80.09	79.85	0.0131	0.7557	76.24	1.3232	18.0	101.5	119.5	0.0407	0.2559	12
13	81.65	81.40	0.0131	0.7415	76.11	1.3486	18.4	101.2	119.6	0.0414	0.2556	13
14	83.23	82.98	0.0132	0.7276	75.97	1.3744	18.7	101.0	119.7	0.0422	0.2554	14
15	84.84	84.58	0.0132	0.7140	75.83	1.4006	19.1	100.7	119.8	0.0430	0.2551	15
16	86.46	86.20	0.0132	0.7007	75.70	1.4272	19.5	100.4	119.9	0.0437	0.2548	16
17	88.11	87.84	0.0132	0.6876	75.56	1.4542	19.8	100.1	119.9	0.0445	0.2545	17
18	89.79	89.51	0.0133	0.6749	75.42	1.4817	20.2	99.8	120.0	0.0452	0.2543	18
19	91.49	91.21	0.0133	0.6625	75.29	1.5095	20.5	99.6	120.1	0.0460	0.2540	19
20	93.21	92.93	0.0133	0.6503	75.15	1.5378	20.9	99.3	120.2	0.0467	0.2537	20
21	94.96	94.67	0.0133	0.6383	75.01	1.5666	21.3	99.0	120.3	0.0475	0.2534	21
22	96.73	96.43	0.0134	0.6267	74.87	1.5958	21.6	98.7	120.3	0.0483	0.2532	22
23	98.53	98.23	0.0134	0.6152	74.73	1.6254	22.0	98.4	120.4	0.0490	0.2529	23
24	100.36	100.04	0.0134	0.6041	74.59	1.6555	22.4	98.1	120.5	0.0498	0.2526	24
25	102.20	101.89	0.0134	0.5931	74.45	1.6860	22.7	97.8	120.6	0.0505	0.2524	25
26	104.08	103.76	0.0135	0.5824	74.31	1.7170	23.1	97.5	120.6	0.0513	0.2521	26
27	105.98	105.65	0.0135	0.5719	74.17	1.7485	23.5	97.2	120.7	0.0520	0.2518	27
28	107.91	107.57	0.0135	0.5616	74.03	1.7805	23.8	96.9	120.8	0.0528	0.2516	28
29	109.86	109.52	0.0135	0.5516	73.89	1.8130	24.2	96.6	120.9	0.0535	0.2513	29

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_f	Vapor p_g	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid H_f	Latent H_{fg}	Vapor H_g	Liquid S_f	Vapor S_g	
30	111.84	111.49	0.0136	0.5417	73.74	1.8459	24.6	96.3	120.9	0.0543	0.2510	30
31	113.85	113.49	0.0136	0.5321	73.60	1.8794	24.9	96.0	121.0	0.0550	0.2508	31
32	115.88	115.52	0.0136	0.5227	73.46	1.9133	25.3	95.7	121.1	0.0558	0.2505	32
33	117.94	117.57	0.0136	0.5134	73.31	1.9478	25.7	95.4	121.1	0.0565	0.2502	33
34	120.03	119.66	0.0137	0.5043	73.17	1.9828	26.1	95.1	121.2	0.0573	0.2500	34
35	122.15	121.77	0.0137	0.4955	73.02	2.0183	26.4	94.8	121.3	0.0580	0.2497	35
36	124.30	123.90	0.0137	0.4868	72.86	2.0544	26.8	94.5	121.3	0.0588	0.2495	36
37	126.47	126.07	0.0137	0.4782	72.73	2.0910	27.2	94.2	121.4	0.0595	0.2492	37
38	128.67	128.27	0.0138	0.4699	72.58	2.1282	27.5	93.9	121.5	0.0602	0.2489	38
39	130.91	130.49	0.0138	0.4617	72.43	2.1659	27.9	93.6	121.5	0.0610	0.2487	39
40	133.17	132.74	0.0138	0.4537	72.29	2.2042	28.3	93.3	121.6	0.0617	0.2484	40
41	135.48	135.03	0.0139	0.4458	72.14	2.2431	28.7	93.0	121.6	0.0625	0.2482	41
42	137.78	137.34	0.0139	0.4381	71.99	2.2826	29.1	92.7	121.7	0.0632	0.2479	42
43	140.13	139.68	0.0139	0.4305	71.84	2.3226	29.4	92.3	121.8	0.0640	0.2477	43
44	142.51	142.05	0.0139	0.4231	71.69	2.3633	29.8	92.0	121.8	0.0647	0.2474	44
45	144.92	144.46	0.0140	0.4159	71.54	2.4046	30.2	91.7	121.9	0.0655	0.2471	45
46	147.36	146.89	0.0140	0.4087	71.39	2.4465	30.6	91.4	121.9	0.0662	0.2469	46
47	149.83	149.35	0.0140	0.4018	71.23	2.4890	30.9	91.0	122.0	0.0669	0.2466	47
48	152.34	151.85	0.0141	0.3949	71.08	2.5322	31.3	90.7	122.0	0.0677	0.2464	48
49	154.87	154.37	0.0141	0.3882	70.93	2.5761	31.7	90.4	122.1	0.0684	0.2461	49
50	157.44	156.93	0.0141	0.3816	70.77	2.6206	32.1	90.1	122.2	0.0692	0.2459	50
51	160.04	159.52	0.0142	0.3751	70.62	2.6657	32.5	89.7	122.2	0.0699	0.2456	51
52	162.67	162.14	0.0142	0.3688	70.46	2.7116	32.9	89.4	122.3	0.0706	0.2454	52
53	165.33	164.80	0.0142	0.3626	70.31	2.7581	33.2	89.1	122.3	0.0714	0.2451	53
54	168.03	167.48	0.0143	0.3565	70.15	2.8054	33.6	88.7	122.3	0.0721	0.2448	54
55	170.76	170.20	0.0143	0.3505	69.99	2.8533	34.0	88.4	122.4	0.0729	0.2446	55
56	173.52	172.96	0.0143	0.3446	69.83	2.9020	34.4	88.0	122.4	0.0736	0.2443	56
57	176.32	175.74	0.0144	0.3388	69.67	2.9514	34.8	87.7	122.5	0.0743	0.2441	57
58	179.15	178.57	0.0144	0.3332	69.51	3.0016	35.2	87.4	122.5	0.0751	0.2438	58
59	182.01	181.42	0.0144	0.3276	69.35	3.0526	35.6	87.0	122.6	0.0758	0.2436	59
60	184.91	184.31	0.0145	0.3221	69.19	3.1043	36.0	86.7	122.6	0.0766	0.2433	60
61	187.84	187.23	0.0145	0.3168	69.03	3.1568	36.3	86.3	122.7	0.0773	0.2431	61
62	190.81	190.19	0.0145	0.3115	68.87	3.2101	36.7	86.0	122.7	0.0780	0.2428	62
63	193.82	193.18	0.0146	0.3064	68.70	3.2642	37.1	85.6	122.7	0.0788	0.2426	63
64	196.86	196.21	0.0146	0.3013	68.54	3.3191	37.5	85.3	122.8	0.0795	0.2423	64
65	199.93	199.28	0.0146	0.2963	68.37	3.3749	37.9	84.9	122.8	0.0802	0.2420	65
66	203.04	202.38	0.0147	0.2914	68.21	3.4316	38.3	84.5	122.8	0.0810	0.2418	66
67	206.19	205.51	0.0147	0.2866	68.04	3.4891	38.7	84.2	122.9	0.0817	0.2415	67
68	209.38	208.69	0.0147	0.2819	67.87	3.5475	39.1	83.9	122.9	0.0825	0.2413	68
69	212.60	211.90	0.0148	0.2773	67.71	3.6066	39.5	83.4	122.9	0.0832	0.2410	69
70	215.86	215.14	0.0148	0.2727	67.54	3.6670	39.9	83.1	123.0	0.0839	0.2408	70
71	219.15	218.43	0.0148	0.2682	67.37	3.7281	40.3	82.7	123.0	0.0847	0.2405	71
72	222.49	221.75	0.0149	0.2638	67.19	3.7902	40.7	82.3	123.0	0.0854	0.2402	72
73	225.86	225.11	0.0149	0.2595	67.02	3.8533	41.1	81.9	123.0	0.0861	0.2400	73
74	229.27	228.51	0.0150	0.2553	66.85	3.9173	41.5	81.6	123.1	0.0869	0.2397	74
75	232.72	231.94	0.0150	0.2511	66.68	3.9823	41.9	81.2	123.1	0.0876	0.2395	75
76	236.20	235.42	0.0150	0.2470	66.50	4.0484	42.3	80.8	123.1	0.0884	0.2392	76
77	239.73	238.93	0.0151	0.2430	66.32	4.1155	42.7	80.4	123.1	0.0891	0.2389	77
78	243.30	242.49	0.0151	0.2390	66.15	4.1836	43.1	80.0	123.1	0.0898	0.2387	78
79	246.91	246.08	0.0152	0.2351	65.97	4.2529	43.5	79.6	123.2	0.0906	0.2384	79
80	250.55	249.71	0.0152	0.2313	65.79	4.3232	43.9	79.2	123.2	0.0913	0.2381	80
81	254.24	253.39	0.0152	0.2276	65.61	4.3946	44.3	78.8	123.2	0.0921	0.2379	81
82	257.97	257.10	0.0153	0.2239	65.43	4.4672	44.8	78.4	123.2	0.0928	0.2376	82
83	261.74	260.85	0.0153	0.2202	65.25	4.5409	45.2	78.0	123.2	0.0936	0.2373	83
84	265.55	264.65	0.0154	0.2166	65.06	4.6159	45.6	77.6	123.2	0.0943	0.2371	84
85	269.40	268.49	0.0154	0.2131	64.88	4.6920	46.0	77.2	123.2	0.0950	0.2368	85
86	273.29	272.37	0.0155	0.2097	64.69	4.7693	46.4	76.8	123.2	0.0958	0.2365	86
87	277.23	276.29	0.0155	0.2063	64.51	4.8480	46.8	76.4	123.2	0.0965	0.2363	87
88	281.21	280.25	0.0155	0.2029	64.32	4.9278	47.3	76.0	123.2	0.0973	0.2360	88
89	285.23	284.26	0.0156	0.1996	64.13	5.0090	47.7	75.5	123.2	0.0980	0.2357	89

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_l	Vapor p_g	Liquid v_l	Vapor v_g	Liquid $1/v_l$	Vapor $1/v_g$	Liquid H_l	Latent H_{lg}	Vapor H_g	Liquid S_l	Vapor S_g	
90	289.29	288.31	0.0156	0.1964	63.94	5.0916	48.1	75.1	123.2	0.0988	0.2354	90
91	293.40	292.40	0.0157	0.1932	63.74	5.1755	48.5	74.7	123.2	0.0995	0.2352	91
92	297.55	296.54	0.0157	0.1901	63.55	5.2609	48.9	74.3	123.2	0.1003	0.2349	92
93	301.75	300.72	0.0158	0.1870	63.36	5.3474	49.4	73.9	123.2	0.1010	0.2346	93
94	305.99	304.95	0.0158	0.1840	63.16	5.4356	49.8	73.4	123.2	0.1018	0.2343	94
95	310.27	309.22	0.0159	0.1810	62.96	5.5252	50.2	72.9	123.2	0.1025	0.2340	95
96	314.60	313.53	0.0159	0.1781	62.76	5.6164	50.7	72.5	123.2	0.1033	0.2338	96
97	318.98	317.89	0.0160	0.1752	62.56	5.7090	51.1	72.1	123.1	0.1040	0.2335	97
98	323.40	322.29	0.0160	0.1723	62.36	5.8033	51.5	71.6	123.1	0.1048	0.2332	98
99	327.87	326.75	0.0161	0.1695	62.16	5.8992	52.0	71.1	123.1	0.1056	0.2329	99
100	332.38	331.24	0.0161	0.1668	61.95	5.9967	52.4	70.7	123.1	0.1063	0.2326	100
101	336.94	335.79	0.0162	0.1640	61.74	6.0959	52.8	70.2	123.1	0.1071	0.2323	101
102	341.54	340.38	0.0163	0.1614	61.53	6.1969	53.3	69.7	123.0	0.1079	0.2320	102
103	346.20	345.02	0.0163	0.1587	61.32	6.2996	53.7	69.3	123.0	0.1086	0.2317	103
104	350.90	349.70	0.0164	0.1561	61.11	6.4041	54.2	68.8	123.0	0.1094	0.2314	104
105	355.65	354.44	0.0164	0.1536	60.90	6.5105	54.6	68.3	122.9	0.1102	0.2311	105
106	360.45	359.22	0.0165	0.1511	60.68	6.6188	55.1	67.8	122.9	0.1109	0.2308	106
107	365.29	364.05	0.0165	0.1486	60.46	6.7290	55.5	67.3	122.9	0.1117	0.2305	107
108	370.19	368.93	0.0166	0.1462	60.24	6.8413	56.0	66.8	122.8	0.1125	0.2302	108
109	375.13	373.86	0.0167	0.1438	60.02	6.9555	56.5	66.3	122.8	0.1133	0.2299	109
110	380.12	378.84	0.0167	0.1414	59.79	7.0719	56.9	65.8	122.7	0.1141	0.2296	110
111	385.17	383.86	0.0168	0.1391	59.57	7.1904	57.4	65.3	122.7	0.1148	0.2293	111
112	390.26	388.94	0.0169	0.1368	59.34	7.3112	57.8	64.8	122.6	0.1156	0.2289	112
113	395.40	394.07	0.0169	0.1345	59.10	7.4342	58.3	64.3	122.6	0.1164	0.2286	113
114	400.60	399.25	0.0170	0.1323	58.87	7.5596	58.8	63.7	122.5	0.1172	0.2283	114
115	405.84	404.49	0.0171	0.1301	58.63	7.6873	59.3	63.2	122.5	0.1180	0.2280	115
116	411.14	409.77	0.0171	0.1279	58.39	7.8176	59.7	62.6	122.4	0.1188	0.2276	116
117	416.49	415.11	0.0172	0.1258	58.15	7.9504	60.2	62.1	122.3	0.1196	0.2273	117
118	421.89	420.49	0.0173	0.1237	57.91	8.0858	60.7	61.5	122.3	0.1204	0.2270	118
119	427.34	425.94	0.0173	0.1216	57.66	8.2239	61.2	61.0	122.2	0.1213	0.2266	119
120	432.85	431.43	0.0174	0.1195	57.41	8.3648	61.7	60.4	122.1	0.1221	0.2263	120
121	438.41	436.98	0.0175	0.1175	57.16	8.5085	62.2	59.8	122.0	0.1229	0.2259	121
122	444.02	442.58	0.0176	0.1155	56.90	8.6553	62.7	59.2	121.9	0.1237	0.2256	122
123	449.68	448.24	0.0177	0.1136	56.64	8.8051	63.2	58.7	121.9	0.1246	0.2252	123
124	455.40	453.95	0.0177	0.1116	56.37	8.9581	63.7	58.1	121.8	0.1254	0.2249	124
125	461.18	459.72	0.0178	0.1097	56.11	9.1144	64.2	57.4	121.7	0.1263	0.2245	125
126	467.01	465.54	0.0179	0.1078	55.83	9.2741	64.8	56.9	121.6	0.1271	0.2242	126
127	472.89	471.42	0.0180	0.1060	55.56	9.4374	65.3	56.2	121.5	0.1280	0.2238	127
128	478.83	477.35	0.0181	0.1041	55.28	9.6043	65.8	55.6	121.4	0.1289	0.2234	128
129	484.83	483.35	0.0182	0.1023	54.99	9.7752	66.3	54.9	121.3	0.1298	0.2230	129
130	490.88	489.39	0.0183	0.1005	54.70	9.9500	66.9	54.3	121.2	0.1306	0.2227	130
131	496.98	495.50	0.0184	0.0987	54.41	10.1290	67.4	53.6	121.0	0.1315	0.2223	131
132	503.15	501.66	0.0185	0.0970	54.11	10.3125	68.0	52.9	120.9	0.1324	0.2219	132
133	509.37	507.89	0.0186	0.0952	53.80	10.5005	68.6	52.2	120.8	0.1334	0.2215	133
134	515.65	514.17	0.0187	0.0935	53.49	10.6935	69.1	51.5	120.7	0.1343	0.2211	134
135	521.98	520.51	0.0188	0.0918	53.18	10.8915	69.7	50.8	120.5	0.1352	0.2207	135
136	528.37	526.91	0.0189	0.0901	52.85	11.0950	70.3	50.1	120.4	0.1362	0.2203	136
137	534.83	533.37	0.0190	0.0885	52.52	11.3043	70.9	49.3	120.3	0.1372	0.2198	137
138	541.34	539.89	0.0192	0.0868	52.18	11.5197	71.5	48.6	120.1	0.1381	0.2194	138
139	547.90	546.47	0.0193	0.0852	51.84	11.7418	72.1	47.8	119.9	0.1391	0.2190	139
140	554.53	553.12	0.0194	0.0835	51.48	11.9709	72.8	47.0	119.8	0.1401	0.2185	140
141	561.22	559.82	0.0196	0.0819	51.12	12.2077	73.4	46.2	119.6	0.1412	0.2181	141
142	567.97	566.59	0.0197	0.0803	50.74	12.4528	74.1	45.4	119.4	0.1422	0.2176	142
143	574.77	573.42	0.0199	0.0787	50.36	12.7071	74.8	44.5	119.3	0.1433	0.2171	143
144	581.64	580.31	0.0200	0.0771	49.96	12.9714	75.4	43.6	119.1	0.1444	0.2167	144
145	588.57	587.27	0.0202	0.0755	49.55	13.2468	76.2	42.7	118.9	0.1455	0.2162	145
146	595.55	594.29	0.0204	0.0739	49.13	13.5347	76.9	41.8	118.7	0.1467	0.2157	146
147	602.60	601.37	0.0205	0.0723	48.69	13.8367	77.6	40.8	118.4	0.1479	0.2151	147
148	609.71	608.52	0.0207	0.0706	48.23	14.1547	78.4	39.8	118.2	0.1491	0.2146	148
149	616.88	615.74	0.0209	0.0690	47.76	14.4913	79.2	38.7	117.9	0.1504	0.2140	149

