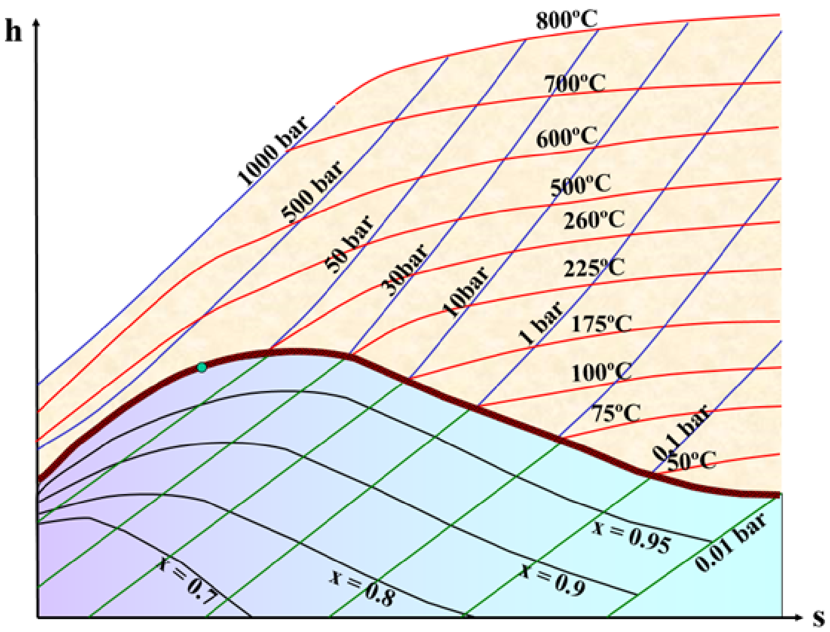
ThermoProcess

ThermoSuite
Technical Software Suite

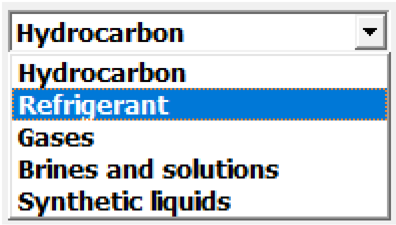
Exercise 1

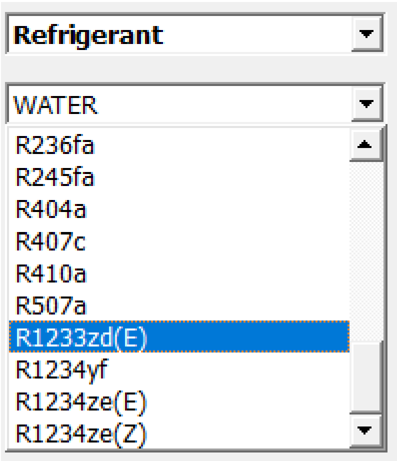
R1233zd(E) is an HFO (hydro-fluoro-olefin) that is used as a replacement for R123 in centrifugal chillers offering better capacity and efficiency similar to R-123. It is used in low-pressure centrifugal chillers, which are most often used to cool large buildings. Obtain the thermodynamic variables for the saturation states at -40ºC, and in states of compressed liquid at -20ºC and 101325 Pa and superheated steam at 120ºC and 101325 Pa. Obtain all the thermodynamic diagrams.

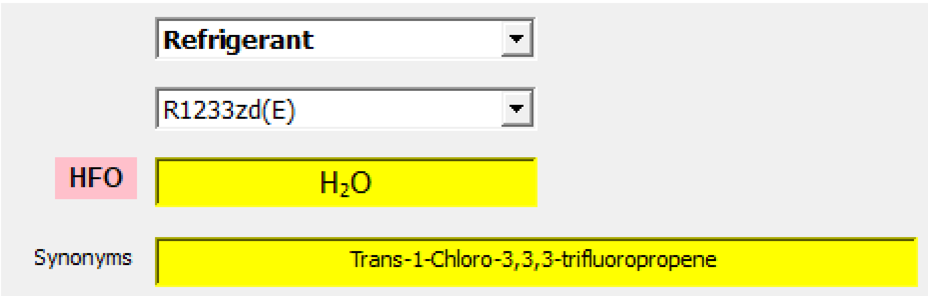
Thermophysical Properties of Chemicals & Hydrocarbons:
Thermodynamic Process

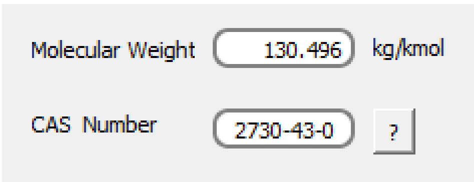


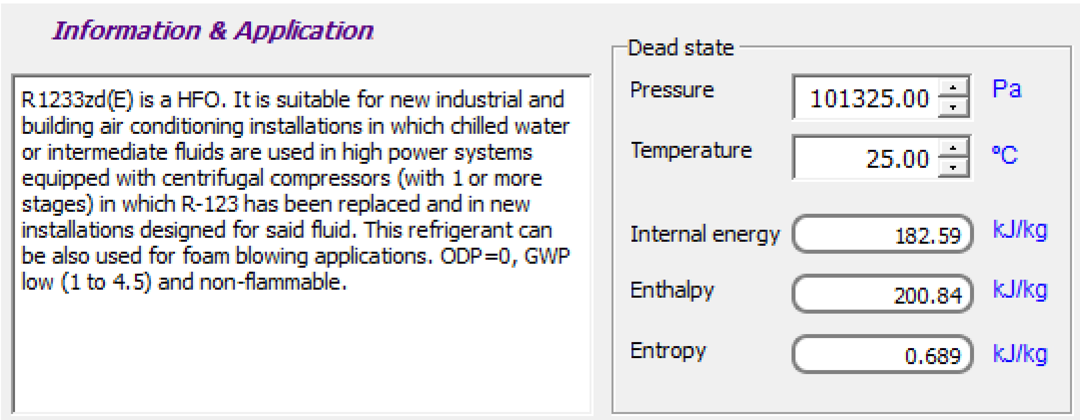
THERMOProcess is a simulator of thermodynamic processes in general, which makes use of correlations and the principles of Thermodynamics to generate robust algorithms for the prediction of thermodynamic and transport properties of the most common substances used in engineering, with modules that solve basic problems of Thermodynamics applied to engineering, in closed and open systems. This program is a powerful tool in the accomplishment of these tasks. It is an easy-to-use software package that covers the resolution of practically all problems in the field of Applied Thermodynamics.