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia]		Volume [ft³/lb]		Density [ft³/lb]		Enthalpy [Btu/lb]			Entropy [Btu/lb-°R]		Temp [°F]
	Liquid p_l	Vapor p_g	Liquid v_l	Vapor v_g	Liquid $1/v_l$	Vapor $1/v_g$	Liquid H_l	Latent H_{lg}	Vapor H_g	Liquid S_l	Vapor S_g	
90	289.29	288.31	0.0156	0.1964	63.94	5.0916	48.1	75.1	123.2	0.0988	0.2354	90
91	293.40	292.40	0.0157	0.1932	63.74	5.1755	48.5	74.7	123.2	0.0995	0.2352	91
92	297.55	296.54	0.0157	0.1901	63.55	5.2609	48.9	74.3	123.2	0.1003	0.2349	92
93	301.75	300.72	0.0158	0.1870	63.36	5.3474	49.4	73.9	123.2	0.1010	0.2346	93
94	305.99	304.95	0.0158	0.1840	63.16	5.4356	49.8	73.4	123.2	0.1018	0.2343	94
95	310.27	309.22	0.0159	0.1810	62.96	5.5252	50.2	72.9	123.2	0.1025	0.2340	95
96	314.60	313.53	0.0159	0.1781	62.76	5.6164	50.7	72.5	123.2	0.1033	0.2338	96
97	318.98	317.89	0.0160	0.1752	62.56	5.7090	51.1	72.1	123.1	0.1040	0.2335	97
98	323.40	322.29	0.0160	0.1723	62.36	5.8033	51.5	71.6	123.1	0.1048	0.2332	98
99	327.87	326.75	0.0161	0.1695	62.16	5.8992	52.0	71.1	123.1	0.1056	0.2329	99
100	332.38	331.24	0.0161	0.1668	61.95	5.9967	52.4	70.7	123.1	0.1063	0.2326	100
101	336.94	335.79	0.0162	0.1640	61.74	6.0959	52.8	70.2	123.1	0.1071	0.2323	101
102	341.54	340.38	0.0163	0.1614	61.53	6.1969	53.3	69.7	123.0	0.1079	0.2320	102
103	346.20	345.02	0.0163	0.1587	61.32	6.2996	53.7	69.3	123.0	0.1096	0.2317	103
104	350.90	349.70	0.0164	0.1561	61.11	6.4041	54.2	68.8	123.0	0.1094	0.2314	104
105	355.65	354.44	0.0164	0.1536	60.90	6.5105	54.6	68.3	122.9	0.1102	0.2311	105
106	360.45	359.22	0.0165	0.1511	60.68	6.6188	55.1	67.8	122.9	0.1109	0.2308	106
107	365.29	364.05	0.0165	0.1486	60.46	6.7290	55.5	67.3	122.9	0.1117	0.2305	107
108	370.19	368.93	0.0166	0.1462	60.24	6.8413	56.0	66.8	122.8	0.1125	0.2302	108
109	375.13	373.86	0.0167	0.1438	60.02	6.9555	56.5	66.3	122.8	0.1133	0.2299	109
110	380.12	378.84	0.0167	0.1414	59.79	7.0719	56.9	65.8	122.7	0.1141	0.2296	110
111	385.17	383.86	0.0168	0.1391	59.57	7.1904	57.4	65.3	122.7	0.1148	0.2293	111
112	390.26	388.94	0.0169	0.1368	59.34	7.3112	57.8	64.8	122.6	0.1156	0.2289	112
113	395.40	394.07	0.0169	0.1345	59.10	7.4342	58.3	64.3	122.6	0.1164	0.2286	113
114	400.60	399.25	0.0170	0.1323	58.87	7.5596	58.8	63.7	122.5	0.1172	0.2283	114
115	405.84	404.49	0.0171	0.1301	58.63	7.6873	59.3	63.2	122.5	0.1180	0.2280	115
116	411.14	409.77	0.0171	0.1279	58.39	7.8176	59.7	62.6	122.4	0.1188	0.2276	116
117	416.49	415.11	0.0172	0.1258	58.15	7.9504	60.2	62.1	122.3	0.1196	0.2273	117
118	421.89	420.49	0.0173	0.1237	57.91	8.0858	60.7	61.5	122.3	0.1204	0.2270	118
119	427.34	425.94	0.0173	0.1216	57.66	8.2239	61.2	61.0	122.2	0.1213	0.2266	119
120	432.85	431.43	0.0174	0.1195	57.41	8.3648	61.7	60.4	122.1	0.1221	0.2263	120
121	438.41	436.98	0.0175	0.1175	57.16	8.5085	62.2	59.8	122.0	0.1229	0.2259	121
122	444.02	442.58	0.0176	0.1155	56.90	8.6553	62.7	59.2	121.9	0.1237	0.2256	122
123	449.68	448.24	0.0177	0.1136	56.64	8.8051	63.2	58.7	121.9	0.1246	0.2252	123
124	455.40	453.95	0.0177	0.1116	56.37	8.9581	63.7	58.1	121.8	0.1254	0.2249	124
125	461.18	459.72	0.0178	0.1097	56.11	9.1144	64.2	57.4	121.7	0.1263	0.2245	125
126	467.01	465.54	0.0179	0.1078	55.83	9.2741	64.8	56.8	121.6	0.1271	0.2242	126
127	472.89	471.42	0.0180	0.1060	55.56	9.4374	65.3	56.2	121.5	0.1280	0.2238	127
128	478.83	477.35	0.0181	0.1041	55.28	9.6043	65.8	55.6	121.4	0.1289	0.2234	128
129	484.83	483.35	0.0182	0.1023	54.99	9.7752	66.3	54.9	121.3	0.1298	0.2230	129
130	490.88	489.39	0.0183	0.1005	54.70	9.9500	66.9	54.3	121.2	0.1306	0.2227	130
131	496.98	495.50	0.0184	0.0987	54.41	10.1290	67.4	53.6	121.0	0.1315	0.2223	131
132	503.15	501.66	0.0185	0.0970	54.11	10.3125	68.0	52.9	120.9	0.1324	0.2219	132
133	509.37	507.89	0.0186	0.0952	53.80	10.5005	68.6	52.2	120.8	0.1334	0.2215	133
134	515.65	514.17	0.0187	0.0935	53.49	10.6935	69.1	51.5	120.7	0.1343	0.2211	134
135	521.98	520.51	0.0188	0.0918	53.18	10.8915	69.7	50.8	120.5	0.1352	0.2207	135
136	528.37	526.91	0.0189	0.0901	52.85	11.0950	70.3	50.1	120.4	0.1362	0.2203	136
137	534.83	533.37	0.0190	0.0885	52.52	11.3043	70.9	49.3	120.3	0.1372	0.2198	137
138	541.34	539.89	0.0192	0.0868	52.18	11.5197	71.5	48.6	120.1	0.1381	0.2194	138
139	547.90	546.47	0.0193	0.0852	51.84	11.7418	72.1	47.8	119.9	0.1391	0.2190	139
140	554.53	553.12	0.0194	0.0835	51.48	11.9709	72.8	47.0	119.8	0.1401	0.2185	140
141	561.22	559.82	0.0196	0.0819	51.12	12.2077	73.4	46.2	119.6	0.1412	0.2181	141
142	567.97	566.59	0.0197	0.0803	50.74	12.4528	74.1	45.4	119.4	0.1422	0.2176	142
143	574.77	573.42	0.0199	0.0787	50.36	12.7071	74.8	44.5	119.3	0.1433	0.2171	143
144	581.64	580.31	0.0200	0.0771	49.96	12.9714	75.4	43.6	119.1	0.1444	0.2167	144
145	588.57	587.27	0.0202	0.0755	49.55	13.2468	76.2	42.7	118.9	0.1455	0.2162	145
146	595.55	594.29	0.0204	0.0739	49.13	13.5347	76.9	41.8	118.7	0.1467	0.2157	146
147	602.60	601.37	0.0205	0.0723	48.69	13.8367	77.6	40.8	118.4	0.1479	0.2151	147
148	609.71	608.52	0.0207	0.0706	48.23	14.1547	78.4	39.8	118.2	0.1491	0.2146	148
149	616.88	615.74	0.0209	0.0690	47.76	14.4913	79.2	38.7	117.9	0.1504	0.2140	149

Table 1. Freon™ 410A Saturation Properties—Temperature Table (continued)

Temp [°F]	Pressure [psia] Liquid p_f	Pressure [psia] Vapor p_g	Volume [ft³/lb] Liquid v_f	Volume [ft³/lb] Vapor v_g	Density [ft³/lb] Liquid $1/v_f$	Density [ft³/lb] Vapor $1/v_g$	Enthalpy [Btu/lb] Liquid H_f	Enthalpy [Btu/lb] Latent H_{fg}	Enthalpy [Btu/lb] Vapor H_g	Entropy [Btu/lb-°R] Liquid S_f	Entropy [Btu/lb-°R] Vapor S_g	Temp [°F]
150	624.12	623.02	0.0212	0.0673	47.26	14.8496	80.0	37.6	117.7	0.1517	0.2135	150
151	631.41	630.37	0.0214	0.0656	46.73	15.2337	80.9	36.5	117.4	0.1531	0.2129	151
152	638.77	637.78	0.0217	0.0639	46.18	15.6486	81.8	35.3	117.1	0.1545	0.2122	152
153	646.19	645.26	0.0219	0.0621	45.59	16.1014	82.8	34.0	116.8	0.1560	0.2116	153
154	653.67	652.81	0.0222	0.0602	44.96	16.6006	83.8	32.7	116.5	0.1576	0.2109	154
155	661.22	660.43	0.0226	0.0583	44.28	17.1576	84.9	31.3	116.1	0.1593	0.2102	155
156	668.82	668.12	0.0230	0.0562	43.54	17.7852	86.0	29.8	115.8	0.1612	0.2095	156
157	676.49	675.87	0.0234	0.0541	42.71	18.4945	87.3	28.2	115.5	0.1632	0.2089	157
158	684.23	683.70	0.0239	0.0518	41.77	19.2867	88.7	26.5	115.2	0.1654	0.2083	158
159	692.02	691.60	0.0246	0.0496	40.65	20.1422	90.3	24.8	115.1	0.1680	0.2080	159
160	699.88	699.56	0.0255	0.0476	39.25	21.0231	92.3	23.0	115.2	0.1711	0.2081	160

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 1.00 (−135.23 °F) V	H	S	2.00 (−119.38 °F) V	H	S	3.00 (−109.16 °F) V	H	S	4.00 (−101.46 °F) V	H	S	Temp [°F]
	47.6197	102.2	0.3257	24.8559	104.4	0.3135	17.0065	105.8	0.3065	12.9642	106.8	0.3017	
−130	48.4112	103.0	0.3281										−130
−120	49.9202	104.5	0.3327										−120
−110	51.4258	106.1	0.3372	25.5747	105.9	0.3177							−110
−100	52.9283	107.6	0.3416	26.3382	107.4	0.3222	17.4741	107.2	0.3107	13.0415	107.0	0.3024	−100
−90	54.4281	109.2	0.3459	27.0990	109.1	0.3266	17.9887	108.9	0.3151	13.4331	108.7	0.3069	−90
−80	55.9256	110.8	0.3502	27.8575	110.7	0.3309	18.5009	110.5	0.3196	13.8223	110.3	0.3113	−80
−70	57.4211	112.5	0.3544	28.6138	112.3	0.3352	19.0110	112.2	0.3238	14.2093	112.0	0.3156	−70
−60	58.9148	114.1	0.3586	29.3684	114.0	0.3394	19.5192	113.8	0.3280	14.5944	113.7	0.3199	−60
−50	60.4069	115.8	0.3627	30.1213	115.7	0.3435	20.0258	115.5	0.3322	14.9779	115.4	0.3241	−50
−40	61.8976	117.5	0.3668	30.8728	117.4	0.3476	20.5310	117.2	0.3363	15.3598	117.1	0.3282	−40
−30	63.3871	119.2	0.3709	31.6231	119.1	0.3517	21.0349	119.0	0.3404	15.7407	118.9	0.3323	−30
−20	64.8755	120.9	0.3748	32.3723	120.8	0.3557	21.5378	120.7	0.3444	16.1204	120.6	0.3364	−20
−10	66.3630	122.7	0.3788	33.1205	122.6	0.3597	22.0396	122.5	0.3484	16.4990	122.4	0.3404	−10
0	67.8496	124.5	0.3827	33.8679	124.4	0.3636	22.5406	124.3	0.3523	16.8768	124.2	0.3443	0
10	69.3354	126.2	0.3866	34.6145	126.2	0.3675	23.0408	126.1	0.3562	17.2538	126.0	0.3482	10
20	70.8206	128.1	0.3904	35.3604	128.0	0.3713	23.5403	127.9	0.3601	17.6302	127.8	0.3521	20
30	72.3051	129.9	0.3942	36.1057	129.8	0.3751	24.0392	129.8	0.3639	18.0059	129.7	0.3559	30
40	73.7891	131.8	0.3979	36.8505	131.7	0.3789	24.5376	131.6	0.3677	18.3811	131.6	0.3597	40
50	75.2727	133.6	0.4017	37.5948	133.6	0.3826	25.0355	133.5	0.3714	18.7558	133.5	0.3635	50
60	76.7558	135.5	0.4054	38.3387	135.5	0.3863	25.5329	135.4	0.3751	19.1300	135.4	0.3672	60
70	78.2385	137.5	0.4090	39.0821	137.4	0.3900	26.0300	137.4	0.3788	19.5039	137.3	0.3709	70
80	79.7209	139.4	0.4126	39.8253	139.4	0.3936	26.5267	139.3	0.3824	19.8774	139.3	0.3745	80
90	81.2030	141.4	0.4162	40.5681	141.3	0.3972	27.0231	141.3	0.3861	20.2506	141.2	0.3781	90
100	82.6848	143.3	0.4198	41.3106	143.3	0.4008	27.5192	143.3	0.3896	20.6235	143.2	0.3817	100
110	84.1663	145.3	0.4234	42.0529	145.3	0.4043	28.0151	145.3	0.3932	20.9962	145.2	0.3853	110
120	85.6477	147.4	0.4269	42.7950	147.3	0.4079	28.5108	147.3	0.3967	21.3686	147.2	0.3888	120
130	87.1288	149.4	0.4304	43.5369	149.4	0.4114	29.0062	149.3	0.4002	21.7409	149.3	0.3923	130
140	88.6097	151.5	0.4338	44.2785	151.4	0.4148	29.5015	151.4	0.4037	22.1129	151.4	0.3958	140
150	90.0905	153.5	0.4373	45.0201	153.5	0.4183	29.9966	153.5	0.4071	22.4848	153.4	0.3992	150
160	91.5711	155.6	0.4407	45.7614	155.6	0.4217	30.4915	155.6	0.4106	22.8566	155.5	0.4026	160
170	93.0516	157.8	0.4441	46.5026	157.7	0.4251	30.9863	157.7	0.4139	[illegible]	157.7	0.4060	170
170				47.2437	159.9	0.4284	31.4810	159.8	[illegible]	[illegible]	[illegible]	0.4094	170
180				47.9847	162.0	0.4318	31.9756	162.0	[illegible]	[illegible]	[illegible]	0.4128	180
190							32.4700	164.2	[illegible]	[illegible]	164.2	0.4161	190