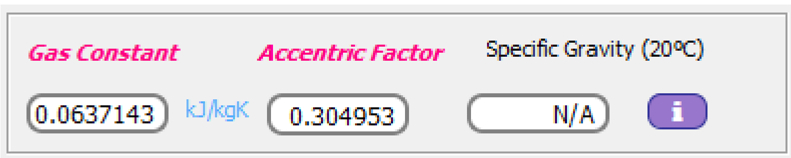

Hydrocarbon
Hydrocarbon
Refrigerant
Gases
Brines and solutions
Synthetic liquids

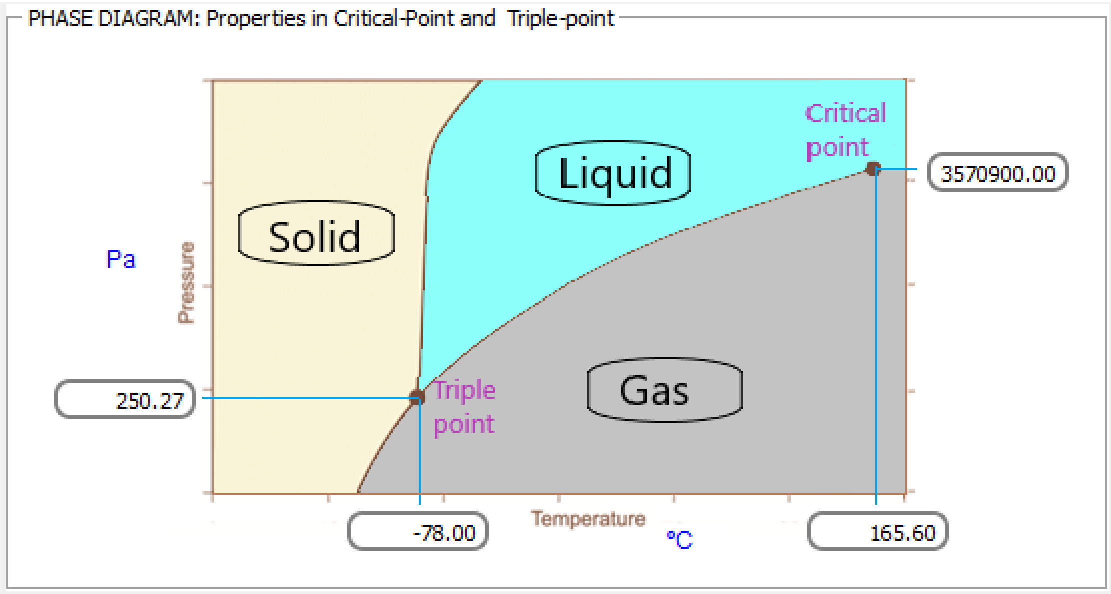

Refrigerant
WATER
R236fa
R245fa
R404a
R407c
R410a
R507a
R1233zd(E)
R1234yf
R1234ze(E)
R1234ze(Z)


Refrigerant
R1233zd(E)
HFO
H2O
Synonyms
Trans-1-Chloro-3,3,3-trifluoropropene

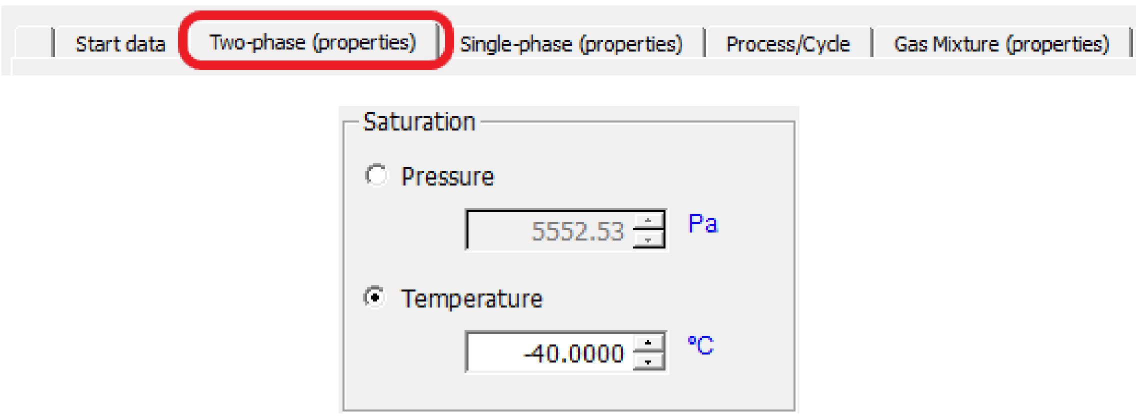

Molecular Weight
130.496
kg/kmol
CAS Number
2730-43-0
?


Information & Application
R1233zd(E) is a HFO. It is suitable for new industrial and building air conditioning installations in which chilled water or intermediate fluids are used in high power systems equipped with centrifugal compressors (with 1 or more stages) in which R-123 has been replaced and in new installations designed for said fluid. This refrigerant can be also used for foam blowing applications. ODP=0, GWP low (1 to 4.5) and non-flammable.
Dead state
Pressure
101325.00
Pa
Temperature
25.00
°C
Internal energy
182.59
kJ/kg
Enthalpy
200.84
kJ/kg
Entropy
0.689
kJ/kg


Gas Constant
Accentric Factor
Specific Gravity (20ºC)
0.0637143
kJ/kgK
0.304953
N/A



	Critical-point		Triple-point	
Density	478.92	kg/m³	1488.79	kg/m³
Specific volume	0.00209	m³/kg	0.00067	m³/kg
Internal energy	227.47	kJ/kg	-118.18	kJ/kg
Enthalpy	234.93	kJ/kg	-118.16	kJ/kg
Entropy	0.62337	kJ/kg °C	-0.49202	kJ/kg °C
Compressibility factor	0.2667		0.0000	



Thermodynamic Properties	Saturated liquid	Saturated vapor	Units
Temperature	-40	-40	°C
Pressure	5552.53	5552.53	Pa
Density	1408.8	0.375648	kg/m^3
Specific volume	0.000709823	2.66206	m^3/kg
Internal energy	-71.4461	139.029	kJ/kg
Enthalpy	-71.4422	153.811	kJ/kg
Entropy	-0.273156	0.692972	kJ/kg K
Exergy	14.5847	-48.2136	kJ/kg
Gibbs function	-7.75579	-7.75579	kJ/kg
Compressibility factor	0.000265334	0.995087	
Surface tension	0.0224839	0.0224839	N/m

Thermal Transport Properties	Saturated liquid	Saturated vapor	Units
Thermal conductivity	0.102653	0.00840638	W/mK
Dynamic viscosity	0.000848755	8.58144e-06	kg/m s
Kinematic viscosity	6.02466e-07	2.28443e-05	m^2/s
Isobaric specific heat	1.22156	0.721547	kJ/kgK
Isochoric specific heat	0.656219	0.656219	kJ/kgK
Thermal difussivity	5.96498e-08	3.10144e-05	m^2/s
Prandtl number	10.1	0.736573	[--]

Saturated Mixture (Liquid+Vapor): Thermodynamic and Thermal Transport Properties

Known Property

Quality

Quality
Density
Specific Volume
Internal Energy
Enthalpy
Entropy

Known Property

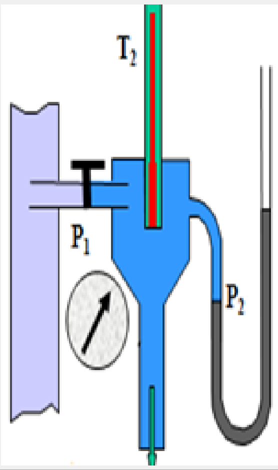
Quality

70.0000 %

Quality 70 %

Enthalpy of vaporization

225.253 kJ/kg



Thermodynamic Properties	Value	Units
Temperature	-40	°C
Pressure	5552.53	Pa
Density	0.536579	kg/m³
Specific volume	1.86366	m³/kg
Internal energy	75.8867	kJ/kg
Enthalpy	86.2347	kJ/kg
Entropy	0.403133	kJ/kg K
Exergy	-29.3741	kJ/kg
Gibbs function	-7.75579	kJ/kg
Compressibility factor	0.696641	[--]
Surface tension	0.0224839	N/m