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 5.00 (−95.19 °F)			6.00 (−89.86 °F)			7.00 (−85.21 °F)			8.00 (−81.08 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	10.5348	107.6	0.2980	8.8803	108.3	0.2951	7.6853	108.9	0.2926	6.7804	109.5	0.2904	
−90	10.6994	108.5	0.3004										−90
−80	11.0149	110.2	0.3048	9.1429	110.0	0.2995	7.8056	109.8	0.2949	6.8024	109.7	0.2909	−80
−70	11.3280	111.9	0.3092	9.4070	111.7	0.3039	8.0346	111.5	0.2994	7.0052	111.4	0.2954	−70
−60	11.6393	113.6	0.3135	9.6691	113.4	0.3082	8.2618	113.3	0.3037	7.2059	113.1	0.2998	−60
−50	11.9490	115.3	0.3177	9.9295	115.1	0.3125	8.4870	115.0	0.3080	7.4050	114.9	0.3041	−50
−40	12.2572	117.0	0.3219	10.1885	116.9	0.3167	8.7108	116.8	0.3123	7.6025	116.6	0.3084	−40
−30	12.5641	118.7	0.3260	10.4462	118.6	0.3209	8.9334	118.5	0.3164	7.7987	118.4	0.3126	−30
−20	12.8698	120.5	0.3301	10.7027	120.4	0.3249	9.1547	120.3	0.3205	7.9937	120.2	0.3167	−20
−10	13.1746	122.3	0.3341	10.9583	122.2	0.3290	9.3751	122.1	0.3246	8.1877	122.0	0.3208	−10
0	13.4785	124.1	0.3381	11.2129	124.0	0.3329	9.5946	123.9	0.3286	8.3808	123.8	0.3248	0
10	13.7816	125.9	0.3420	11.4668	125.8	0.3369	9.8133	125.8	0.3325	8.5731	125.7	0.3287	10
20	14.0841	127.8	0.3459	11.7199	127.7	0.3408	10.0313	127.6	0.3364	8.7647	127.5	0.3327	20
30	14.3859	129.6	0.3497	11.9725	129.6	0.3446	10.2486	129.5	0.3403	8.9557	129.4	0.3365	30
40	14.6871	131.5	0.3535	12.2245	131.4	0.3484	10.4654	131.4	0.3441	9.1461	131.3	0.3404	40
50	14.9879	133.4	0.3573	12.4760	133.3	0.3522	10.6817	133.3	0.3479	9.3360	133.2	0.3441	50
60	15.2882	135.3	0.3610	12.7270	135.3	0.3559	10.8976	135.2	0.3516	9.5255	135.1	0.3479	60
70	15.5882	137.2	0.3647	12.9777	137.2	0.3596	11.1131	137.1	0.3553	9.7146	137.1	0.3516	70
80	15.8878	139.2	0.3683	13.2280	139.2	0.3633	11.3282	139.1	0.3590	9.9033	139.1	0.3553	80
90	16.1871	141.2	0.3720	13.4780	141.1	0.3669	11.5430	141.1	0.3626	10.0917	141.0	0.3589	90
100	16.4861	143.2	0.3755	13.7278	143.1	0.3705	11.7575	143.1	0.3662	10.2799	143.0	0.3625	100
110	16.7848	145.2	0.3791	13.9772	145.1	0.3741	11.9718	145.1	0.3698	10.4677	145.1	0.3661	110
120	17.0834	147.2	0.3826	14.2265	147.2	0.3776	12.1859	147.1	0.3733	10.6554	147.1	0.3696	120
130	17.3817	149.3	0.3861	14.4755	149.2	0.3811	12.3997	149.2	0.3768	10.8428	149.1	0.3731	130
140	17.6798	151.3	0.3896	14.7244	151.3	0.3846	12.6134	151.3	0.3803	11.0301	151.2	0.3766	140
150	17.9778	153.4	0.3931	14.9731	153.4	0.3880	12.8268	153.3	0.3838	11.2172	153.3	0.3801	150
160	18.2756	155.5	0.3965	15.2216	155.5	0.3915	13.0402	155.5	0.3872	11.4041	155.4	0.3835	160
170	18.5733	157.6	0.3999	15.4700	157.6	0.3949	13.2534	157.6	0.3906	11.5909	157.5	0.3869	170
180	18.8708	159.8	0.4033	15.7183	159.8	0.3983	13.4664	159.7	0.3940	11.7776	159.7	0.3903	180
190	19.1682	161.9	0.4066	15.9664	161.9	0.4016	13.6794	161.9	0.3974	11.9641	161.9	0.3937	190
200	19.4656	164.1	0.4100	16.2145	164.1	0.4049	13.8922	164.1	0.4007	12.1505	164.0	0.3970	200
210	19.7628	166.3	0.4133	16.4624	166.3	0.4083	14.1050	166.3	0.4040	12.3369	166.2	0.4003	210
220				16.7103	168.5	0.4115	14.3176	168.5	0.4073	12.5232	168.5	0.4036	220

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia]												Temp [°F]
	9.00			10.00			11.00			12.00			
	−77.33 °F			−73.91 °F			−70.75 °F			−67.81 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	6.0708	109.9	0.2886	5.4988	110.4	0.2869	5.0277	110.8	0.2854	4.6327	111.1	0.2840	
−70	6.2043	111.2	0.2919	5.5635	111.1	0.2887	5.0391	110.9	0.2857				−70
−60	6.3847	113.0	0.2963	5.7276	112.8	0.2931	5.1899	112.7	0.2903	4.7417	112.5	0.2876	−60
−50	6.5633	114.7	0.3007	5.8899	114.6	0.2975	5.3388	114.5	0.2947	4.8795	114.3	0.2920	−50
−40	6.7403	116.5	0.3050	6.0506	116.4	0.3018	5.4861	116.3	0.2990	5.0157	116.1	0.2964	−40
−30	6.9161	118.3	0.3092	6.2099	118.2	0.3061	5.6321	118.1	0.3033	5.1505	118.0	0.3007	−30
−20	7.0906	120.1	0.3133	6.3681	120.0	0.3102	5.7769	119.9	0.3075	5.2842	119.8	0.3049	−20
−10	7.2641	121.9	0.3174	6.5252	121.8	0.3143	5.9206	121.7	0.3116	5.4167	121.6	0.3090	−10
0	7.4367	123.8	0.3214	6.6814	123.7	0.3184	6.0634	123.6	0.3156	5.5484	123.5	0.3131	0
10	7.6085	125.6	0.3254	6.8368	125.5	0.3224	6.2054	125.4	0.3196	5.6792	125.4	0.3171	10
20	7.7796	127.5	0.3293	6.9915	127.4	0.3263	6.3466	127.3	0.3236	5.8092	127.2	0.3211	20
30	7.9501	129.3	0.3332	7.1455	129.3	0.3302	6.4873	129.2	0.3275	5.9387	129.1	0.3250	30
40	8.1199	131.2	0.3370	7.2990	131.2	0.3341	6.6273	131.1	0.3313	6.0676	131.0	0.3289	40
50	8.2893	133.2	0.3408	7.4520	133.1	0.3379	6.7669	133.0	0.3352	6.1959	133.0	0.3327	50
60	8.4583	135.1	0.3446	7.6045	135.0	0.3416	6.9060	135.0	0.3389	6.3238	134.9	0.3365	60
70	8.6269	137.0	0.3483	7.7567	137.0	0.3453	7.0447	136.9	0.3427	6.4514	136.9	0.3402	70
80	8.7951	139.0	0.3520	7.9085	138.9	0.3490	7.1830	138.9	0.3463	6.5785	138.8	0.3439	80
90	8.9630	141.0	0.3556	8.0599	140.9	0.3527	7.3211	140.9	0.3500	6.7053	140.8	0.3476	90
100	9.1306	143.0	0.3592	8.2111	142.9	0.3563	7.4588	142.9	0.3536	6.8319	142.9	0.3512	100
110	9.2979	145.0	0.3628	8.3620	145.0	0.3599	7.5963	144.9	0.3572	6.9582	144.9	0.3548	110
120	9.4650	147.0	0.3664	8.5127	147.0	0.3634	7.7335	147.0	0.3608	7.0842	146.9	0.3583	120
130	9.6319	149.1	0.3699	8.6632	149.1	0.3669	7.8706	149.0	0.3643	7.2101	149.0	0.3619	130
140	9.7986	151.2	0.3734	8.8135	151.1	0.3704	8.0074	151.1	0.3678	7.3357	151.1	0.3654	140
150	9.9652	153.3	0.3768	8.9636	153.2	0.3739	8.1441	153.2	0.3713	7.4612	153.2	0.3688	150
160	10.1316	155.4	0.3803	9.1136	155.4	0.3773	8.2807	155.3	0.3747	7.5866	155.3	0.3723	160
170	10.2978	157.5	0.3837	9.2634	157.5	0.3808	8.4171	157.5	0.3781	7.7118	157.4	0.3757	170
180	10.4640	159.7	0.3871	9.4131	159.6	0.3841	8.5533	159.6	0.3815	7.8368	159.6	0.3791	180
190	10.6300	161.8	0.3904	9.5627	161.8	0.3875	8.6895	161.8	0.3849	7.9618	161.7	0.3825	190
200	10.7959	164.0	0.3938	9.7122	164.0	0.3908	8.8255	164.0	0.3882	8.0866	163.9	0.3858	200
210	10.9617	166.2	0.3971	9.8616	166.2	0.3942	8.9615	166.2	0.3915	8.2114	166.1	0.3891	210
220	11.1275	168.4	0.4004	10.0109	168.4	0.3975	9.0973	168.4	0.3948	8.3360	168.4	0.3924	220
230	11.2931	170.7	0.4036	10.1601	170.7	0.4007	9.2331	170.6	0.3981	8.4606	170.6	0.3957	230
240										8.5851	172.9	0.3989	240

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 13.00 (−65.06 °F) V	H	S	14.00 (−62.48 °F) V	H	S	14.696 (−60.76 °F) V	H	S	15.00 (−60.03 °F) V	H	S	Temp [°F]
	4.2967	111.5	0.2828	4.0070	111.8	0.2817	3.8280	112.0	0.2809	3.7548	112.1	0.2806	
−60	4.3623	112.4	0.2851	4.0371	112.2	0.2828	3.8368	112.1	0.2813	3.7552	112.1	0.2806	−60
−50	4.4908	114.2	0.2896	4.1575	114.1	0.2873	3.9523	114.0	0.2858	3.8687	113.9	0.2852	−50
−40	4.6175	116.0	0.2940	4.2763	115.9	0.2917	4.0662	115.8	0.2902	3.9805	115.8	0.2896	−40
−30	4.7430	117.8	0.2983	4.3937	117.7	0.2961	4.1786	117.7	0.2946	4.0909	117.6	0.2940	−30
−20	4.8672	119.7	0.3025	4.5098	119.6	0.3003	4.2897	119.5	0.2989	4.2000	119.5	0.2982	−20
−10	4.9903	121.5	0.3067	4.6248	121.4	0.3045	4.3998	121.4	0.3030	4.3080	121.3	0.3024	−10
0	5.1125	123.4	0.3109	4.7389	123.3	0.3086	4.5089	123.2	0.3072	4.4151	123.2	0.3066	0
10	5.2339	125.3	0.3148	4.8522	125.2	0.3126	4.6172	125.1	0.3112	4.5214	125.1	0.3106	10
20	5.3545	127.2	0.3188	4.9647	127.1	0.3166	4.7247	127.0	0.3152	4.6269	127.0	0.3146	20
30	5.4745	129.1	0.3227	5.0766	129.0	0.3206	4.8316	128.9	0.3192	4.7317	128.9	0.3186	30
40	5.5939	131.0	0.3266	5.1879	130.9	0.3244	4.9379	130.9	0.3230	4.8360	130.8	0.3225	40
50	5.7128	132.9	0.3304	5.2987	132.6	0.3283	5.0437	132.8	0.3269	4.9398	132.8	0.3263	50
60	5.8313	134.9	0.3342	5.4090	134.8	0.3321	5.1491	134.8	0.3307	5.0431	134.7	0.3301	60
70	5.9493	136.8	0.3379	5.5190	136.8	0.3358	5.2540	136.7	0.3344	5.1460	136.7	0.3339	70
80	6.0670	138.8	0.3416	5.6285	138.7	0.3395	5.3586	138.7	0.3382	5.2485	138.7	0.3376	80
90	6.1843	140.8	0.3453	5.7378	140.7	0.3432	5.4628	140.7	0.3418	5.3507	140.7	0.3413	90
100	6.3014	142.8	0.3489	5.8467	142.8	0.3468	5.5668	142.7	0.3455	5.4527	142.7	0.3449	100
110	6.4182	144.8	0.3525	5.9554	144.8	0.3504	5.6705	144.8	0.3491	5.5543	144.8	0.3485	110
120	6.5348	146.9	0.3561	6.0639	146.8	0.3540	5.7739	146.8	0.3527	5.6557	146.8	0.3521	120
130	6.6512	149.0	0.3596	6.1721	148.9	0.3576	5.8772	148.9	0.3562	5.7570	148.9	0.3556	130
140	6.7674	151.0	0.3631	6.2802	151.0	0.3611	5.9803	151.0	0.3597	5.8580	151.0	0.3591	140
150	6.8834	153.1	0.3666	6.3881	153.1	0.3645	6.0832	153.1	0.3632	5.9588	153.1	0.3626	150
160	6.9993	155.3	0.3701	6.4958	155.2	0.3680	6.1859	155.2	0.3666	6.0595	155.2	0.3661	160
170	7.1150	157.4	0.3735	6.6034	157.4	0.3714	6.2885	157.3	0.3701	6.1601	157.3	0.3695	170
180	7.2306	159.5	0.3769	6.7109	159.5	0.3748	6.3910	159.5	0.3735	6.2605	159.5	0.3729	180
190	7.3460	161.7	0.3802	6.8183	161.7	0.3782	6.4933	161.7	0.3768	6.3608	161.7	0.3763	190
200	7.4614	163.9	0.3836	6.9255	163.9	0.3815	6.5956	163.9	0.3802	6.4611	163.9	0.3796	200
210	7.5767	166.1	0.3869	7.0327	166.1	0.3848	6.6977	166.1	0.3835	6.5612	166.1	0.3829	210
220	7.6919	168.3	0.3902	7.1397	168.3	0.3881	6.7998	168.3	0.3868	6.6612	168.3	0.3862	220
230	7.8070	170.6	0.3935	7.2467	170.6	0.3914	6.9018	170.5	0.3901	6.7611	170.5	0.3895	230
240	7.9220	172.8	0.3967	7.3536	172.6	0.3947	7.0037	172.8	0.3933	6.8610	172.8	0.3928	240

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 16.00 (−57.71 °F) V	H	S	17.00 (−55.50 °F) V	H	S	18.00 (−53.40 °F) V	H	S	19.00 (−51.38 °F) V	H	S	Temp [°F]
	3.5331	112.4	0.2796	3.3367	112.6	0.2787	3.1614	112.9	0.2778	3.0039	113.1	0.2770	
−50	3.6158	113.8	0.2831	3.3927	113.6	0.2812	3.1943	113.5	0.2794	3.0167	113.4	0.2776	−50
−40	3.7215	115.6	0.2876	3.4931	115.5	0.2857	3.2899	115.4	0.2839	3.1081	115.3	0.2822	−40
−30	3.8259	117.5	0.2920	3.5920	117.4	0.2901	3.3841	117.3	0.2884	3.1980	117.2	0.2867	−30
−20	3.9289	119.4	0.2963	3.6897	119.3	0.2944	3.4770	119.2	0.2927	3.2866	119.0	0.2910	−20
−10	4.0309	121.2	0.3005	3.7862	121.1	0.2987	3.5687	121.0	0.2969	3.3741	120.9	0.2953	−10
0	4.1318	123.1	0.3046	3.8816	123.0	0.3028	3.6595	122.9	0.3011	3.4606	122.9	0.2995	0
10	4.2319	125.0	0.3087	3.9765	124.9	0.3069	3.7494	124.9	0.3052	3.5462	124.8	0.3036	10
20	4.3313	126.9	0.3127	4.0704	126.8	0.3109	3.8385	126.8	0.3093	3.6310	126.7	0.3077	20
30	4.4300	128.8	0.3167	4.1637	128.8	0.3149	3.9270	128.7	0.3132	3.7152	128.6	0.3116	30
40	4.5281	130.8	0.3206	4.2564	130.7	0.3188	4.0149	130.6	0.3172	3.7988	130.6	0.3156	40
50	4.6257	132.7	0.3244	4.3486	132.7	0.3227	4.1023	132.6	0.3210	3.8819	132.5	0.3195	50
60	4.7229	134.7	0.3283	4.4403	134.6	0.3265	4.1892	134.6	0.3249	3.9645	134.5	0.3233	60
70	4.8196	136.7	0.3320	4.5317	136.6	0.3303	4.2757	136.5	0.3286	4.0467	136.5	0.3271	70
80	4.9160	138.6	0.3357	4.6226	138.6	0.3340	4.3618	138.5	0.3324	4.1285	138.5	0.3308	80
90	5.0121	140.6	0.3394	4.7132	140.6	0.3377	4.4476	140.6	0.3361	4.2100	140.5	0.3345	90
100	5.1078	142.7	0.3431	4.8036	142.6	0.3414	4.5331	142.6	0.3397	4.2911	142.5	0.3382	100
110	5.2033	144.7	0.3467	4.8937	144.7	0.3450	4.6184	144.6	0.3433	4.3721	144.6	0.3418	110
120	5.2986	146.8	0.3503	4.9835	146.7	0.3485	4.7034	146.7	0.3469	4.4528	146.6	0.3454	120
130	5.3937	148.8	0.3538	5.0731	148.8	0.3521	4.7882	148.8	0.3505	4.5332	148.7	0.3490	130
140	5.4885	150.9	0.3573	5.1626	150.9	0.3556	4.8728	150.9	0.3540	4.6135	150.8	0.3525	140
150	5.5932	153.0	0.3608	5.2518	153.0	0.3591	4.9572	153.0	0.3575	4.6936	152.9	0.3560	150
160	5.6778	155.2	0.3643	5.3409	155.1	0.3626	5.0415	155.1	0.3610	4.7736	155.1	0.3594	160
170	5.7722	157.3	0.3677	5.4299	157.3	0.3660	5.1256	157.2	0.3644	4.8534	157.2	0.3629	170
180	5.8664	159.5	0.3711	5.5187	159.4	0.3694	5.2096	159.4	0.3678	4.9331	159.4	0.3663	180
190	5.9606	161.6	0.3745	5.6075	161.6	0.3728	5.2935	161.6	0.3712	5.0127	161.6	0.3697	190
200	6.0547	163.8	0.3778	5.6961	163.8	0.3761	5.3773	163.8	0.3745	5.0921	163.7	0.3730	200
210	6.1486	166.0	0.3811	5.7846	166.0	0.3795	5.4610	166.0	0.3779	5.1715	166.0	0.3764	210
220	6.2425	168.3	0.3844	5.8730	168.2	0.3928	5.5446	168.2	0.3812	5.2508	168.2	0.3797	220
230	6.3363	170.5	0.3877	5.9614	170.5	0.3960	5.6281	170.5	0.3845	5.3300	170.4	0.3829	230
240	6.4300	172.8	0.3910	6.0497	172.6	0.3893	5.7116	172.7	0.3877	5.4091	172.7	0.3862	240
250	6.5236	175.1	0.3942	6.1379	175.0	0.3925	5.7950	175.0	0.3910	5.4882	175.0	0.3894	250

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia]												Temp [°F]
	20.00			21.00			22.00			23.00			
	−49.45 °F			−47.59 °F			−45.80 °F			−44.07 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	2.8617	113.3	0.2762	2.7326	113.5	0.2755	2.6148	113.8	0.2748	2.5070	114.0	0.2741	
−40	2.9445	115.1	0.2806	2.7963	115.0	0.2790	2.6616	114.9	0.2775	2.5386	114.7	0.2760	−40
−30	3.0305	117.0	0.2850	2.8790	116.9	0.2835	2.7412	116.8	0.2820	2.6153	116.7	0.2806	−30
−20	3.1153	118.9	0.2894	2.9603	118.8	0.2879	2.8193	118.7	0.2864	2.6906	118.6	0.2850	−20
−10	3.1989	120.8	0.2937	3.0404	120.7	0.2922	2.8963	120.6	0.2908	2.7647	120.5	0.2894	−10
0	3.2816	122.8	0.2979	3.1196	122.7	0.2964	2.9723	122.6	0.2950	2.8378	122.5	0.2936	0
10	3.3633	124.7	0.3021	3.1976	124.6	0.3006	3.0474	124.5	0.2992	2.4104	124.4	0.2978	10
20	3.4443	126.6	0.3061	3.2753	126.5	0.3047	3.1217	126.5	0.3033	2.9814	126.4	0.3019	20
30	3.5246	128.6	0.3101	3.3521	128.5	0.3087	3.1953	128.4	0.3073	3.0521	128.3	0.3060	30
40	3.6043	130.5	0.3141	3.4283	130.4	0.3126	3.2683	130.4	0.3113	3.1222	130.3	0.3099	40
50	3.6835	132.5	0.3180	3.5040	132.4	0.3165	3.3408	132.3	0.3152	3.1918	132.3	0.3139	50
60	3.7622	134.4	0.3218	3.5792	134.4	0.3204	3.4126	134.3	0.3190	3.2608	134.3	0.3177	60
70	3.8405	136.4	0.3256	3.6540	136.4	0.3242	3.4844	136.3	0.3228	3.3296	136.3	0.3215	70
80	3.9184	138.4	0.3294	3.7284	138.4	0.3279	3.5557	138.3	0.3266	3.3979	138.3	0.3253	80
90	3.9960	140.5	0.3331	3.8025	140.4	0.3317	3.6266	140.4	0.3303	3.4659	140.3	0.3290	90
100	4.0734	142.5	0.3367	3.8763	142.4	0.3353	3.6972	142.4	0.3340	3.5336	142.4	0.3327	100
110	4.1504	144.5	0.3404	3.9498	144.5	0.3390	3.7675	144.5	0.3376	3.6010	144.4	0.3364	110
120	4.2272	146.6	0.3439	4.0231	146.6	0.3426	3.8376	146.5	0.3412	3.6682	146.5	0.3400	120
130	4.3039	148.7	0.3475	4.0962	148.6	0.3461	3.9075	148.6	0.3448	3.7351	148.6	0.3435	130
140	4.3802	150.8	0.3510	4.1691	150.7	0.3497	3.9771	150.7	0.3483	3.8019	150.7	0.3471	140
150	4.4564	152.9	0.3545	4.2418	152.9	0.3532	4.0467	152.8	0.3518	3.8685	152.8	0.3506	150
160	4.5325	155.0	0.3580	4.3143	155.0	0.3566	4.1160	155.0	0.3553	3.9349	154.9	0.3541	160
170	4.6084	157.2	0.3614	4.3867	157.1	0.3601	4.1852	157.1	0.3586	4.0012	157.1	0.3575	170
180	4.6842	159.3	0.3648	4.4590	159.3	0.3635	4.2543	159.3	0.3622	4.0674	159.3	0.3609	180
190	4.7599	161.5	0.3682	4.5312	161.5	0.3669	4.3233	161.5	0.3656	4.1334	161.4	0.3643	190
200	4.8355	163.7	0.3716	4.6032	163.7	0.3702	4.3921	163.7	0.3689	4.1994	163.6	0.3677	200
210	4.9109	165.9	0.3749	4.6752	165.9	0.3736	4.4609	165.9	0.3723	4.2652	165.9	0.3710	210
220	4.9863	168.2	0.3782	4.7471	168.1	0.3769	4.5295	168.1	0.3756	4.3309	168.1	0.3743	220
230	5.0616	170.4	0.3815	4.8188	170.4	0.3802	4.5981	170.4	0.3789	4.3966	170.3	0.3776	230
240	5.1369	172.7	0.3848	4.8906	172.7	0.3834	4.6666	172.6	0.3821	4.4622	172.6	0.3809	240
250	5.2120	175.0	0.3880	4.9622	174.9	0.3867	4.7351	174.9	0.3854	4.5277	174.9	0.3841	250
260	5.2871	177.3	0.3912	5.0338	177.3	0.3899	4.8035	177.2	0.3886	4.5932	177.2	0.3874	260

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia]												Temp [°F]
	20.00			21.00			22.00			23.00			
	−49.45 °F			−47.59 °F			−45.80 °F			−44.07 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	2.8617	113.3	0.2762	2.7326	113.5	0.2755	2.6148	113.8	0.2748	2.5070	114.0	0.2741	
−40	2.9445	115.1	0.2806	2.7963	115.0	0.2790	2.6616	114.9	0.2775	2.5386	114.7	0.2760	−40
−30	3.0305	117.0	0.2850	2.8790	116.9	0.2835	2.7412	116.8	0.2820	2.6153	116.7	0.2806	−30
−20	3.1153	118.9	0.2894	2.9603	118.8	0.2879	2.8193	118.7	0.2864	2.6906	118.6	0.2850	−20
−10	3.1989	120.8	0.2937	3.0404	120.7	0.2922	2.8963	120.6	0.2908	2.7647	120.5	0.2894	−10
0	3.2816	122.8	0.2979	3.1196	122.7	0.2964	2.9723	122.6	0.2950	2.8378	122.5	0.2936	0
10	3.3633	124.7	0.3021	3.1976	124.6	0.3006	3.0474	124.5	0.2992	2.4104	124.4	0.2978	10
20	3.4443	126.6	0.3061	3.2753	126.5	0.3047	3.1217	126.5	0.3033	2.9814	126.4	0.3019	20
30	3.5246	128.6	0.3101	3.3521	128.5	0.3087	3.1953	128.4	0.3073	3.0521	128.3	0.3060	30
40	3.6043	130.5	0.3141	3.4283	130.4	0.3126	3.2683	130.4	0.3113	3.1222	130.3	0.3099	40
50	3.6835	132.5	0.3180	3.5040	132.4	0.3165	3.3408	132.3	0.3152	3.1918	132.3	0.3139	50
60	3.7622	134.4	0.3218	3.5792	134.4	0.3204	3.4126	134.3	0.3190	3.2608	134.3	0.3177	60
70	3.8405	136.4	0.3256	3.6540	136.4	0.3242	3.4844	136.3	0.3228	3.3296	136.3	0.3215	70
80	3.9184	138.4	0.3294	3.7284	138.4	0.3279	3.5557	138.3	0.3266	3.3979	138.3	0.3253	80
90	3.9960	140.5	0.3331	3.8025	140.4	0.3317	3.6266	140.4	0.3303	3.4659	140.3	0.3290	90
100	4.0734	142.5	0.3367	3.8763	142.4	0.3353	3.6972	142.4	0.3340	3.5336	142.4	0.3327	100
110	4.1504	144.5	0.3404	3.9498	144.5	0.3390	3.7675	144.5	0.3376	3.6010	144.4	0.3364	110
120	4.2272	146.6	0.3439	4.0231	146.6	0.3426	3.8376	146.5	0.3412	3.6682	146.5	0.3400	120
130	4.3038	148.7	0.3475	4.0962	148.6	0.3461	3.9075	148.6	0.3448	3.7351	148.6	0.3435	130
140	4.3802	150.8	0.3510	4.1691	150.7	0.3497	3.9771	150.7	0.3483	3.8019	150.7	0.3471	140
150	4.4564	152.9	0.3545	4.2418	152.9	0.3532	4.0467	152.8	0.3518	3.8685	152.8	0.3506	150
160	4.5325	155.0	0.3580	4.3143	155.0	0.3566	4.1160	155.0	0.3553	3.9349	154.9	0.3541	160
170	4.6084	157.2	0.3614	4.3867	157.1	0.3601	4.1852	157.1	0.3588	4.0012	157.1	0.3575	170
180	4.6842	159.3	0.3648	4.4590	159.3	0.3635	4.2543	159.3	0.3622	4.0674	159.3	0.3609	180
190	4.7599	161.5	0.3682	4.5312	161.5	0.3669	4.3233	161.5	0.3656	4.1334	161.4	0.3643	190
200	4.8355	163.7	0.3716	4.6032	163.7	0.3702	4.3921	163.7	0.3689	4.1994	163.6	0.3677	200
210	4.9109	165.9	0.3749	4.6752	165.9	0.3736	4.4609	165.9	0.3723	4.2652	165.9	0.3710	210
220	4.9863	168.2	0.3782	4.7471	168.1	0.3769	4.5295	168.1	0.3756	4.3309	168.1	0.3743	220
230	5.0616	170.4	0.3815	4.8188	170.4	0.3802	4.5981	170.4	0.3789	4.3966	170.3	0.3776	230
240	5.1369	172.7	0.3848	4.8906	172.7	0.3834	4.6666	172.6	0.3821	4.4622	172.6	0.3809	240
250	5.2120	175.0	0.3880	4.9622	174.9	0.3867	4.7351	174.9	0.3854	4.5277	174.9	0.3841	250
260	5.2871	177.3	0.3912	5.0338	177.3	0.3899	4.8035	177.2	0.3886	4.5932	177.2	0.3874	260

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 24.00 (−42.40 °F)			25.00 (−40.78 °F)			26.00 (−39.21 °F)			27.00 (−37.69 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	2.4078	114.1	0.2735	2.3163	114.3	0.2729	2.2316	114.5	0.2723	2.1530	114.7	0.2717	
−40	2.4258	114.6	0.2746	2.3220	114.5	0.2732							−40
−30	2.4999	116.6	0.2792	2.3937	116.4	0.2779	2.2956	116.3	0.2766	2.2048	116.2	0.2753	−30
−20	2.5726	118.5	0.2837	2.4639	118.4	0.2824	2.3637	118.3	0.2811	2.2709	118.2	0.2799	−20
−10	2.6440	120.4	0.2880	2.5330	120.3	0.2868	2.4305	120.2	0.2855	2.3356	120.1	0.2843	−10
0	2.7145	122.4	0.2923	2.6010	122.3	0.2911	2.4963	122.2	0.2898	2.3993	122.1	0.2886	0
10	2.7840	124.3	0.2965	2.6681	124.3	0.2953	2.5612	124.2	0.2941	2.4621	124.1	0.2929	10
20	2.8528	126.3	0.3006	2.7345	126.2	0.2994	2.6252	126.1	0.2982	2.5241	126.1	0.2970	20
30	2.9208	128.3	0.3047	2.8001	128.2	0.3035	2.6886	128.1	0.3023	2.5854	128.0	0.3011	30
40	2.9883	130.2	0.3087	2.8651	130.2	0.3075	2.7513	130.1	0.3063	2.6460	130.0	0.3051	40
50	3.0552	132.2	0.3126	2.9296	132.2	0.3114	2.8136	132.1	0.3102	2.7061	132.0	0.3091	50
60	3.1217	134.2	0.3165	2.9936	134.1	0.3153	2.8753	134.1	0.3141	2.7658	134.0	0.3130	60
70	3.1877	136.2	0.3203	3.0571	136.2	0.3191	2.9366	136.1	0.3180	2.8250	136.0	0.3168	70
80	3.2533	138.2	0.3241	3.1203	138.2	0.3229	2.9975	138.1	0.3217	2.8838	138.1	0.3206	80
90	3.3186	140.3	0.3278	3.1832	140.2	0.3266	3.0581	140.2	0.3255	2.9423	140.1	0.3244	90
100	3.3837	142.3	0.3315	3.2457	142.3	0.3303	3.1184	142.2	0.3292	3.0005	142.2	0.3281	100
110	3.4484	144.4	0.3351	3.3080	144.3	0.3340	3.1784	144.3	0.3328	3.0584	144.2	0.3318	110
120	3.5129	146.4	0.3388	3.3700	146.4	0.3376	3.2381	146.4	0.3365	3.1160	146.3	0.3354	120
130	3.5772	148.5	0.3423	3.4318	148.5	0.3412	3.2977	148.5	0.3400	3.1735	148.4	0.3390	130
140	3.6413	150.6	0.3459	3.4935	150.6	0.3447	3.3571	150.6	0.3436	3.2307	150.5	0.3425	140
150	3.7052	152.8	0.3494	3.5549	152.7	0.3482	3.4162	152.7	0.3471	3.2878	152.7	0.3460	150
160	3.7689	154.9	0.3529	3.6162	154.9	0.3517	3.4753	154.8	0.3506	3.3447	154.8	0.3495	160
170	3.8325	157.1	0.3563	3.6774	157.0	0.3552	3.5341	157.0	0.3540	3.4015	157.0	0.3530	170
180	3.8960	159.2	0.3597	3.7384	159.2	0.3586	3.5929	159.2	0.3575	3.4581	159.1	0.3564	180
190	3.9594	161.4	0.3631	3.7993	161.4	0.3620	3.6515	161.4	0.3609	3.5147	161.3	0.3598	190
200	4.0227	163.6	0.3665	3.8601	163.6	0.3653	3.7100	163.6	0.3642	3.5711	163.5	0.3632	200
210	4.0858	165.8	0.3698	3.9208	165.8	0.3687	3.7685	165.8	0.3676	3.6274	165.8	0.3665	210
220	4.1489	168.1	0.3731	3.9814	168.0	0.3720	3.8268	168.0	0.3709	3.6836	168.0	0.3698	220
230	4.2119	170.3	0.3764	4.0419	170.3	0.3753	3.8850	170.3	0.3742	3.7398	170.3	0.3731	230
240	4.2748	172.6	0.3797	4.1024	172.6	0.3786	3.9432	172.5	0.3775	3.7959	172.5	0.3764	240
250	4.3376	174.9	0.3829	4.1628	174.9	0.3818	4.0013	174.8	0.3807	3.8519	174.8	0.3797	250
260	4.4004	177.2	0.3862	4.2231	177.2	0.3850	4.0594	177.1	0.3839	3.9078	177.1	0.3829	260
270							4.1174	179.5	0.3871	3.9637	179.4	0.3861	270