Thermal Transport Properties	Value	Units
Thermal conductivity	0.0366804	W/mK
Dynamic viscosity	0.000260634	kg/m s
Kinematic viscosity	1.61718e-05	m²/s
Isobaric specific heat	0.87155	kJ/kgK
Isochoric specific heat	0.656219	kJ/kgK
Thermal difussivity	2.17279e-05	m²/s
Prandtl number	3.54562	

| Start data | Two-phase (properties) | Single-phase (properties) | Process/Cycle | Gas Mixture (properties) |

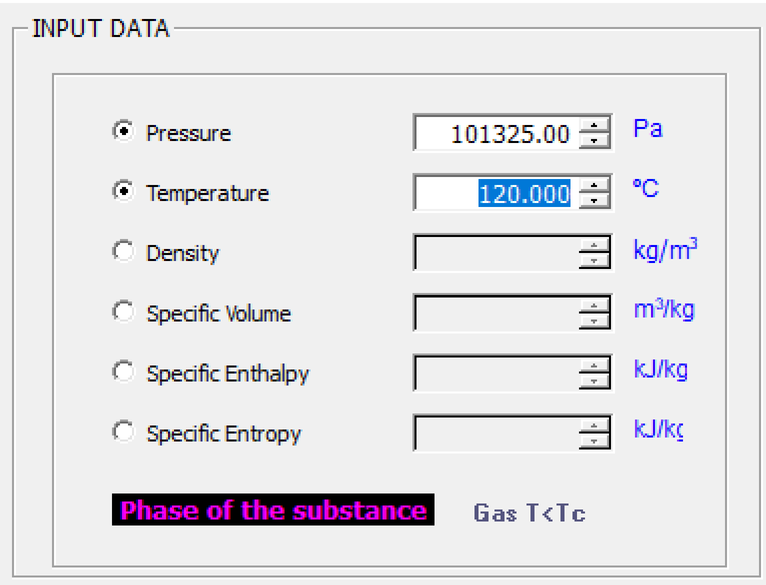
INPUT DATA

(•) Pressure	101325.00	Pa
(•) Temperature	-20.000	°C
( ) Density		kg/m³
( ) Specific Volume		m³/kg
( ) Specific Enthalpy		kJ/kg
( ) Specific Entropy		kJ/kg

Phase of the substance Liquid

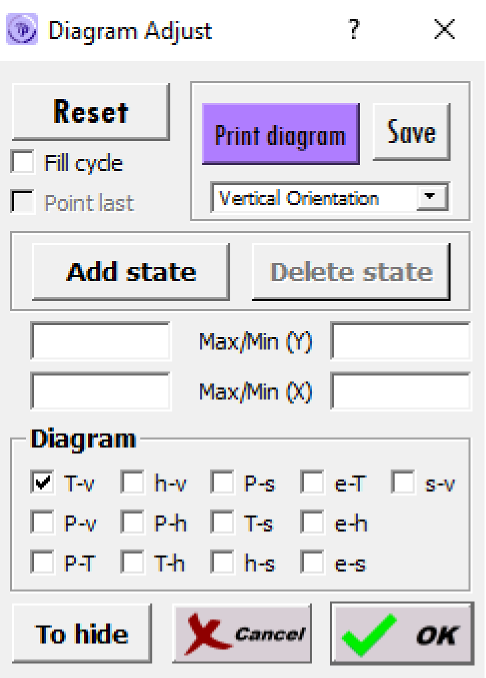
Thermodynamic Properties	Value	Units
Temperature	-20	°C
Pressure	101325	Pa
Density	1365.9	kg/m³
Specific volume	0.000732119	m³/kg
Internal energy	-47.0676	kJ/kg
Enthalpy	-46.9934	kJ/kg
Entropy	-0.172832	kJ/kg K
Exergy	9.12196	kJ/kg
Gibbs function	-3.24085	kJ/kg
Compressibility factor	0.00459947	
Surface tension	0.0198596	N/m

Thermal Transport Properties	Value	Units
Thermal conductivity	0.0955975	W/mK
Dynamic viscosity	0.000600435	kg/m s
Kinematic viscosity	4.3959e-07	m²/s
Isobaric specific heat	1.22016	kJ/kgK
Isochoric specific heat	0.878454	kJ/kgK
Thermal difussivity	5.73604e-08	m²/s
Prandtl number	7.66365	[--]