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 28.00 (−36.21 °F) V	H	S	29.00 (−34.78 °F) V	H	S	30.00 (−33.38 °F) V	H	S	31.00 (−32.02 °F) V	H	S	Temp [°F]
	2.0798	114.8	0.2712	2.0115	115.0	0.2707	1.9476	115.1	0.2702	1.8877	115.3	0.2697	
−30	2.1204	116.1	0.2741	2.0418	115.9	0.2729	1.9685	115.8	0.2718	1.8998	115.7	0.2706	−30
−20	2.1845	118.1	0.2787	2.1042	117.9	0.2775	2.0292	117.8	0.2764	1.9590	117.7	0.2753	−20
−10	2.2474	120.0	0.2831	2.1653	119.9	0.2820	2.0887	119.8	0.2809	2.0169	119.7	0.2798	−10
0	2.3092	122.0	0.2875	2.2253	121.9	0.2864	2.1470	121.8	0.2853	2.0738	121.7	0.2842	0
10	2.3701	124.0	0.2917	2.2844	123.9	0.2906	2.2044	123.8	0.2896	2.1296	123.7	0.2885	10
20	2.4301	126.0	0.2959	2.3427	125.9	0.2948	2.2610	125.8	0.2938	2.1846	125.7	0.2928	20
30	2.4895	128.0	0.3000	2.4002	127.9	0.2989	2.3169	127.8	0.2979	2.2389	127.7	0.2969	30
40	2.5482	130.0	0.3040	2.4571	129.9	0.3030	2.3721	129.8	0.3020	2.2926	129.8	0.3009	40
50	2.6064	132.0	0.3080	2.5135	131.9	0.3070	2.4268	131.8	0.3059	2.3457	131.8	0.3049	50
60	2.6641	134.0	0.3119	2.5694	133.9	0.3109	2.4810	133.9	0.3099	2.3983	133.8	0.3089	60
70	2.7213	136.0	0.3158	2.6248	135.9	0.3147	2.5348	135.9	0.3137	2.4505	135.8	0.3128	70
80	2.7782	138.0	0.3196	2.6799	138.0	0.3185	2.5881	137.9	0.3175	2.5023	137.9	0.3166	80
90	2.8347	140.1	0.3233	2.7346	140.0	0.3223	2.6412	140.0	0.3213	2.5537	139.9	0.3203	90
100	2.8910	142.1	0.3270	2.7890	142.1	0.3260	2.6939	142.0	0.3250	2.6049	142.0	0.3241	100
110	2.9469	144.2	0.3307	2.8432	144.2	0.3297	2.7463	144.1	0.3287	2.6557	144.1	0.3277	110
120	3.0026	146.3	0.3343	2.8971	146.2	0.3333	2.7985	146.2	0.3323	2.7063	146.2	0.3314	120
130	3.0581	148.4	0.3379	2.9507	148.3	0.3369	2.8505	148.3	0.3359	2.7567	148.3	0.3350	130
140	3.1134	150.5	0.3415	3.0042	150.5	0.3405	2.9023	150.4	0.3395	2.8069	150.4	0.3386	140
150	3.1686	152.6	0.3450	3.0575	152.6	0.3440	2.9539	152.6	0.3430	2.8570	152.5	0.3421	150
160	3.2235	154.8	0.3485	3.1107	154.7	0.3475	3.0054	154.7	0.3465	2.9068	154.7	0.3456	160
170	3.2783	156.9	0.3519	3.1637	156.9	0.3509	3.0567	156.9	0.3500	2.9565	156.8	0.3491	170
180	3.3330	159.1	0.3554	3.2166	159.1	0.3544	3.1078	159.0	0.3534	3.0061	159.0	0.3525	180
190	3.3876	161.3	0.3588	3.2693	161.3	0.3578	3.1589	161.2	0.3568	3.0556	161.2	0.3559	190
200	3.4421	163.5	0.3621	3.3219	163.5	0.3612	3.2098	163.4	0.3602	3.1050	163.4	0.3593	200
210	3.4964	165.7	0.3655	3.3745	165.7	0.3645	3.2607	165.7	0.3635	3.1542	165.7	0.3626	210
220	3.5507	168.0	0.3688	3.4269	167.9	0.3678	3.3114	167.9	0.3669	3.2034	167.9	0.3660	220
230	3.6049	170.2	0.3721	3.4793	170.2	0.3711	3.3621	170.2	0.3702	3.2525	170.2	0.3693	230
240	3.6590	172.5	0.3754	3.5316	172.5	0.3744	3.4127	172.5	0.3735	3.3015	172.4	0.3725	240
250	3.7131	174.8	0.3786	3.5839	174.8	0.3777	3.4632	174.7	0.3767	3.3504	174.7	0.3758	250
260	3.7671	177.1	0.3819	3.6360	177.1	0.3809	3.5137	177.1	0.3799	3.3993	177.0	0.3790	260
270	3.8210	179.4	0.3851	3.6881	179.4	0.3841	3.5641	179.4	0.3831	3.4481	179.4	0.3822	270

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 32.00 (−30.69 °F) V	H	S	33.00 (−29.39 °F) V	H	S	34.00 (−28.13 °F) V	H	S	35.00 (−26.89 °F) V	H	S	Temp [°F]
	1.8314	115.4	0.2692	1.7784	115.6	0.2688	1.7284	115.7	0.2683	1.6812	115.8	0.2679	
−30	1.8354	115.6	0.2695										−30
−20	1.8932	117.6	0.2742	1.8314	117.5	0.2732	1.7731	117.4	0.2722	1.7182	117.3	0.2712	−20
−10	1.9497	119.6	0.2788	1.8865	119.5	0.2777	1.8270	119.4	0.2767	1.7709	119.3	0.2758	−10
0	2.0051	121.6	0.2832	1.9405	121.5	0.2822	1.8797	121.4	0.2812	1.8224	121.3	0.2803	0
10	2.0595	123.6	0.2875	1.9935	123.6	0.2865	1.9315	123.5	0.2856	1.8730	123.4	0.2846	10
20	2.1130	125.7	0.2918	2.0457	125.6	0.2908	1.9824	125.5	0.2898	1.9227	125.4	0.2889	20
30	2.1658	127.7	0.2959	2.0972	127.6	0.2949	2.0325	127.5	0.2940	1.9716	127.4	0.2931	30
40	2.2180	129.7	0.3000	2.1480	129.6	0.2990	2.0821	129.5	0.2981	2.0199	129.5	0.2972	40
50	2.2697	131.7	0.3040	2.1982	131.6	0.3030	2.1310	131.6	0.3021	2.0676	131.5	0.3012	50
60	2.3209	133.7	0.3079	2.2480	133.7	0.3070	2.1794	133.6	0.3061	2.1148	133.6	0.3052	60
70	2.3715	135.8	0.3118	2.2973	135.7	0.3109	2.2274	135.7	0.3100	2.1616	135.6	0.3091	70
80	2.4218	137.8	0.3156	2.3462	137.8	0.3147	2.2750	137.7	0.3138	2.2079	137.7	0.3130	80
90	2.4718	139.9	0.3194	2.3948	139.8	0.3185	2.3223	139.8	0.3176	2.2540	139.7	0.3168	90
100	2.5214	141.9	0.3231	2.4430	141.9	0.3222	2.3692	141.8	0.3214	2.2997	141.8	0.3206	100
110	2.5708	144.0	0.3269	2.4910	144.0	0.3259	2.4159	143.9	0.3251	2.3451	143.9	0.3242	110
120	2.6199	146.1	0.3305	2.5387	146.1	0.3296	2.4623	146.0	0.3287	2.3903	146.0	0.3279	120
130	2.6688	148.2	0.3341	2.5863	148.2	0.3332	2.5085	148.1	0.3323	2.4352	148.1	0.3315	130
140	2.7175	150.3	0.3376	2.6336	150.3	0.3368	2.5545	150.3	0.3359	2.4800	150.2	0.3351	140
150	2.7661	152.5	0.3412	2.6807	152.4	0.3403	2.6004	152.4	0.3394	2.5246	152.4	0.3386	150
160	2.8145	154.6	0.3447	2.7277	154.6	0.3438	2.6460	154.6	0.3429	2.5690	154.5	0.3421	160
170	2.8627	156.8	0.3481	2.7745	156.8	0.3473	2.6915	156.7	0.3464	2.6133	156.7	0.3456	170
180	2.9108	159.0	0.3516	2.8212	159.0	0.3507	2.7369	158.9	0.3499	2.6574	158.9	0.3490	180
190	2.9588	161.2	0.3550	2.8678	161.2	0.3541	2.7822	161.1	0.3533	2.7014	161.1	0.3524	190
200	3.0066	163.4	0.3584	2.9143	163.4	0.3575	2.8273	163.3	0.3567	2.7454	163.3	0.3558	200
210	3.0544	165.6	0.3617	2.9606	165.6	0.3609	2.8724	165.6	0.3600	2.7892	165.5	0.3592	210
220	3.1021	167.9	0.3651	3.0069	167.8	0.3642	2.9173	167.8	0.3633	2.8329	167.8	0.3625	220
230	3.1497	170.1	0.3684	3.0531	170.1	0.3675	2.9622	170.1	0.3667	2.8765	170.1	0.3658	230
240	3.1972	172.4	0.3716	3.0992	172.4	0.3708	3.0070	172.4	0.3699	2.9201	172.3	0.3691	240
250	3.2446	174.7	0.3749	3.1453	174.7	0.3740	3.0518	174.7	0.3732	2.9636	174.6	0.3724	250
260	3.2920	177.0	0.3781	3.1913	177.0	0.3773	3.0964	177.0	0.3764	3.0070	176.9	0.3756	260
270	3.3394	179.3	0.3813	3.2372	179.3	0.3805	3.1411	179.3	0.3796	3.0504	179.3	0.3788	270
280				3.2831	181.7	0.3837	3.1856	181.6	0.3828	3.0937	181.6	0.3820	280

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 36.00 (-25.67 °F)			37.00 (-24.49 °F)			38.00 (-23.33 °F)			39.00 (-22.19 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	1.6365	116.0	0.2675	1.5941	116.1	0.2671	1.5539	116.2	0.2667	1.5157	116.3	0.2663	
-20	1.6663	117.1	0.2702	1.6172	117.0	0.2692	1.5707	116.9	0.2683	1.5265	116.8	0.2674	-20
-10	1.7179	119.2	0.2748	1.6678	119.1	0.2739	1.6202	119.0	0.2730	1.5751	118.9	0.2721	-10
0	1.7683	121.3	0.2793	1.7171	121.2	0.2784	1.6686	121.1	0.2775	1.6225	121.0	0.2766	0
10	1.8177	123.3	0.2837	1.7654	123.2	0.2828	1.7159	123.1	0.2819	1.6688	123.0	0.2811	10
20	1.8662	125.3	0.2880	1.8129	125.2	0.2871	1.7623	125.2	0.2863	1.7143	125.1	0.2854	20
30	1.9140	127.4	0.2922	1.8596	127.3	0.2913	1.8080	127.2	0.2905	1.7590	127.1	0.2897	30
40	1.9612	129.4	0.2963	1.9056	129.3	0.2955	1.8530	129.3	0.2946	1.8030	129.2	0.2938	40
50	2.0077	131.4	0.3004	1.9511	131.4	0.2995	1.8974	131.3	0.2987	1.8465	131.2	0.2979	50
60	2.0539	133.5	0.3043	1.9960	133.4	0.3035	1.9413	133.4	0.3027	1.8894	133.3	0.3019	60
70	2.0994	135.5	0.3083	2.0405	135.5	0.3074	1.9847	135.4	0.3066	1.9318	135.4	0.3058	70
80	2.1446	137.6	0.3121	2.0846	137.6	0.3113	2.0278	137.5	0.3105	1.9739	137.4	0.3097	80
90	2.1894	139.7	0.3159	2.1284	139.6	0.3151	2.0705	139.6	0.3143	2.0156	139.5	0.3135	90
100	2.2340	141.8	0.3197	2.1718	141.7	0.3189	2.1129	141.7	0.3181	2.0570	141.6	0.3173	100
110	2.2782	143.8	0.3234	2.2150	143.8	0.3226	2.1550	143.8	0.3218	2.0982	143.7	0.3210	110
120	2.3222	146.0	0.3270	2.2579	145.9	0.3262	2.1969	145.9	0.3255	2.1390	145.8	0.3247	120
130	2.3660	148.1	0.3307	2.3006	148.0	0.3299	2.2385	148.0	0.3291	2.1797	148.0	0.3283	130
140	2.4096	150.2	0.3342	2.3430	150.2	0.3334	2.2800	150.1	0.3327	2.2201	150.1	0.3319	140
150	2.4530	152.3	0.3378	2.3853	152.3	0.3370	2.3212	152.3	0.3362	2.2604	152.2	0.3355	150
160	2.4963	154.5	0.3413	2.4275	154.5	0.3405	2.3623	154.4	0.3397	2.3005	154.4	0.3390	160
170	2.5394	156.7	0.3448	2.4695	156.6	0.3440	2.4032	156.6	0.3432	2.3404	156.6	0.3425	170
180	2.5823	158.9	0.3482	2.5113	158.9	0.3474	2.4441	158.8	0.3467	2.3802	158.8	0.3459	180
190	2.6252	161.1	0.3516	2.5531	161.0	0.3509	2.4848	161.0	0.3501	2.4199	161.0	0.3494	190
200	2.6679	163.3	0.3550	2.5947	163.3	0.3543	2.5253	163.2	0.3535	2.4595	163.2	0.3528	200
210	2.7106	165.5	0.3584	2.6362	165.5	0.3576	2.5658	165.5	0.3569	2.4990	165.4	0.3561	210
220	2.7531	167.8	0.3617	2.6777	167.7	0.3610	2.6062	167.7	0.3602	2.5384	167.7	0.3595	220
230	2.7956	170.0	0.3650	2.7190	170.0	0.3643	2.6465	170.0	0.3635	2.5777	170.0	0.3628	230
240	2.8380	172.3	0.3683	2.7603	172.3	0.3675	2.6867	172.3	0.3668	2.6169	172.2	0.3661	240
250	2.8803	174.6	0.3716	2.8015	174.6	0.3708	2.7269	174.6	0.3701	2.6561	174.5	0.3693	250
260	2.9226	176.9	0.3748	2.8427	176.9	0.3740	2.7670	176.9	0.3733	2.6952	176.9	0.3726	260
270	2.9648	179.3	0.3780	2.8838	179.2	0.3773	2.8070	179.2	0.3765	2.7342	179.2	0.3758	270
280	3.0069	181.6	0.3812	2.9248	181.6	0.3805	2.8470	181.6	0.3797	2.7732	181.5	0.3790	280

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 40.00 (−21.08 °F)			41.00 (−19.98 °F)			42.00 (−18.91 °F)			43.00 (−17.86 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	1.4793	116.4	0.2659	1.4447	116.6	0.2656	1.4116	116.7	0.2652	1.3801	116.8	0.2649	
−20	1.4846	116.7	0.2665										−20
−10	1.5323	118.8	0.2712	1.4915	118.7	0.2703	1.4526	118.6	0.2695	1.4155	118.4	0.2687	−10
0	1.5787	120.9	0.2758	1.5371	120.8	0.2749	1.4974	120.7	0.2741	1.4596	120.6	0.2733	0
10	1.6242	122.9	0.2802	1.5817	122.8	0.2794	1.5412	122.8	0.2786	1.5025	122.7	0.2778	10
20	1.6687	125.0	0.2846	1.6253	124.9	0.2838	1.5840	124.8	0.2830	1.5446	124.8	0.2822	20
30	1.7125	127.1	0.2889	1.6682	127.0	0.2881	1.6261	126.9	0.2873	1.5858	126.8	0.2865	30
40	1.7556	129.1	0.2930	1.7104	129.1	0.2922	1.6674	129.0	0.2915	1.6264	128.9	0.2907	40
50	1.7981	131.2	0.2971	1.7520	131.1	0.2963	1.7082	131.1	0.2956	1.6664	131.0	0.2948	50
60	1.8401	133.2	0.3011	1.7931	133.2	0.3003	1.7485	133.1	0.2996	1.7058	133.1	0.2989	60
70	1.8816	135.3	0.3051	1.8338	135.3	0.3043	1.7882	135.2	0.3036	1.7448	135.1	0.3028	70
80	1.9227	137.4	0.3089	1.8740	137.3	0.3082	1.8276	137.3	0.3075	1.7834	137.2	0.3067	80
90	1.9635	139.5	0.3128	1.9139	139.4	0.3120	1.8667	139.4	0.3113	1.8216	139.3	0.3106	90
100	2.0040	141.6	0.3165	1.9535	141.5	0.3158	1.9054	141.5	0.3151	1.8595	141.4	0.3144	100
110	2.0441	143.7	0.3203	1.9927	143.6	0.3195	1.9438	143.6	0.3188	1.8971	143.5	0.3181	110
120	2.0841	145.8	0.3239	2.0318	145.7	0.3232	1.9820	145.7	0.3225	1.9345	145.7	0.3218	120
130	2.1238	147.9	0.3276	2.0706	147.9	0.3269	2.0199	147.8	0.3261	1.9716	147.8	0.3255	130
140	2.1633	150.1	0.3312	2.1092	150.0	0.3305	2.0577	150.0	0.3298	2.0086	149.9	0.3291	140
150	2.2026	152.2	0.3347	2.1476	152.2	0.3340	2.0952	152.1	0.3333	2.0453	152.1	0.3326	150
160	2.2417	154.4	0.3383	2.1858	154.3	0.3375	2.1326	154.3	0.3368	2.0819	154.3	0.3362	160
170	2.2807	156.6	0.3417	2.2239	156.5	0.3410	2.1699	156.5	0.3403	2.1183	156.5	0.3397	170
180	2.3196	158.7	0.3452	2.2619	158.7	0.3445	2.2070	158.7	0.3438	2.1546	158.7	0.3431	180
190	2.3583	161.0	0.3486	2.2998	160.9	0.3479	2.2440	160.9	0.3472	2.1908	160.9	0.3466	190
200	2.3970	163.2	0.3520	2.3375	163.1	0.3513	2.2809	163.1	0.3506	2.2268	163.1	0.3500	200
210	2.4355	165.4	0.3554	2.3751	165.4	0.3547	2.3176	165.4	0.3540	2.2628	165.3	0.3533	210
220	2.4740	167.7	0.3587	2.4127	167.6	0.3580	2.3543	167.6	0.3573	2.2987	167.6	0.3567	220
230	2.5123	169.9	0.3621	2.4502	169.9	0.3614	2.3909	169.9	0.3607	2.3345	169.9	0.3600	230
240	2.5506	172.2	0.3653	2.4875	172.2	0.3646	2.4275	172.2	0.3640	2.3702	172.2	0.3633	240
250	2.5888	174.5	0.3686	2.5249	174.5	0.3679	2.4639	174.5	0.3672	2.4058	174.5	0.3666	250
260	2.6270	176.8	0.3719	2.5621	176.8	0.3712	2.5003	176.8	0.3705	2.4414	176.8	0.3698	260
270	2.6651	179.2	0.3751	2.5993	179.2	0.3744	2.5367	179.1	0.3737	2.4769	179.1	0.3730	270
280	2.7031	181.5	0.3783	2.6364	181.5	0.3776	2.5729	181.5	0.3769	2.5124	181.5	0.3762	280
290	2.6735	183.9	0.3807	2.6092	183.8	0.3801	2.5478	183.8	0.3794				290

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 44.00			45.00			46.00			47.00			Temp [°F]
	−16.82 °F			−15.81 °F			−14.81 °F			−13.82 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	1.3499	116.9	0.2646	1.3210	117.0	0.2642	1.2933	117.1	0.2639	1.2668	117.2	0.2636	
−10	1.3801	118.3	0.2678	1.3463	118.2	0.2670	1.3139	118.1	0.2662	1.2829	118.0	0.2655	−10
0	1.4234	120.5	0.2725	1.3889	120.4	0.2717	1.3559	120.3	0.2710	1.3242	120.2	0.2702	0
10	1.4657	122.6	0.2770	1.4304	122.5	0.2763	1.3967	122.4	0.2755	1.3644	122.3	0.2748	10
20	1.5070	124.7	0.2815	1.4710	124.6	0.2807	1.4366	124.5	0.2800	1.4037	124.4	0.2792	20
30	1.5475	126.8	0.2858	1.5108	126.7	0.2850	1.4757	126.6	0.2843	1.4421	126.5	0.2836	30
40	1.5873	128.8	0.2900	1.5499	128.8	0.2893	1.5141	128.7	0.2885	1.4798	128.6	0.2878	40
50	1.6265	130.9	0.2941	1.5883	130.9	0.2934	1.5519	130.8	0.2927	1.5169	130.7	0.2920	50
60	1.6652	133.0	0.2981	1.6263	132.9	0.2974	1.5891	132.9	0.2968	1.5535	132.8	0.2961	60
70	1.7034	135.1	0.3021	1.6638	135.0	0.3014	1.6259	135.0	0.3007	1.5896	134.9	0.3001	70
80	1.7412	137.2	0.3060	1.7008	137.1	0.3053	1.6622	137.1	0.3047	1.6253	137.0	0.3040	80
90	1.7786	139.3	0.3099	1.7375	139.2	0.3092	1.6982	139.2	0.3085	1.6606	139.1	0.3079	90
100	1.8158	141.4	0.3137	1.7739	141.3	0.3130	1.7339	141.3	0.3123	1.6956	141.2	0.3117	100
110	1.8526	143.5	0.3174	1.8100	143.5	0.3168	1.7693	143.4	0.3161	1.7303	143.4	0.3155	110
120	1.8892	145.6	0.3211	1.8459	145.6	0.3205	1.8044	145.5	0.3198	1.7648	145.5	0.3192	120
130	1.9255	147.8	0.3248	1.8815	147.7	0.3241	1.8393	147.7	0.3235	1.7990	147.6	0.3228	130
140	1.9617	149.9	0.3284	1.9169	149.9	0.3277	1.8740	149.8	0.3271	1.8330	149.8	0.3264	140
150	1.9976	152.1	0.3320	1.9521	152.0	0.3313	1.9085	152.0	0.3307	1.8668	152.0	0.3300	150
160	2.0334	154.2	0.3355	1.9872	154.2	0.3348	1.9429	154.2	0.3342	1.9005	154.1	0.3336	160
170	2.0691	156.4	0.3390	2.0221	156.4	0.3383	1.9771	156.4	0.3377	1.9340	156.3	0.3371	170
180	2.1046	158.6	0.3425	2.0568	158.6	0.3418	2.0111	158.6	0.3412	1.9674	158.5	0.3406	180
190	2.1400	160.8	0.3459	2.0915	160.8	0.3452	2.0451	160.8	0.3446	2.0006	160.8	0.3440	190
200	2.1753	163.1	0.3493	2.1260	163.0	0.3487	2.0789	163.0	0.3480	2.0338	163.0	0.3474	200
210	2.2105	165.3	0.3527	2.1605	165.3	0.3520	2.1126	165.3	0.3514	2.0668	165.2	0.3508	210
220	2.2456	167.6	0.3560	2.1948	167.5	0.3554	2.1463	167.5	0.3548	2.0998	167.5	0.3541	220
230	2.2806	169.8	0.3593	2.2291	169.8	0.3587	2.1798	169.8	0.3581	2.1326	169.8	0.3575	230
240	2.3155	172.1	0.3626	2.2633	172.1	0.3620	2.2133	172.1	0.3614	2.1654	172.1	0.3608	240
250	2.3504	174.4	0.3659	2.2974	174.4	0.3653	2.2467	174.4	0.3646	2.1981	174.4	0.3640	250
260	2.3852	176.8	0.3692	2.3314	176.7	0.3685	2.2800	176.7	0.3679	2.2308	176.7	0.3673	260
270	2.4199	179.1	0.3724	2.3654	179.1	0.3717	2.3133	179.0	0.3711	2.2634	179.0	0.3705	270
280	2.4546	181.4	0.3756	2.3993	181.4	0.3749	2.3465	181.4	0.3743	2.2959	181.4	0.3737	280
290	2.4892	183.8	0.3788	2.4332	183.8	0.3781	2.3797	183.8	0.3775	2.3284	183.8	0.3769	290

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 48.00			49.00			50.00			55.00			Temp [°F]
	−12.86 °F			−11.91 °F			−10.97 °F			−6.50 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	1.2413	117.3	0.2633	1.2169	117.4	0.2630	1.1933	117.5	0.2627	1.0882	117.9	0.2613	
−10	1.2532	117.9	0.2647	1.2247	117.8	0.2639	1.1972	117.7	0.2632				−10
0	1.2939	120.1	0.2694	1.2648	120.0	0.2687	1.2368	119.9	0.2680	1.1121	119.3	0.2645	0
10	1.3335	122.2	0.2741	1.3038	122.1	0.2733	1.2752	122.0	0.2726	1.1481	121.5	0.2692	10
20	1.3721	124.3	0.2785	1.3418	124.2	0.2778	1.3127	124.2	0.2771	1.1830	123.7	0.2738	20
30	1.4099	126.4	0.2829	1.3790	126.4	0.2822	1.3493	126.3	0.2815	1.2171	125.9	0.2783	30
40	1.4470	128.6	0.2872	1.4155	128.5	0.2865	1.3852	128.4	0.2858	1.2504	128.0	0.2827	40
50	1.4834	130.7	0.2913	1.4513	130.6	0.2907	1.4205	130.5	0.2900	1.2830	130.2	0.2869	50
60	1.5194	132.8	0.2954	1.4866	132.7	0.2948	1.4552	132.6	0.2941	1.3151	132.3	0.2910	60
70	1.5548	134.9	0.2994	1.5215	134.8	0.2988	1.4894	134.7	0.2981	1.3468	134.5	0.2951	70
80	1.5899	137.0	0.3034	1.5559	136.9	0.3027	1.5233	136.9	0.3021	1.3779	136.6	0.2991	80
90	1.6245	139.1	0.3072	1.5899	139.0	0.3066	1.5567	139.0	0.3060	1.4088	138.7	0.3030	90
100	1.6589	141.2	0.3111	1.6237	141.1	0.3104	1.5899	141.1	0.3098	1.4392	140.9	0.3069	100
110	1.6929	143.3	0.3148	1.6571	143.3	0.3142	1.6227	143.2	0.3136	1.4694	143.0	0.3107	110
120	1.7267	145.5	0.3185	1.6903	145.4	0.3179	1.6553	145.4	0.3173	1.4993	145.2	0.3144	120
130	1.7603	147.6	0.3222	1.7232	147.6	0.3216	1.6876	147.5	0.3210	1.5290	147.3	0.3181	130
140	1.7937	149.8	0.3258	1.7560	149.7	0.3252	1.7198	149.7	0.3246	1.5585	149.5	0.3218	140
150	1.8269	151.9	0.3294	1.7885	151.9	0.3288	1.7517	151.9	0.3282	1.5877	151.7	0.3254	150
160	1.8599	154.1	0.3330	1.8209	154.1	0.3324	1.7835	154.0	0.3318	1.6169	153.9	0.3290	160
170	1.8927	156.3	0.3365	1.8531	156.3	0.3359	1.8151	156.2	0.3353	1.6458	156.1	0.3325	170
180	1.9254	158.5	0.3399	1.8852	158.5	0.3393	1.8466	158.4	0.3388	1.6746	158.3	0.3360	180
190	1.9580	160.7	0.3434	1.9172	160.7	0.3428	1.8780	160.7	0.3422	1.7033	160.5	0.3394	190
200	1.9905	163.0	0.3468	1.9491	162.9	0.3462	1.9092	162.9	0.3456	1.7319	162.8	0.3429	200
210	2.0229	165.2	0.3502	1.9808	165.2	0.3496	1.9404	165.2	0.3490	1.7603	165.0	0.3463	210
220	2.0552	167.5	0.3535	2.0125	167.4	0.3529	1.9715	167.4	0.3524	1.7887	167.3	0.3496	220
230	2.0874	169.7	0.3569	2.0441	169.7	0.3563	2.0024	169.7	0.3557	1.8170	169.6	0.3530	230
240	2.1196	172.0	0.3602	2.0756	172.0	0.3596	2.0334	172.0	0.3590	1.8452	171.9	0.3563	240
250	2.1516	174.3	0.3634	2.1070	174.3	0.3629	2.0642	174.3	0.3623	1.8734	174.2	0.3596	250
260	2.1836	176.7	0.3667	2.1384	176.6	0.3661	2.0950	176.6	0.3655	1.9015	176.5	0.3628	260
270	2.2156	179.0	0.3699	2.1697	179.0	0.3693	2.1257	179.0	0.3688	1.9295	178.9	0.3660	270
280	2.2475	181.4	0.3731	2.2010	181.3	0.3725	2.1563	181.3	0.3720	1.9575	181.2	0.3693	280
290	2.2793	183.7	0.3763	2.2322	183.7	0.3757	2.1869	183.7	0.3752	1.9854	183.6	0.3724	290
300										2.0133	186.0	0.3756	300

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 60.00 (-2.32 °F) V	H	S	65.00 (1.59 °F) V	H	S	70.00 (5.28 °F) V	H	S	75.00 (8.78 °F) V	H	S	Temp [°F]
	1.0000	118.3	0.2601	0.9249	118.6	0.2589	0.8602	119.0	0.2578	0.8039	119.3	0.2568	
0	1.0080	118.8	0.2612										0
10	1.0419	121.1	0.2661	0.9519	120.6	0.2631	0.8746	120.1	0.2602	0.8074	119.6	0.2574	10
20	1.0749	123.3	0.2708	0.9831	122.8	0.2678	0.9043	122.4	0.2651	0.8360	121.9	0.2624	20
30	1.1067	125.5	0.2753	1.0133	125.1	0.2725	0.9331	124.7	0.2698	0.8634	124.2	0.2672	30
40	1.1379	127.7	0.2797	1.0427	127.3	0.2769	0.9610	126.9	0.2743	0.8900	126.5	0.2718	40
50	1.1684	129.8	0.2840	1.0714	129.5	0.2813	0.9881	129.1	0.2787	0.9159	128.8	0.2763	50
60	1.1984	132.0	0.2882	1.0995	131.7	0.2855	1.0147	131.4	0.2830	0.9411	131.0	0.2807	60
70	1.2278	134.2	0.2923	1.1271	133.9	0.2897	1.0407	133.6	0.2872	0.9658	133.3	0.2849	70
80	1.2569	136.3	0.2963	1.1542	136.0	0.2938	1.0663	135.8	0.2913	0.9900	135.5	0.2891	80
90	1.2854	138.5	0.3003	1.1810	138.2	0.2978	1.0915	137.9	0.2954	1.0138	137.7	0.2931	90
100	1.3137	140.6	0.3042	1.2074	140.4	0.3017	1.1163	140.1	0.2993	1.0373	139.9	0.2971	100
110	1.3416	142.8	0.3080	1.2335	142.6	0.3055	1.1408	142.3	0.3032	1.0604	142.1	0.3010	110
120	1.3693	145.0	0.3118	1.2593	144.7	0.3093	1.1650	144.5	0.3070	1.0832	144.3	0.3049	120
130	1.3968	147.1	0.3155	1.2849	146.9	0.3131	1.1890	146.7	0.3108	1.1058	146.5	0.3086	130
140	1.4240	149.3	0.3192	1.3102	149.1	0.3167	1.2127	148.9	0.3145	1.1282	148.7	0.3124	140
150	1.4511	151.5	0.3228	1.3354	151.3	0.3204	1.2363	151.1	0.3181	1.1503	151.0	0.3160	150
160	1.4779	153.7	0.3264	1.3604	153.5	0.3240	1.2597	153.4	0.3218	1.1723	153.2	0.3197	160
170	1.5047	155.9	0.3299	1.3853	155.8	0.3275	1.2829	155.6	0.3253	1.1942	155.4	0.3233	170
180	1.5313	158.1	0.3334	1.4100	158.0	0.3311	1.3060	157.8	0.3289	1.2158	157.7	0.3268	180
190	1.5577	160.4	0.3369	1.4345	160.2	0.3346	1.3289	160.1	0.3323	1.2374	159.9	0.3303	190
200	1.5841	162.6	0.3403	1.4590	162.5	0.3380	1.3518	162.3	0.3358	1.2588	162.2	0.3338	200
210	1.6103	164.9	0.3437	1.4833	164.8	0.3414	1.3745	164.6	0.3392	1.2802	164.5	0.3372	210
220	1.6364	167.2	0.3471	1.5076	167.0	0.3448	1.3971	166.9	0.3426	1.3014	166.8	0.3406	220
230	1.6625	169.5	0.3505	1.5318	169.3	0.3481	1.4197	169.2	0.3460	1.3226	169.1	0.3440	230
240	1.6885	171.8	0.3538	1.5559	171.6	0.3515	1.4422	171.5	0.3493	1.3436	171.4	0.3473	240
250	1.7144	174.1	0.3571	1.5799	174.0	0.3548	1.4646	173.8	0.3526	1.3646	173.7	0.3506	250
260	1.7403	176.4	0.3603	1.6038	176.3	0.3580	1.4869	176.2	0.3559	1.3855	176.1	0.3539	260
270	1.7660	178.8	0.3636	1.6277	178.7	0.3613	1.5092	178.5	0.3591	1.4064	178.4	0.3571	270
280	1.7918	181.1	0.3668	1.6516	181.0	0.3645	1.5314	180.9	0.3624	1.4272	180.8	0.3604	280
290	1.8175	183.5	0.3700	1.6754	183.4	0.3677	1.5535	183.3	0.3656	1.4480	183.2	0.3636	290
300	1.8431	185.9	0.3731	1.6991	185.8	0.3709	1.5757	185.7	0.3687	1.4687	185.6	0.3668	300
310				1.7228	188.2	0.3740	1.5977	188.1	0.3719	1.4894	188.0	0.3699	310

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 80.00 (12.10 °F) V	H	S	85.00 (15.26 °F) V	H	S	90.00 (18.29 °F) V	H	S	95.00 (21.19 °F) V	H	S	Temp [°F]
	0.7543	119.5	0.2559	0.7105	119.8	0.2550	0.6713	120.1	0.2542	0.6361	120.3	0.2534	
20	0.7760	121.5	0.2599	0.7229	121.0	0.2574	0.6756	120.5	0.2551				20
30	0.8024	123.8	0.2648	0.7484	123.4	0.2624	0.7004	122.9	0.2601	0.6572	122.5	0.2579	30
40	0.8279	126.1	0.2695	0.7730	125.7	0.2672	0.7241	125.3	0.2650	0.6803	124.9	0.2629	40
50	0.8526	128.4	0.2740	0.7967	128.1	0.2718	0.7470	127.7	0.2697	0.7024	127.3	0.2676	50
60	0.8767	130.7	0.2784	0.8198	130.4	0.2763	0.7692	130.0	0.2742	0.7238	129.7	0.2722	60
70	0.9002	133.0	0.2827	0.8423	132.6	0.2806	0.7908	132.3	0.2786	0.7446	132.0	0.2767	70
80	0.9233	135.2	0.2869	0.8643	134.9	0.2848	0.8119	134.6	0.2829	0.7649	134.3	0.2810	80
90	0.9459	137.4	0.2910	0.8859	137.2	0.2890	0.8325	136.9	0.2870	0.7848	136.6	0.2852	90
100	0.9681	139.6	0.2950	0.9071	139.4	0.2930	0.8528	139.2	0.2911	0.8042	138.9	0.2893	100
110	0.9900	141.9	0.2989	0.9279	141.6	0.2970	0.8727	141.4	0.2951	0.8233	141.2	0.2933	110
120	1.0117	144.1	0.3028	0.9485	143.9	0.3009	0.8923	143.7	0.2990	0.8421	143.4	0.2973	120
130	1.0330	146.3	0.3066	0.9688	146.1	0.3047	0.9117	145.9	0.3029	0.8606	145.7	0.3011	130
140	1.0542	148.5	0.3104	0.9889	148.4	0.3085	0.9308	148.2	0.3067	0.8789	148.0	0.3049	140
150	1.0751	150.8	0.3141	1.0088	150.6	0.3122	0.9498	150.4	0.3104	0.8970	150.2	0.3087	150
160	1.0959	153.0	0.3177	1.0285	152.8	0.3158	0.9685	152.7	0.3141	0.9149	152.5	0.3124	160
170	1.1165	155.3	0.3213	1.0480	155.1	0.3194	0.9871	154.9	0.3177	0.9326	154.8	0.3160	170
180	1.1370	157.5	0.3249	1.0674	157.4	0.3230	1.0055	157.2	0.3213	0.9502	157.1	0.3196	180
190	1.1573	159.8	0.3284	1.0866	159.6	0.3265	1.0238	159.5	0.3248	0.9676	159.3	0.3232	190
200	1.1775	162.1	0.3318	1.1058	161.9	0.3300	1.0420	161.8	0.3283	0.9849	161.6	0.3267	200
210	1.1976	164.4	0.3353	1.1248	164.2	0.3335	1.0601	164.1	0.3318	1.0021	163.9	0.3301	210
220	1.2176	166.6	0.3387	1.1437	166.5	0.3369	1.0780	166.4	0.3352	1.0192	166.3	0.3336	220
230	1.2376	169.0	0.3421	1.1626	168.8	0.3403	1.0959	168.7	0.3386	1.0362	168.6	0.3370	230
240	1.2574	171.3	0.3454	1.1813	171.2	0.3436	1.1137	171.0	0.3419	1.0532	170.9	0.3403	240
250	1.2772	173.6	0.3487	1.2000	173.5	0.3470	1.1314	173.4	0.3453	1.0700	173.3	0.3437	250
260	1.2969	176.0	0.3520	1.2186	175.9	0.3502	1.1491	175.8	0.3486	1.0868	175.6	0.3470	260
270	1.3165	178.3	0.3553	1.2372	178.2	0.3535	1.1667	178.1	0.3518	1.1036	178.0	0.3503	270
280	1.3361	180.7	0.3585	1.2557	180.6	0.3568	1.1842	180.5	0.3551	1.1202	180.4	0.3535	280
290	1.3556	183.1	0.3617	1.2741	183.0	0.3600	1.2017	182.9	0.3583	1.1369	182.8	0.3567	290
300	1.3751	185.5	0.3649	1.2925	185.4	0.3632	1.2191	185.3	0.3615	1.1534	185.2	0.3599	300
310	1.3945	187.9	0.3681	1.3109	187.8	0.3663	1.2365	187.7	0.3647	1.1699	187.7	0.3631	310
320	1.4139	190.4	0.3712	1.3292	190.3	0.3695	1.2538	190.2	0.3678	1.1864	190.1	0.3663	320
330	1.2029	192.6	0.3694										330