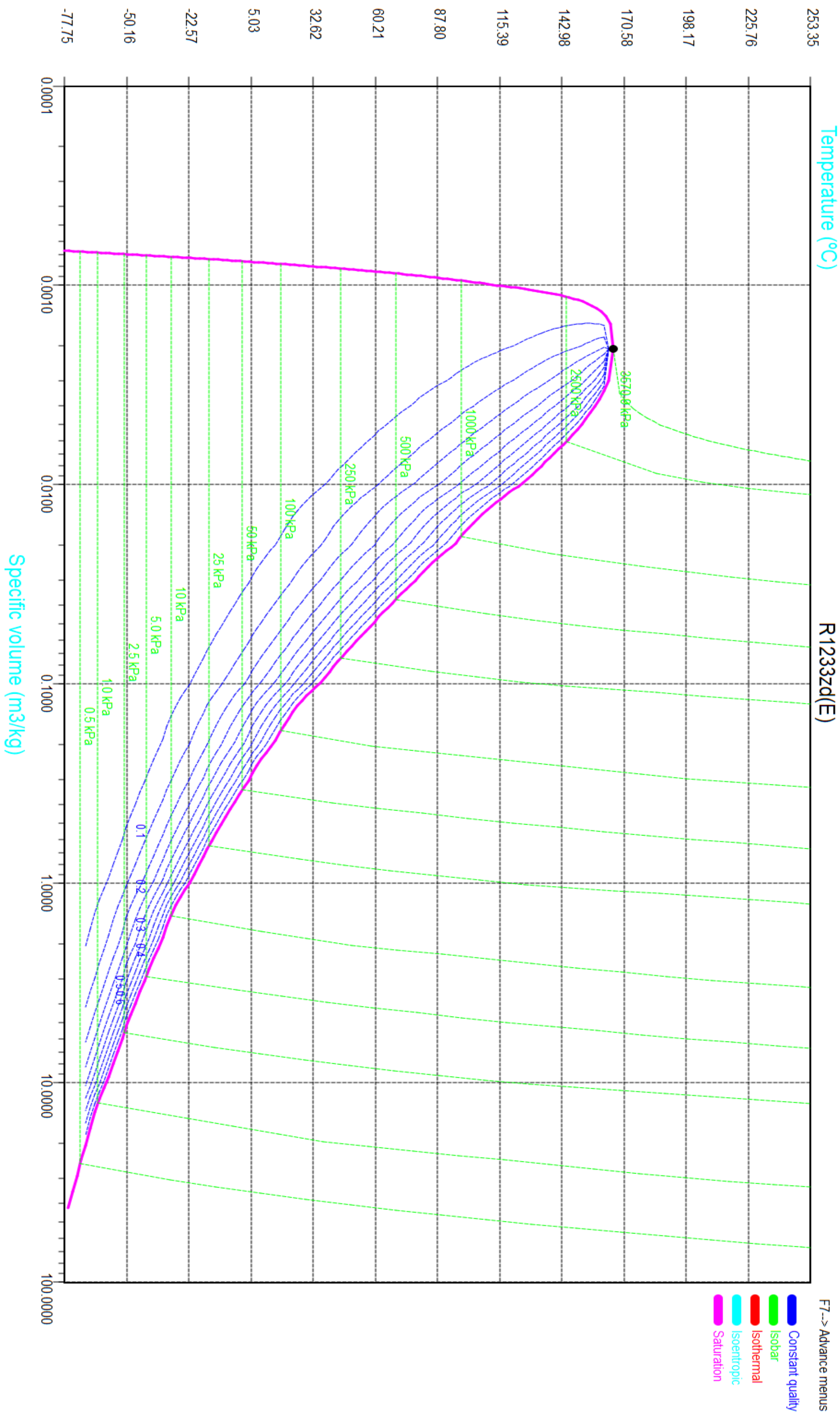


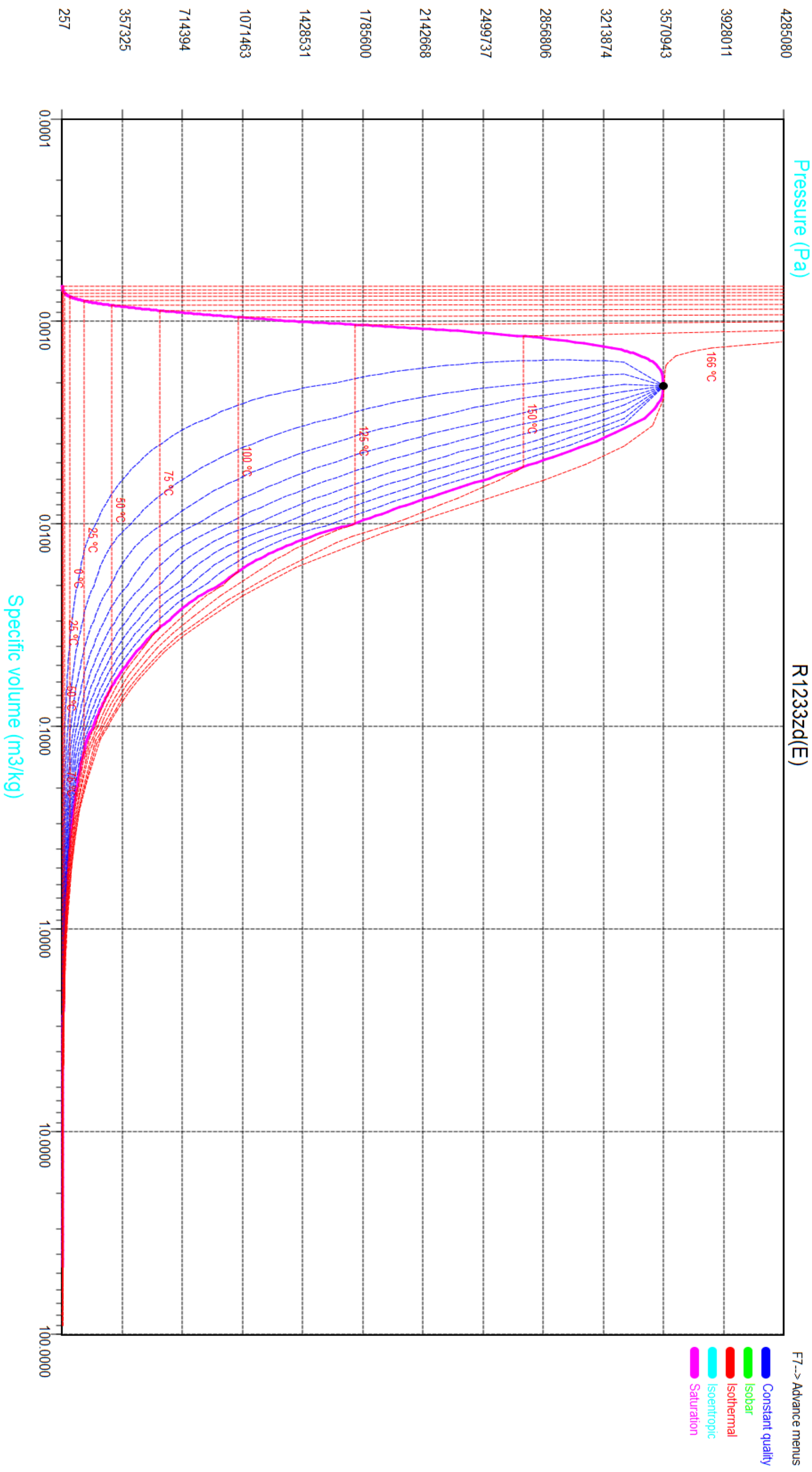
Thermodynamic Properties	Value	Units
Temperature	120	°C
Pressure	101325	Pa
Density	4.10602	kg/m³
Specific volume	0.243545	m³/kg
Internal energy	259.315	kJ/kg
Enthalpy	283.992	kJ/kg
Entropy	0.930279	kJ/kg K
Exergy	11.2143	kJ/kg
Gibbs function	-81.7476	kJ/kg
Compressibility factor	0.9852	
Surface tension	0.0034454	N/m