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 100.00 (23.98 °F)			110.00 (29.25 °F)			120.00 (34.16 °F)			130.00 (38.78 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.6043	120.5	0.2526	0.5491	120.9	0.2512	0.5029	121.2	0.2499	0.4635	121.5	0.2487	
30	0.6183	122.0	0.2558	0.5508	121.1	0.2516							30
40	0.6407	124.5	0.2606	0.5722	123.7	0.2569	0.5148	122.8	0.2531	0.4659	121.8	0.2494	40
50	0.6622	126.9	0.2656	0.5926	126.2	0.2618	0.5344	125.4	0.2582	0.4848	124.5	0.2546	50
60	0.6830	129.3	0.2703	0.6122	128.6	0.2666	0.5531	127.9	0.2632	0.5026	127.2	0.2598	60
70	0.7031	131.7	0.2748	0.6311	131.0	0.2712	0.5710	130.4	0.2679	0.5200	129.7	0.2647	70
80	0.7226	134.0	0.2792	0.6495	133.4	0.2757	0.5884	132.8	0.2724	0.5366	132.2	0.2694	80
90	0.7417	136.3	0.2834	0.6673	135.8	0.2800	0.6053	135.2	0.2769	0.5526	134.7	0.2739	90
100	0.7604	138.6	0.2875	0.6848	138.1	0.2842	0.6217	137.6	0.2812	0.5682	137.1	0.2782	100
110	0.7788	140.9	0.2916	0.7019	140.5	0.2884	0.6377	140.0	0.2853	0.5833	139.5	0.2825	110
120	0.7969	143.2	0.2956	0.7186	142.8	0.2924	0.6534	142.3	0.2894	0.5981	141.9	0.2866	120
130	0.8146	145.5	0.2995	0.7351	145.1	0.2963	0.6688	144.6	0.2934	0.6126	144.2	0.2907	130
140	0.8321	147.8	0.3033	0.7513	147.4	0.3002	0.6839	147.0	0.2973	0.6269	146.6	0.2946	140
150	0.8494	150.0	0.3071	0.7673	149.7	0.3040	0.6988	149.3	0.3012	0.6409	148.9	0.2985	150
160	0.8666	152.3	0.3108	0.7831	152.0	0.3077	0.7135	151.6	0.3049	0.6547	151.3	0.3023	160
170	0.8835	154.6	0.3144	0.7988	154.3	0.3114	0.7281	153.9	0.3087	0.6683	153.6	0.3061	170
180	0.9003	156.9	0.3180	0.8142	156.6	0.3151	0.7425	156.3	0.3123	0.6817	155.9	0.3098	180
190	0.9170	159.2	0.3216	0.8296	158.9	0.3186	0.7567	158.6	0.3159	0.6950	158.3	0.3134	190
200	0.9335	161.5	0.3251	0.8448	161.2	0.3222	0.7708	160.9	0.3195	0.7082	160.6	0.3170	200
210	0.9500	163.8	0.3286	0.8599	163.5	0.3257	0.7848	163.3	0.3230	0.7213	163.0	0.3205	210
220	0.9663	166.1	0.3320	0.8749	165.9	0.3291	0.7987	165.6	0.3265	0.7343	165.3	0.3240	220
230	0.9826	168.5	0.3354	0.8898	168.2	0.3326	0.8125	168.0	0.3299	0.7471	167.7	0.3275	230
240	0.9987	170.8	0.3388	0.9046	170.6	0.3360	0.8262	170.3	0.3333	0.7599	170.1	0.3309	240
250	1.0148	173.2	0.3422	0.9194	172.9	0.3393	0.8399	172.7	0.3367	0.7726	172.5	0.3343	250
260	1.0308	175.5	0.3455	0.9341	175.3	0.3426	0.8534	175.1	0.3400	0.7852	174.9	0.3376	260
270	1.0468	177.9	0.3488	0.9487	177.7	0.3459	0.8669	177.5	0.3433	0.7978	177.3	0.3409	270
280	1.0627	180.3	0.3520	0.9632	180.1	0.3492	0.8804	179.9	0.3466	0.8103	179.7	0.3442	280
290	1.0785	182.7	0.3552	0.9777	182.5	0.3524	0.8938	182.3	0.3499	0.8227	182.1	0.3475	290
300	1.0943	185.1	0.3584	0.9922	184.9	0.3557	0.9071	184.7	0.3531	0.8351	184.5	0.3507	300
310	1.1101	187.6	0.3616	1.0066	187.4	0.3588	0.9204	187.2	0.3563	0.8475	187.0	0.3539	310
320	1.1258	190.0	0.3648	1.0210	189.8	0.3620	0.9337	189.6	0.3595	0.8598	189.5	0.3571	320
330	1.1414	192.5	0.3679	1.0353	192.3	0.3652	0.9469	192.1	0.3626	0.8720	191.9	0.3603	330
340							0.9600	194.6	0.3657	0.8843	194.4	0.3634	340

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 140.00 (43.14 °F)			150.00 (47.26 °F)			160.00 (51.18 °F)			170.00 (54.93 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.4295	121.8	0.2476	0.4000	122.0	0.2466	0.3740	122.2	0.2456	0.3509	122.4	0.2446	
50	0.4421	123.7	0.2514	0.4048	122.8	0.2481							50
60	0.4596	126.4	0.2566	0.4219	125.6	0.2535	0.3887	124.8	0.2505	0.3592	123.9	0.2475	60
70	0.4762	129.0	0.2616	0.4380	128.3	0.2587	0.4044	127.5	0.2558	0.3747	126.8	0.2530	70
80	0.4921	131.6	0.2664	0.4534	130.9	0.2636	0.4194	130.2	0.2608	0.3893	129.5	0.2582	80
90	0.5074	134.1	0.2710	0.4681	133.5	0.2683	0.4336	132.9	0.2657	0.4031	132.2	0.2631	90
100	0.5222	136.5	0.2755	0.4823	136.0	0.2728	0.4474	135.4	0.2703	0.4164	134.8	0.2678	100
110	0.5366	139.0	0.2798	0.4961	138.5	0.2772	0.4606	137.9	0.2747	0.4292	137.4	0.2724	110
120	0.5507	141.4	0.2840	0.5096	140.9	0.2815	0.4735	140.4	0.2791	0.4416	139.9	0.2768	120
130	0.5644	143.8	0.2881	0.5226	143.3	0.2856	0.4860	142.9	0.2833	0.4537	142.4	0.2810	130
140	0.5779	146.2	0.2921	0.5355	145.7	0.2897	0.4983	145.3	0.2874	0.4654	144.9	0.2852	140
150	0.5911	148.5	0.2960	0.5480	148.1	0.2936	0.5103	147.8	0.2914	0.4769	147.4	0.2892	150
160	0.6042	150.9	0.2999	0.5604	150.5	0.2975	0.5220	150.2	0.2953	0.4882	149.8	0.2932	160
170	0.6170	153.3	0.3036	0.5725	152.9	0.3013	0.5336	152.6	0.2992	0.4992	152.2	0.2971	170
180	0.6297	155.6	0.3074	0.5845	155.3	0.3051	0.5450	155.0	0.3029	0.5101	154.6	0.3009	180
190	0.6422	158.0	0.3110	0.5963	157.7	0.3088	0.5562	157.4	0.3067	0.5208	157.0	0.3046	190
200	0.6546	160.3	0.3146	0.6080	160.0	0.3124	0.5673	159.7	0.3103	0.5314	159.5	0.3083	200
210	0.6668	162.7	0.3182	0.6196	162.4	0.3160	0.5783	162.1	0.3139	0.5418	161.9	0.3119	210
220	0.6790	165.1	0.3217	0.6311	164.8	0.3195	0.5892	164.5	0.3175	0.5522	164.3	0.3155	220
230	0.6910	167.5	0.3252	0.6424	167.2	0.3230	0.5999	166.9	0.3210	0.5624	166.7	0.3190	230
240	0.7030	169.8	0.3286	0.6537	169.6	0.3265	0.6106	169.4	0.3244	0.5725	169.1	0.3225	240
250	0.7149	172.2	0.3320	0.6649	172.0	0.3299	0.6212	171.8	0.3279	0.5826	171.5	0.3260	250
260	0.7267	174.6	0.3354	0.6761	174.4	0.3333	0.6317	174.2	0.3313	0.5926	174.0	0.3294	260
270	0.7385	177.1	0.3387	0.6871	176.8	0.3366	0.6421	176.6	0.3346	0.6025	176.4	0.3327	270
280	0.7502	179.5	0.3420	0.6981	179.3	0.3399	0.6525	179.1	0.3379	0.6123	178.8	0.3361	280
290	0.7618	181.9	0.3453	0.7090	181.7	0.3432	0.6629	181.5	0.3412	0.6221	181.3	0.3394	290
300	0.7734	184.4	0.3485	0.7199	184.2	0.3464	0.6731	184.0	0.3445	0.6318	183.8	0.3426	300
310	0.7850	186.8	0.3517	0.7308	186.6	0.3497	0.6834	186.4	0.3477	0.6415	186.2	0.3459	310
320	0.7964	189.3	0.3549	0.7416	189.1	0.3528	0.6935	188.9	0.3509	0.6512	188.7	0.3491	320
330	0.8079	191.8	0.3581	0.7523	191.6	0.3560	0.7037	191.4	0.3541	0.6608	191.2	0.3523	330
340	0.8193	194.3	0.3612	0.7630	194.1	0.3592	0.7138	193.9	0.3572	0.6703	193.7	0.3554	340
350	0.8307	196.8	0.3643	0.7737	196.6	0.3623	0.7239	196.4	0.3604	0.6799	196.3	0.3586	350
360							0.7339	199.0	0.3635	0.6894	198.8	0.3617	360

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 180.00			190.00			200.00			220.00			Temp [°F]
	58.50 °F			61.94 °F			65.23 °F			71.48 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.3303	122.6	0.2437	0.3119	122.7	0.2428	0.2951	122.8	0.2420	0.2661	123.0	0.2404	
60	0.3327	123.0	0.2446										60
70	0.3480	126.0	0.2503	0.3240	125.2	0.2475	0.3022	124.3	0.2449				70
80	0.3624	128.8	0.2556	0.3382	128.1	0.2530	0.3162	127.3	0.2505	0.2780	125.8	0.2455	80
90	0.3759	131.6	0.2606	0.3515	130.9	0.2582	0.3293	130.2	0.2558	0.2906	128.8	0.2512	90
100	0.3888	134.3	0.2655	0.3641	133.7	0.2631	0.3417	133.0	0.2609	0.3029	131.8	0.2565	100
110	0.4013	136.9	0.2701	0.3762	136.3	0.2679	0.3536	135.8	0.2657	0.3143	134.6	0.2615	110
120	0.4133	139.4	0.2746	0.3878	138.9	0.2724	0.3649	138.4	0.2703	0.3251	137.4	0.2663	120
130	0.4249	142.0	0.2789	0.3991	141.5	0.2768	0.3758	141.0	0.2748	0.3355	140.1	0.2709	130
140	0.4362	144.5	0.2831	0.4100	144.0	0.2811	0.3864	143.6	0.2791	0.3456	142.7	0.2753	140
150	0.4472	147.0	0.2872	0.4207	146.5	0.2852	0.3967	146.1	0.2833	0.3553	145.3	0.2796	150
160	0.4581	149.4	0.2912	0.4311	149.0	0.2892	0.4068	148.6	0.2874	0.3648	147.9	0.2838	160
170	0.4686	151.9	0.2951	0.4413	151.5	0.2932	0.4166	151.1	0.2914	0.3740	150.4	0.2879	170
180	0.4791	154.3	0.2989	0.4513	154.0	0.2971	0.4263	153.6	0.2953	0.3830	152.9	0.2918	180
190	0.4893	156.7	0.3027	0.4611	156.4	0.3009	0.4357	156.1	0.2991	0.3919	155.4	0.2957	190
200	0.4994	159.1	0.3064	0.4708	158.9	0.3046	0.4451	158.5	0.3029	0.4006	157.9	0.2996	200
210	0.5094	161.6	0.3101	0.4804	161.3	0.3083	0.4543	161.0	0.3065	0.4091	160.4	0.3033	210
220	0.5193	164.0	0.3137	0.4898	163.7	0.3119	0.4633	163.4	0.3102	0.4175	162.9	0.3070	220
230	0.5290	166.4	0.3172	0.4992	166.2	0.3154	0.4723	165.9	0.3138	0.4258	165.4	0.3106	230
240	0.5387	168.9	0.3207	0.5084	168.6	0.3190	0.4811	168.4	0.3173	0.4341	167.8	0.3142	240
250	0.5483	171.3	0.3242	0.5176	171.1	0.3224	0.4899	170.8	0.3208	0.4422	170.3	0.3177	250
260	0.5578	173.7	0.3276	0.5266	173.5	0.3259	0.4986	173.3	0.3242	0.4502	172.8	0.3211	260
270	0.5672	176.2	0.3309	0.5356	176.0	0.3293	0.5072	175.7	0.3276	0.4582	175.3	0.3246	270
280	0.5766	178.6	0.3343	0.5446	178.4	0.3326	0.5158	178.2	0.3310	0.4661	177.8	0.3280	280
290	0.5859	181.1	0.3376	0.5535	180.9	0.3359	0.5243	180.7	0.3343	0.4739	180.3	0.3313	290
300	0.5951	183.6	0.3409	0.5623	183.4	0.3392	0.5328	183.2	0.3376	0.4817	182.8	0.3346	300
310	0.6044	186.1	0.3441	0.5711	185.9	0.3425	0.5412	185.7	0.3409	0.4894	185.3	0.3379	310
320	0.6135	188.6	0.3473	0.5798	188.4	0.3457	0.5495	188.2	0.3441	0.4971	187.8	0.3412	320
330	0.6226	191.1	0.3505	0.5885	190.9	0.3489	0.5578	190.7	0.3473	0.5048	190.3	0.3444	330
340	0.6317	193.6	0.3537	0.5972	193.4	0.3521	0.5661	193.2	0.3505	0.5124	192.9	0.3476	340
350	0.6408	196.1	0.3569	0.6058	195.9	0.3552	0.5743	195.8	0.3537	0.5199	195.4	0.3508	350
360	0.6498	198.6	0.3600	0.6144	198.5	0.3583	0.5825	198.3	0.3568	0.5275	198.0	0.3539	360
370	0.6229	201.0	0.3614	0.5907	200.9	0.3599	0.5350	200.6	0.3570				370
380										0.5424	203.1	0.3601	380