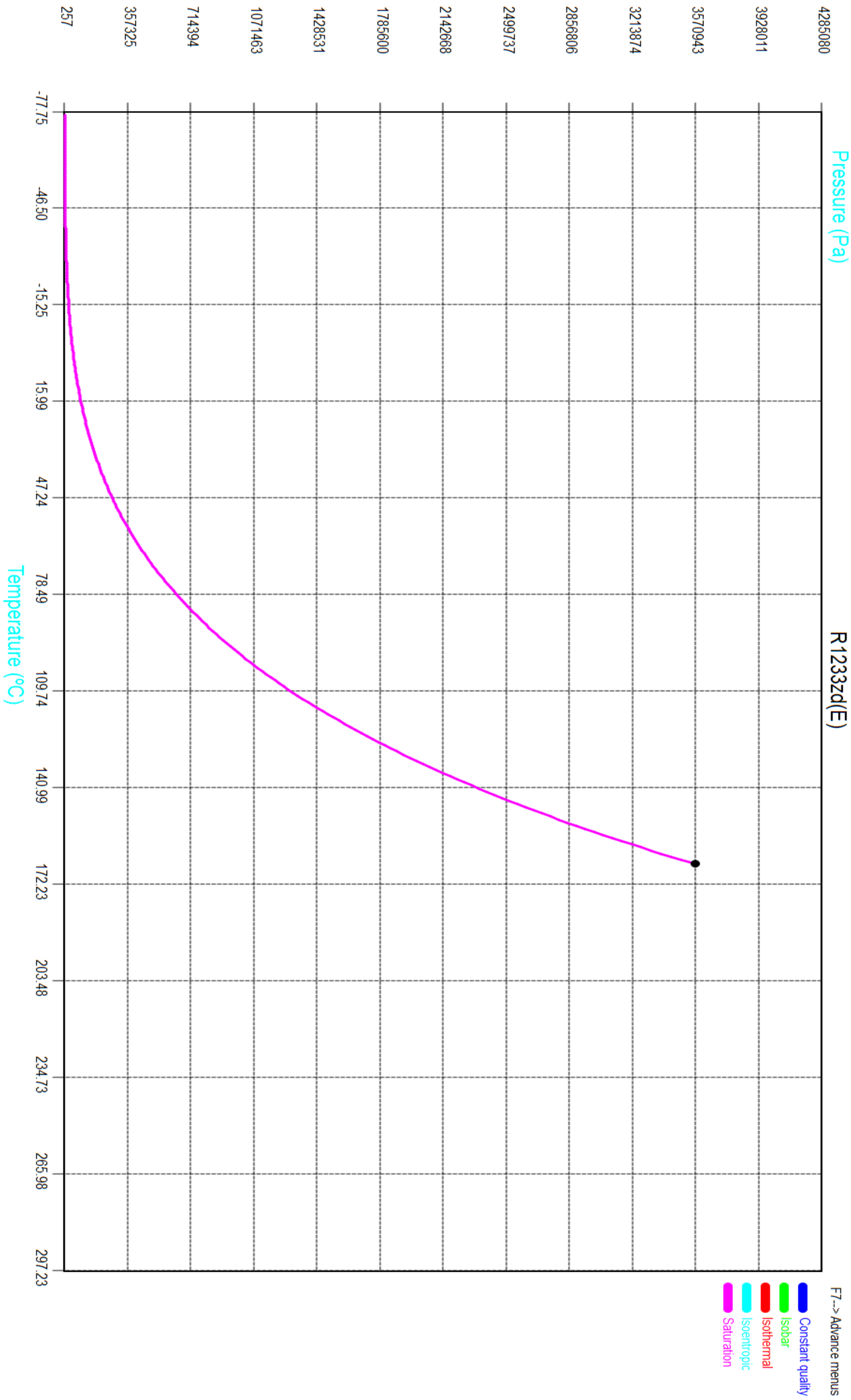
Thermal Transport Properties	Value	Units
Thermal conductivity	0.0183186	W/mK
Dynamic viscosity	1.46626e-05	kg/m s
Kinematic viscosity	3.57099e-06	m²/s
Isobaric specific heat	0.930478	kJ/kgK
Isochoric specific heat	0.861956	kJ/kgK
Thermal difussivity	4.79475e-06	m²/s
Prandtl number	0.744771	[--]



It is useful to plot the changes in the state of a substance during a thermodynamic process. On the following figures it shows the types of plots that are used to describe changes of state. It is possible to perform a series of processes, in which the state is changed during each process, but the gas eventually returns to its original state. Such a series of processes is called a cycle and forms the basis for understanding engines.


R1233zd(E)
Temperature (°C)
Specific volume (m3/kg)
-77.75
-50.16
-22.57
5.03
32.62
60.21
87.80
115.39
142.98
170.58
198.17
225.76
253.35
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
100.0000
3570.0 kPa
2500 kPa
1000 kPa
500 kPa
250 kPa
100 kPa
50 kPa
25 kPa
10 kPa
5.0 kPa
2.5 kPa
1.0 kPa
0.5 kPa
0.1
0.2
0.3
0.4
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isentropic
Saturation


R1233zd(E)
Pressure (Pa)
Specific volume (m3/kg)
257
357325
714394
1071463
1428531
1785600
2142668
2499737
2856806
3213874
3570943
3928011
4285080
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
100.0000
166 °C
150 °C
125 °C
100 °C
75 °C
50 °C
25 °C
0 °C
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isentropic
Saturation


R1233zd(E)
Pressure (Pa)
Temperature (°C)
257
357325
714394
1071463
1428531
1785600
2142668
2499737
2856806
3213874
3570943
3928011
4285080
-77.75
-46.50
-15.25
15.99
47.24
78.49
109.74
140.99
172.23
203.48
234.73
265.98
297.23
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isentropic
Saturation

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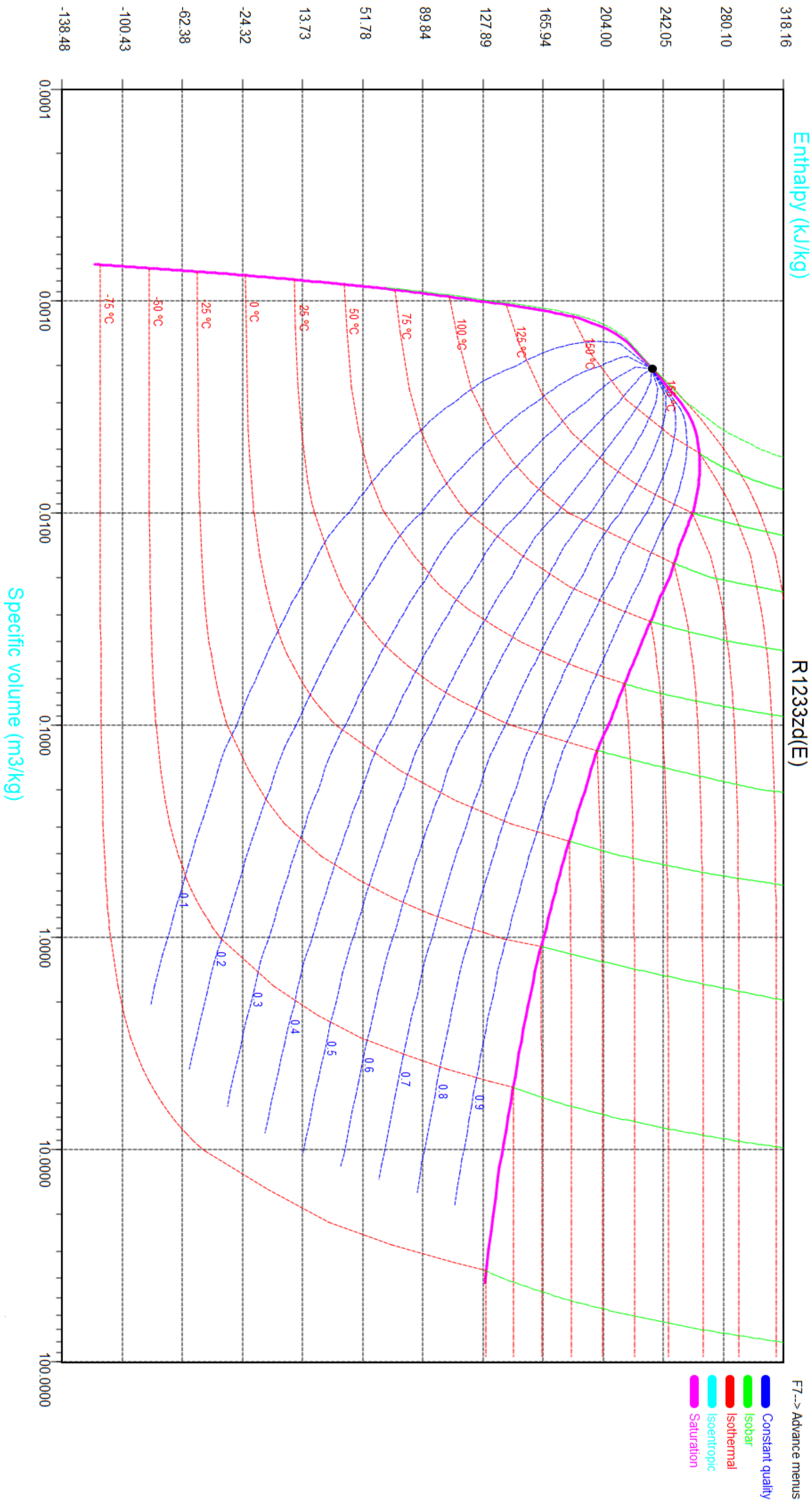

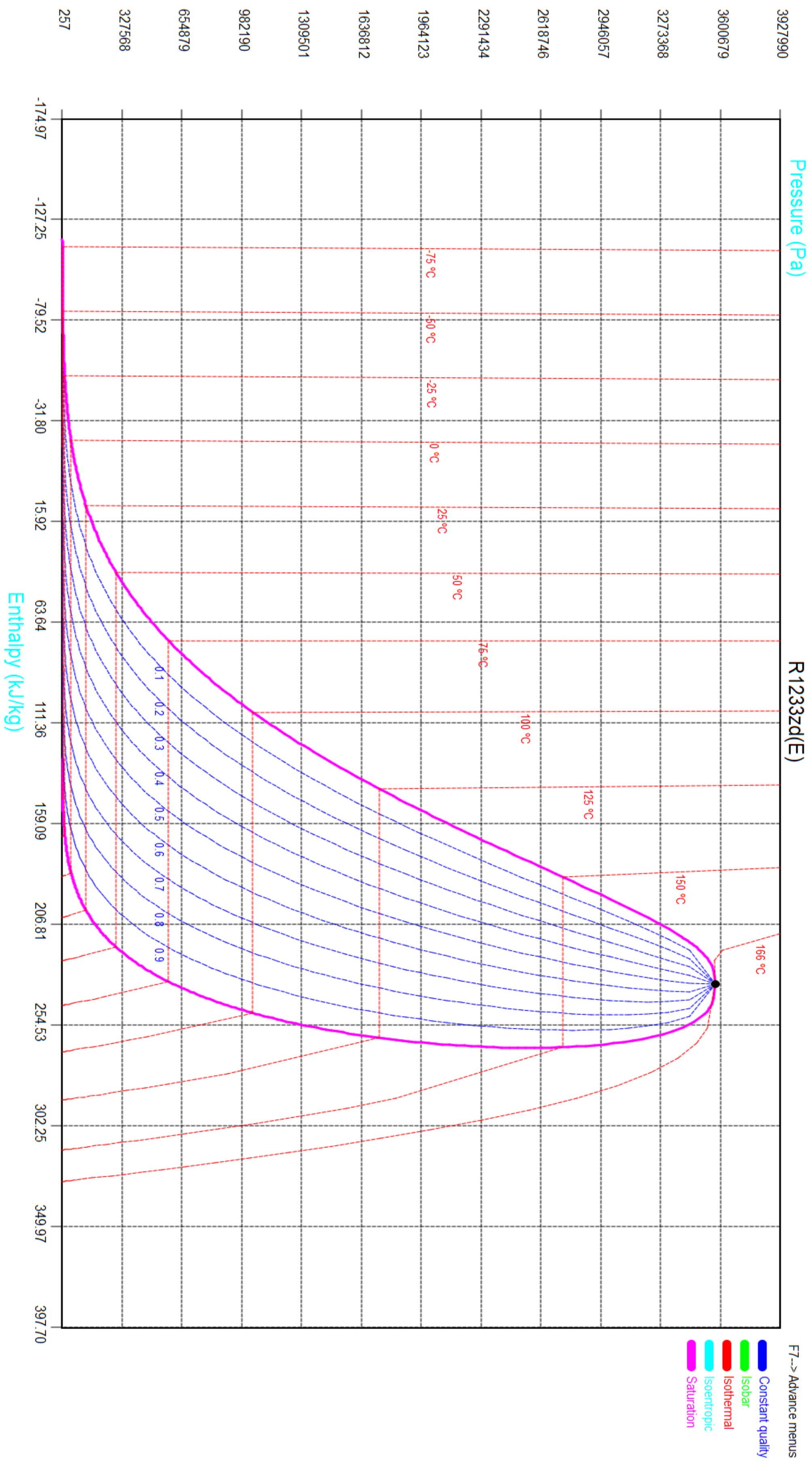
R1233zd(E)
Pressure (Pa)
Enthalpy (kJ/kg)
257
327568
654879
982190
1309501
1636812
1964123
2291434
2618746
2946057
3273368
3600679
3927990
-174.97
-127.25
-79.52
-31.80
15.92
63.64
111.36
159.09
206.81
254.53
302.25
349.97
397.70
-75 °C
-50 °C
-25 °C
0 °C
25 °C
50 °C
75 °C
100 °C
125 °C
150 °C
166 °C
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isentropic
Saturation