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia]												Temp [°F]
	240.00			260.00			280.00			300.00			
	77.30 °F			82.77 °F			87.94 °F			92.83 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.2418	123.1	0.2389	0.2210	123.2	0.2374	0.2031	123.2	0.2360	0.1875	123.2	0.2347	
80	0.2455	124.1	0.2406										80
90	0.2583	127.3	0.2466	0.2303	125.7	0.2420	0.2058	124.0	0.2374				90
100	0.2702	130.4	0.2522	0.2422	129.0	0.2480	0.2178	127.5	0.2438	0.1962	125.8	0.2395	100
110	0.2813	133.4	0.2575	0.2531	132.1	0.2535	0.2287	130.8	0.2496	0.2073	129.4	0.2457	110
120	0.2918	136.3	0.2624	0.2634	135.1	0.2587	0.2389	133.9	0.2550	0.2174	132.7	0.2514	120
130	0.3018	139.1	0.2672	0.2731	138.0	0.2636	0.2484	136.9	0.2602	0.2268	135.8	0.2568	130
140	0.3114	141.8	0.2718	0.2824	140.8	0.2683	0.2574	139.8	0.2650	0.2356	138.8	0.2618	140
150	0.3207	144.4	0.2762	0.2913	143.6	0.2729	0.2660	142.6	0.2697	0.2440	141.7	0.2666	150
160	0.3297	147.1	0.2804	0.2999	146.2	0.2772	0.2743	145.4	0.2742	0.2521	144.5	0.2712	160
170	0.3384	149.7	0.2846	0.3083	148.9	0.2815	0.2823	148.1	0.2785	0.2598	147.3	0.2756	170
180	0.3469	152.2	0.2886	0.3164	151.5	0.2856	0.2901	150.8	0.2827	0.2673	150.0	0.2799	180
190	0.3553	154.8	0.2926	0.3243	154.1	0.2896	0.2976	153.4	0.2868	0.2745	152.7	0.2841	190
200	0.3634	157.3	0.2965	0.3320	156.7	0.2936	0.3050	156.0	0.2908	0.2816	155.4	0.2881	200
210	0.3715	159.8	0.3003	0.3396	159.2	0.2974	0.3122	158.6	0.2947	0.2885	158.0	0.2921	210
220	0.3794	162.3	0.3040	0.3470	161.8	0.3012	0.3193	161.2	0.2985	0.2953	160.6	0.2960	220
230	0.3871	164.8	0.3076	0.3544	164.3	0.3049	0.3262	163.7	0.3022	0.3019	163.2	0.2998	230
240	0.3948	167.3	0.3112	0.3616	166.8	0.3085	0.3331	166.3	0.3059	0.3084	165.8	0.3035	240
250	0.4024	169.8	0.3148	0.3687	169.3	0.3121	0.3398	168.8	0.3095	0.3148	168.3	0.3071	250
260	0.4099	172.3	0.3183	0.3757	171.9	0.3156	0.3465	171.4	0.3131	0.3211	170.9	0.3107	260
270	0.4173	174.8	0.3217	0.3827	174.4	0.3191	0.3530	173.9	0.3166	0.3273	173.5	0.3143	270
280	0.4247	177.4	0.3252	0.3896	176.9	0.3225	0.3595	176.5	0.3201	0.3335	176.0	0.3177	280
290	0.4319	179.9	0.3285	0.3964	179.4	0.3259	0.3660	179.0	0.3235	0.3396	178.6	0.3212	290
300	0.4392	182.4	0.3319	0.4032	182.0	0.3293	0.3723	181.6	0.3269	0.3456	181.2	0.3246	300
310	0.4464	184.9	0.3352	0.4099	184.5	0.3326	0.3787	184.1	0.3302	0.3516	183.7	0.3279	310
320	0.4535	187.4	0.3384	0.4166	187.1	0.3359	0.3849	186.7	0.3335	0.3575	186.3	0.3313	320
330	0.4606	190.0	0.3417	0.4232	189.6	0.3391	0.3911	189.3	0.3368	0.3634	188.9	0.3346	330
340	0.4676	192.5	0.3449	0.4298	192.2	0.3424	0.3973	191.8	0.3400	0.3692	191.5	0.3378	340
350	0.4746	195.1	0.3481	0.4363	194.8	0.3456	0.4035	194.4	0.3432	0.3750	194.1	0.3410	350
360	0.4816	197.7	0.3512	0.4428	197.3	0.3487	0.4096	197.0	0.3464	0.3808	196.7	0.3442	360
370	0.4885	200.2	0.3543	0.4493	199.9	0.3519	0.4156	199.6	0.3496	0.3865	199.3	0.3474	370
380	0.4955	202.8	0.3575	0.4557	202.5	0.3550	0.4217	202.2	0.3527	0.3922	201.9	0.3505	380
390	0.4621	205.1	0.3581	0.4277	204.8	0.3558	0.3978	204.5	0.3536				390
400										0.4035	207.2	0.3567	400

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

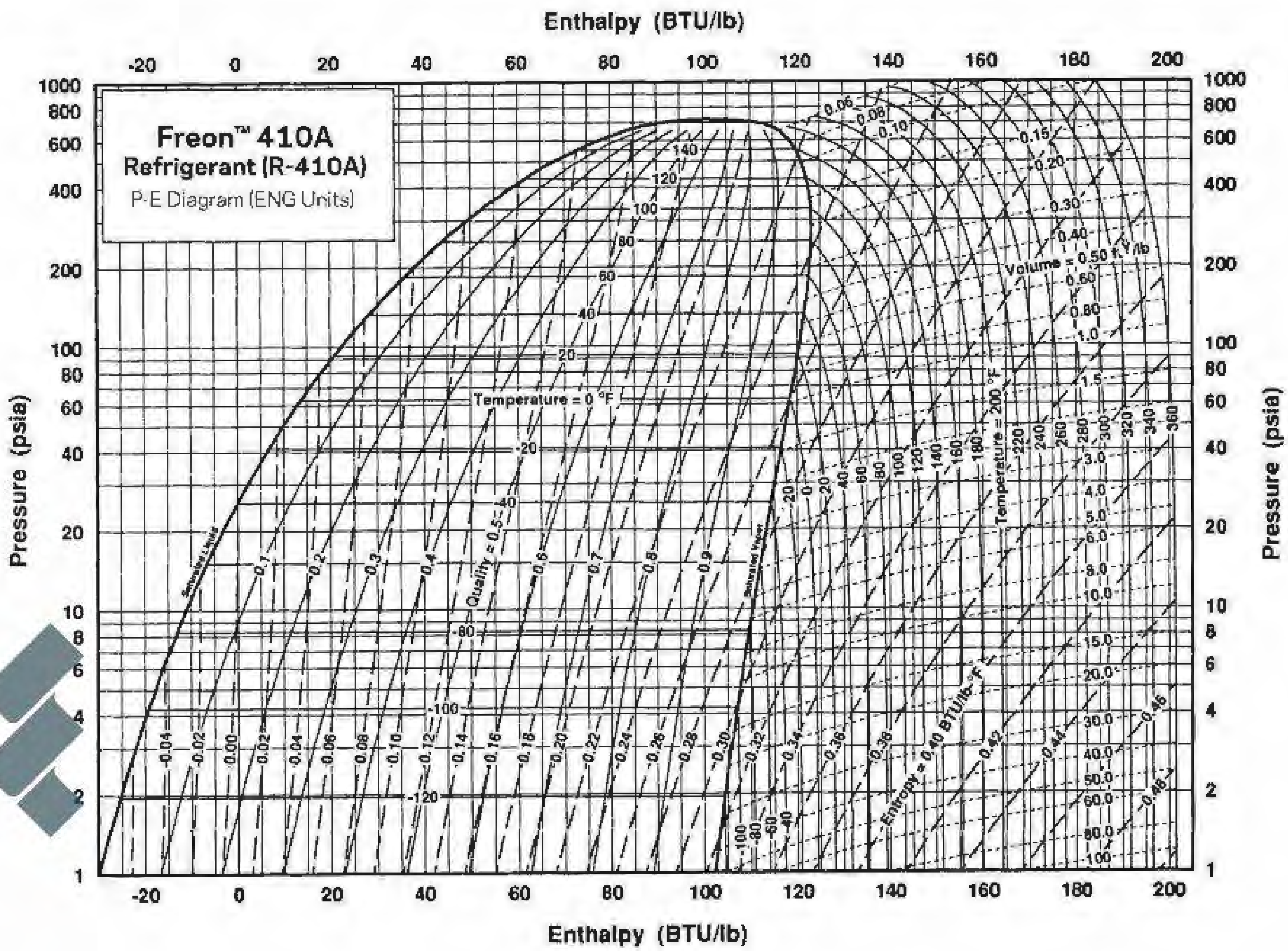
V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 320.00 (97.48 °F)			340.00 (101.92 °F)			360.00 (106.16 °F)			380.00 (110.23 °F)			Temp [°F]
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.1738	123.1	0.2333	0.1616	123.0	0.2320	0.1507	122.9	0.2308	0.1409	122.7	0.2295	
100	0.1769	124.1	0.2351										100
110	0.1882	127.9	0.2418	0.1710	126.3	0.2378	0.1552	124.5	0.2337				110
120	0.1984	131.4	0.2478	0.1813	130.0	0.2442	0.1659	128.5	0.2406	0.1517	126.9	0.2368	120
130	0.2077	134.6	0.2534	0.1907	133.4	0.2501	0.1754	132.1	0.2468	0.1614	130.9	0.2434	130
140	0.2164	137.7	0.2587	0.1994	136.6	0.2555	0.1841	135.5	0.2524	0.1702	134.3	0.2494	140
150	0.2247	140.7	0.2636	0.2075	139.7	0.2607	0.1921	138.7	0.2578	0.1783	137.6	0.2549	150
160	0.2325	143.7	0.2683	0.2152	142.7	0.2655	0.1997	141.8	0.2628	0.1858	140.8	0.2601	160
170	0.2400	146.5	0.2729	0.2225	145.6	0.2702	0.2069	144.8	0.2676	0.1929	143.9	0.2650	170
180	0.2473	149.3	0.2773	0.2296	148.5	0.2747	0.2138	147.7	0.2721	0.1996	146.9	0.2697	180
190	0.2543	152.0	0.2815	0.2364	151.3	0.2790	0.2204	150.5	0.2765	0.2061	149.8	0.2742	190
200	0.2611	154.7	0.2856	0.2430	154.0	0.2832	0.2268	153.3	0.2808	0.2123	152.6	0.2785	200
210	0.2677	157.4	0.2896	0.2494	156.7	0.2872	0.2330	156.1	0.2849	0.2184	155.4	0.2827	210
220	0.2742	160.0	0.2935	0.2556	159.4	0.2912	0.2390	158.8	0.2890	0.2242	158.2	0.2868	220
230	0.2805	162.6	0.2974	0.2617	162.1	0.2951	0.2449	161.5	0.2929	0.2299	160.9	0.2908	230
240	0.2868	165.2	0.3011	0.2677	164.7	0.2989	0.2507	164.2	0.2967	0.2355	163.6	0.2947	240
250	0.2929	167.8	0.3048	0.2735	167.3	0.3026	0.2563	166.8	0.3005	0.2409	166.3	0.2985	250
260	0.2989	170.4	0.3084	0.2793	169.9	0.3063	0.2619	169.4	0.3042	0.2463	168.9	0.3022	260
270	0.3048	173.0	0.3120	0.2850	172.5	0.3099	0.2673	172.1	0.3078	0.2515	171.6	0.3059	270
280	0.3107	175.6	0.3155	0.2906	175.2	0.3134	0.2727	174.7	0.3114	0.2567	174.2	0.3095	280
290	0.3165	178.2	0.3190	0.2961	177.8	0.3169	0.2780	177.3	0.3149	0.2618	176.9	0.3130	290
300	0.3222	180.8	0.3224	0.3016	180.3	0.3204	0.2832	179.9	0.3184	0.2668	179.5	0.3165	300
310	0.3279	183.3	0.3258	0.3070	182.9	0.3238	0.2884	182.6	0.3218	0.2718	182.2	0.3199	310
320	0.3335	185.9	0.3291	0.3124	185.6	0.3271	0.2935	185.2	0.3252	0.2767	184.8	0.3233	320
330	0.3391	188.5	0.3324	0.3177	188.2	0.3304	0.2986	187.8	0.3285	0.2816	187.4	0.3267	330
340	0.3446	191.1	0.3357	0.3229	190.8	0.3337	0.3036	190.4	0.3318	0.2864	190.1	0.3300	340
350	0.3501	193.7	0.3389	0.3281	193.4	0.3370	0.3086	193.0	0.3351	0.2912	192.7	0.3333	350
360	0.3556	196.3	0.3422	0.3333	196.0	0.3402	0.3136	195.7	0.3383	0.2959	195.3	0.3365	360
370	0.3610	199.0	0.3453	0.3385	198.6	0.3434	0.3185	198.3	0.3415	0.3006	198.0	0.3398	370
380	0.3664	201.6	0.3485	0.3436	201.3	0.3465	0.3234	201.0	0.3447	0.3053	200.6	0.3429	380
390	0.3717	204.2	0.3516	0.3487	203.9	0.3497	0.3282	203.6	0.3478	0.3099	203.3	0.3461	390
400	0.3770	206.9	0.3547	0.3537	206.6	0.3528	0.3330	206.3	0.3510	0.3145	206.0	0.3492	400
410				0.3588	209.2	0.3559	0.3378	209.0	0.3541	0.3191	208.7	0.3523	410
420										0.3237	211.4	0.3554	420

Table 2. Freon™ 410A Superheated Vapor—Constant Pressure Table (continued)

V = Volume in ft³/lb H = Enthalpy in Btu/lb S = Entropy in [Btu/lb-°R] Saturation Properties in Light Blue

Temp [°F]	Absolute Pressure [psia] 400.00			450.00			500.00			550.00			Temp [°F]
	114.14 °F			123.31 °F			131.73 °F			139.53 °F			
	V	H	S	V	H	S	V	H	S	V	H	S	
	0.1320	122.5	0.2283	0.1130	121.8	0.2251	0.0974	121.0	0.2220	0.0843	119.9	0.2187	
120	0.1386	125.2	0.2329										120
130	0.1487	129.3	0.2399	0.1205	125.2	0.2308							130
140	0.1576	133.0	0.2462	0.1301	129.6	0.2382	0.1066	125.4	0.2295	0.0849	120.2	0.2193	140
150	0.1656	136.5	0.2520	0.1385	133.5	0.2448	0.1158	130.1	0.2372	0.0958	126.0	0.2289	150
160	0.1731	139.8	0.2574	0.1461	137.2	0.2507	0.1237	134.2	0.2439	0.1046	130.8	0.2367	160
170	0.1802	143.0	0.2624	0.1530	140.6	0.2562	0.1309	138.0	0.2499	0.1121	135.1	0.2435	170
180	0.1868	146.0	0.2672	0.1596	143.9	0.2613	0.1374	141.5	0.2555	0.1188	138.9	0.2497	180
190	0.1932	149.0	0.2718	0.1657	147.0	0.2662	0.1435	144.9	0.2607	0.1250	142.6	0.2553	190
200	0.1993	151.9	0.2763	0.1716	150.1	0.2709	0.1492	148.1	0.2657	0.1307	146.0	0.2605	200
210	0.2051	154.8	0.2806	0.1772	153.0	0.2753	0.1546	151.2	0.2704	0.1360	149.3	0.2655	210
220	0.2108	157.5	0.2847	0.1826	155.9	0.2797	0.1598	154.3	0.2749	0.1411	152.5	0.2702	220
230	0.2164	160.3	0.2887	0.1878	158.8	0.2838	0.1648	157.2	0.2792	0.1459	155.6	0.2748	230
240	0.2218	163.0	0.2927	0.1928	161.6	0.2879	0.1696	160.1	0.2834	0.1505	158.6	0.2791	240
250	0.2271	165.8	0.2965	0.1978	164.4	0.2919	0.1743	163.0	0.2875	0.1550	161.6	0.2833	250
260	0.2322	168.4	0.3003	0.2026	167.2	0.2957	0.1788	165.9	0.2914	0.1593	164.5	0.2874	260
270	0.2373	171.1	0.3040	0.2073	169.9	0.2995	0.1832	168.7	0.2953	0.1635	167.4	0.2914	270
280	0.2423	173.8	0.3076	0.2119	172.6	0.3032	0.1876	171.4	0.2991	0.1676	170.2	0.2953	280
290	0.2472	176.4	0.3112	0.2164	175.3	0.3068	0.1918	174.2	0.3026	0.1716	173.1	0.2991	290
300	0.2521	179.1	0.3147	0.2209	178.0	0.3104	0.1960	177.0	0.3065	0.1756	175.9	0.3028	300
310	0.2569	181.7	0.3182	0.2253	180.7	0.3139	0.2001	179.7	0.3100	0.1794	178.7	0.3064	310
320	0.2616	184.4	0.3216	0.2296	183.4	0.3174	0.2041	182.4	0.3136	0.1832	181.4	0.3100	320
330	0.2663	187.0	0.3249	0.2339	186.1	0.3208	0.2081	185.2	0.3170	0.1869	184.2	0.3135	330
340	0.2709	189.7	0.3283	0.2381	188.8	0.3242	0.2120	187.9	0.3205	0.1906	186.9	0.3170	340
350	0.2755	192.3	0.3316	0.2423	191.5	0.3275	0.2158	190.6	0.3238	0.1942	189.7	0.3204	350
360	0.2800	195.0	0.3348	0.2465	194.2	0.3308	0.2197	193.3	0.3272	0.1978	192.4	0.3238	360
370	0.2845	197.7	0.3381	0.2506	196.8	0.3341	0.2235	196.0	0.3305	0.2013	195.2	0.3271	370
380	0.2890	200.3	0.3413	0.2547	199.5	0.3373	0.2272	198.7	0.3337	0.2048	197.9	0.3304	380
390	0.2934	203.0	0.3444	0.2587	202.2	0.3405	0.2309	201.5	0.3370	0.2083	200.7	0.3337	390
400	0.2979	205.7	0.3476	0.2627	204.9	0.3437	0.2346	204.2	0.3401	0.2117	203.4	0.3369	400
410	0.3022	208.4	0.3507	0.2667	207.7	0.3468	0.2383	206.9	0.3433	0.2151	206.2	0.3401	410
420	0.3066	211.1	0.3538	0.2706	210.4	0.3499	0.2419	209.7	0.3464	0.2184	209.0	0.3432	420
430				0.2746	213.1	0.3530	0.2455	212.4	0.3495	0.2218	211.7	0.3463	430
440							0.2491	215.2	0.3526	0.2251	214.5	0.3494	440


Freon™ 410A
Refrigerant (R-410A)
P-E Diagram (ENG Units)
Enthalpy (BTU/lb)
Pressure (psia)
Saturated Liquid
Saturated Vapor
Quality = 0.5
Temperature = 0 °F
Temperature = 200 °F
Volume = 0.50 ft³/lb
Entropy = 0.40 BTU/lb·°F