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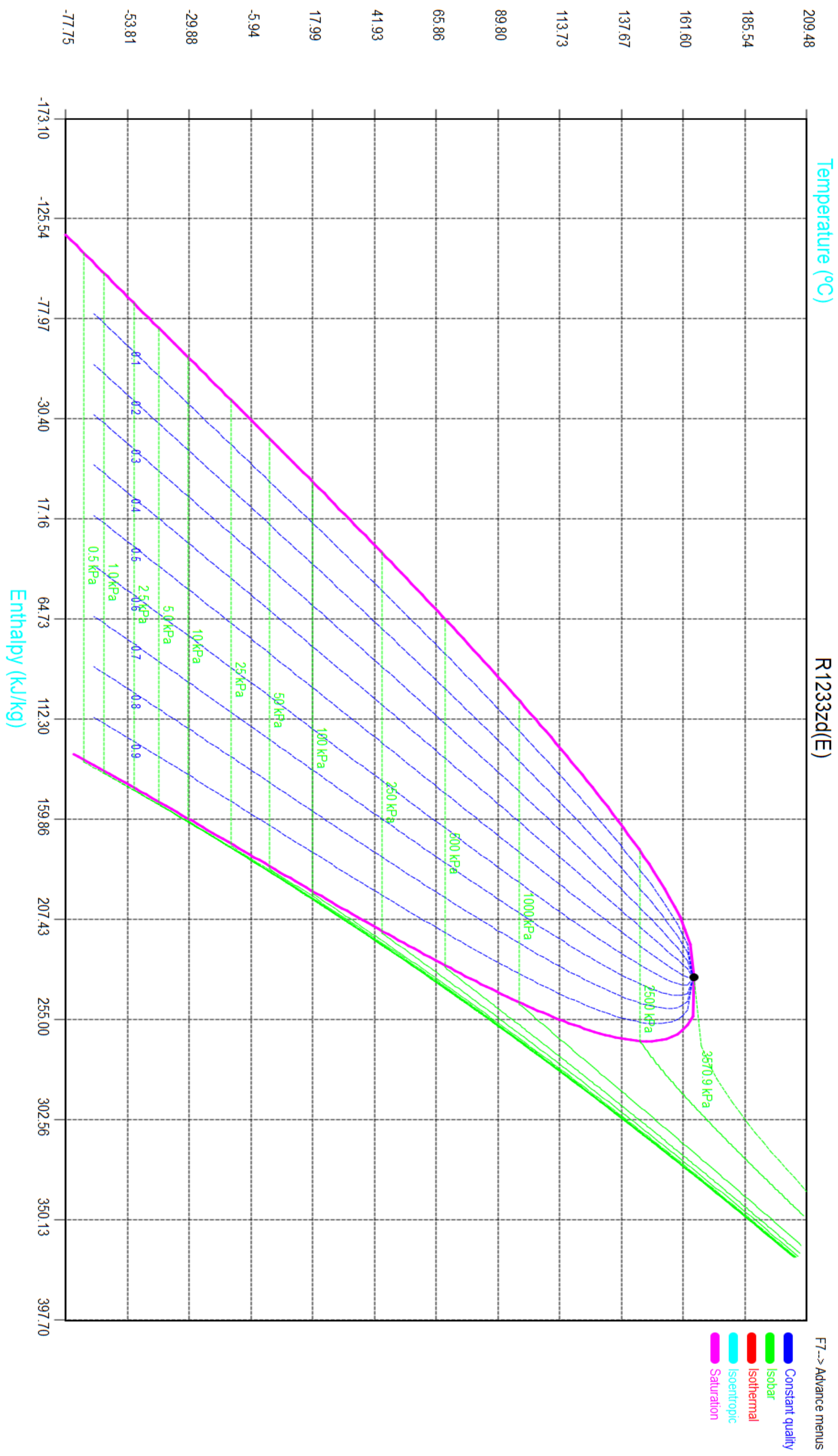
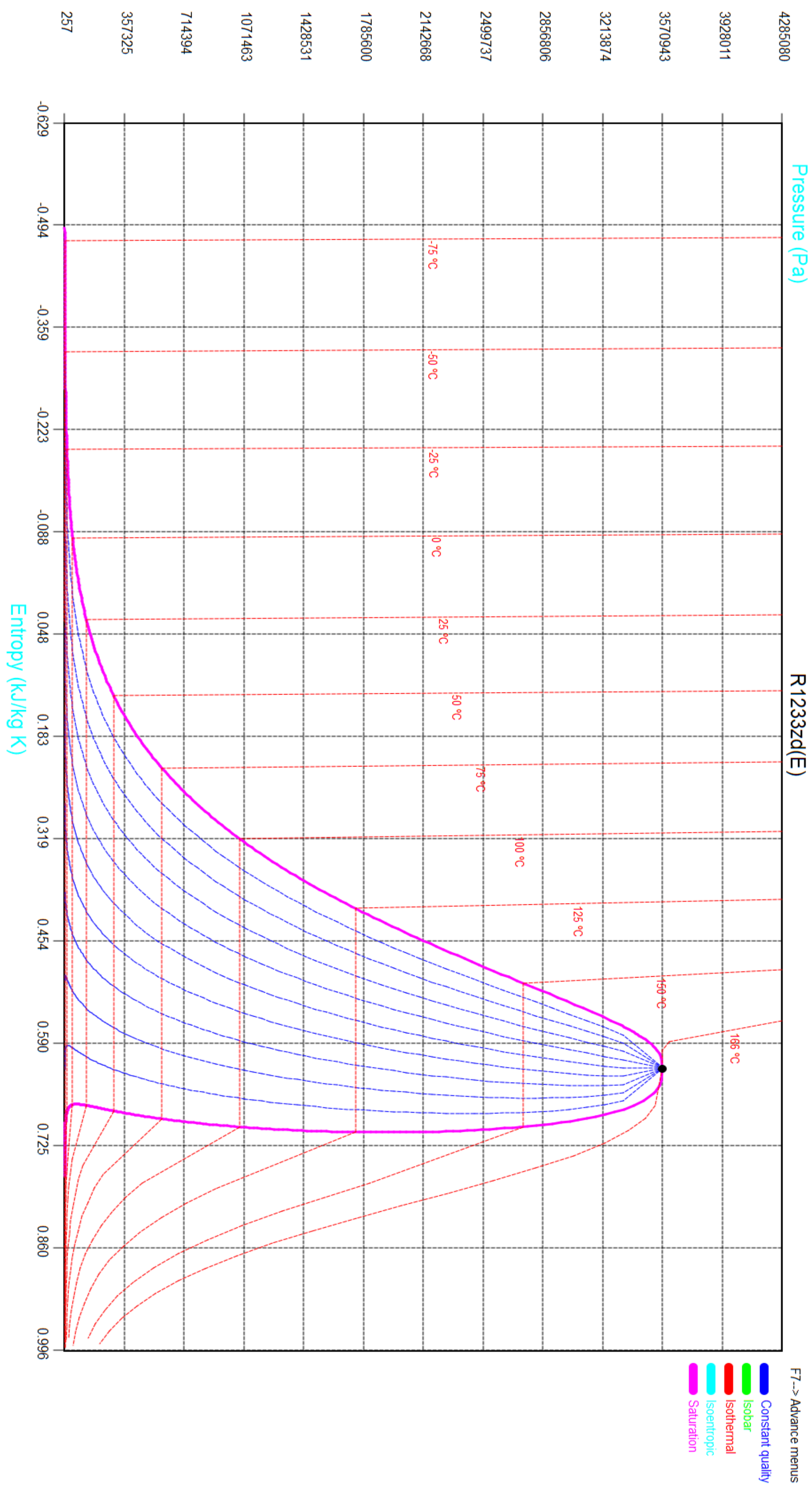
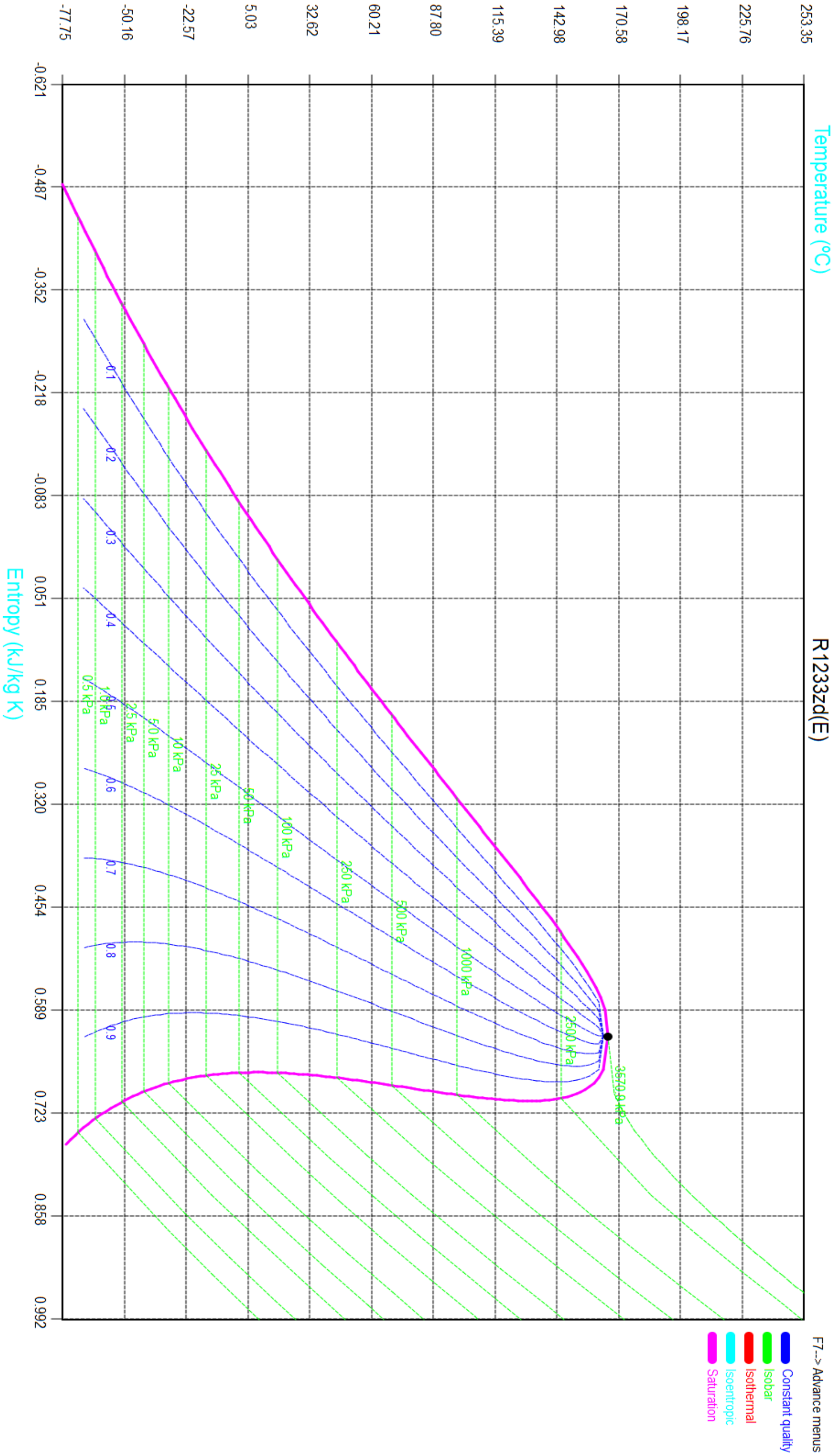
Technical Software Suite




R1233zd(E)
Pressure (Pa)
Entropy (kJ/kg K)
257
357325
714394
1071463
1428531
1785600
2142668
2499737
2856806
3213874
3570943
3928011
4285080
-0.629
-0.494
-0.359
-0.223
-0.088
0.048
0.183
0.319
0.454
0.590
0.725
0.860
0.996
-75 °C
-50 °C
-25 °C
0 °C
25 °C
50 °C
75 °C
100 °C
125 °C
150 °C
166 °C
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isoentropic
Saturation


R1233zd(E)
Temperature (°C)
Entropy (kJ/kg K)
-77.75
-50.16
-22.57
5.03
32.62
60.21
87.80
115.39
142.98
170.58
198.17
225.76
253.35
-0.621
-0.487
-0.352
-0.218
-0.083
0.051
0.185
0.320
0.454
0.589
0.723
0.858
0.992
0.1
0.2
0.3
0.4
0.6
0.7
0.8
0.9
25 kPa
100 kPa
250 kPa
1000 kPa
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isentropic
Saturation

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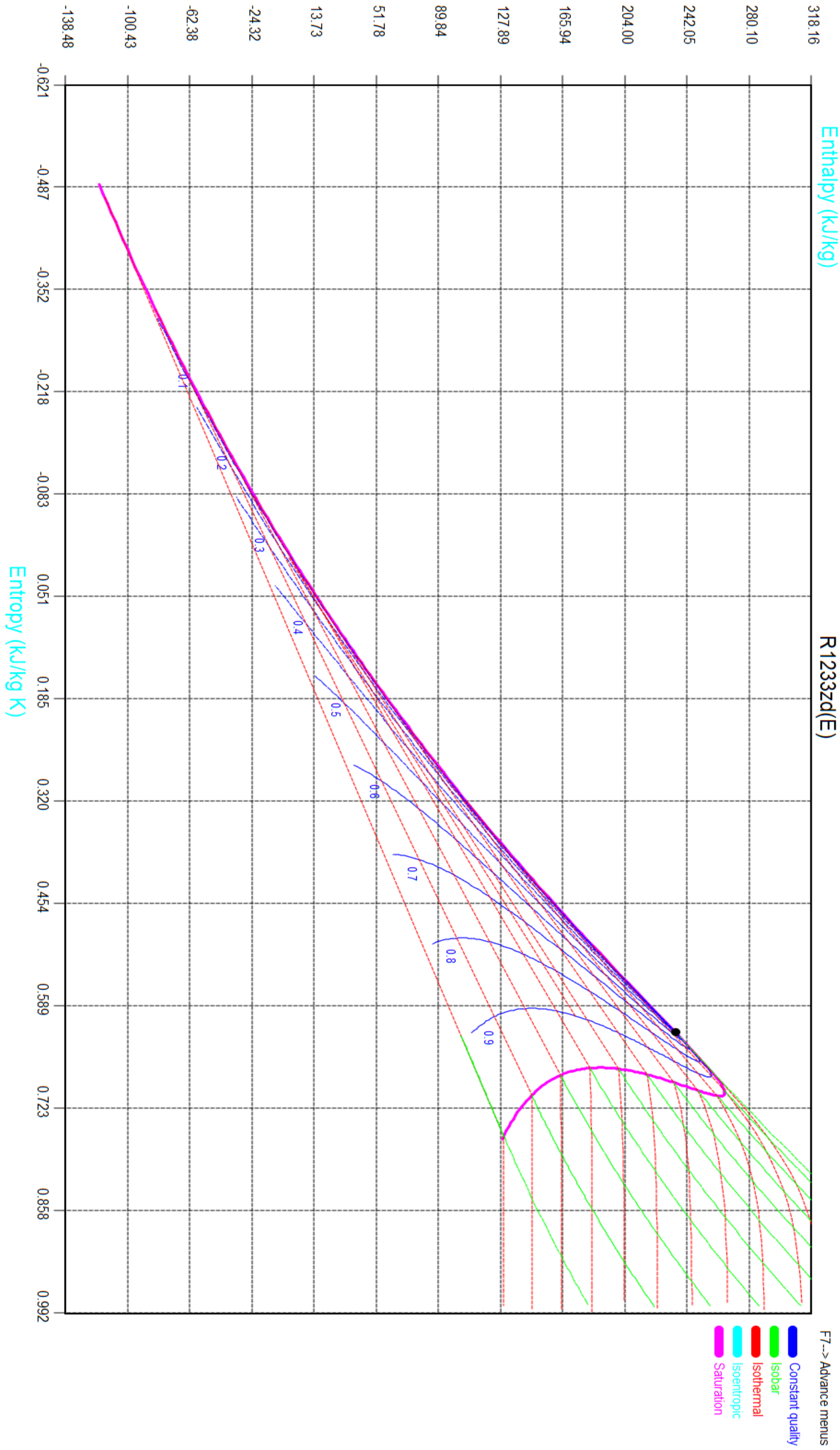
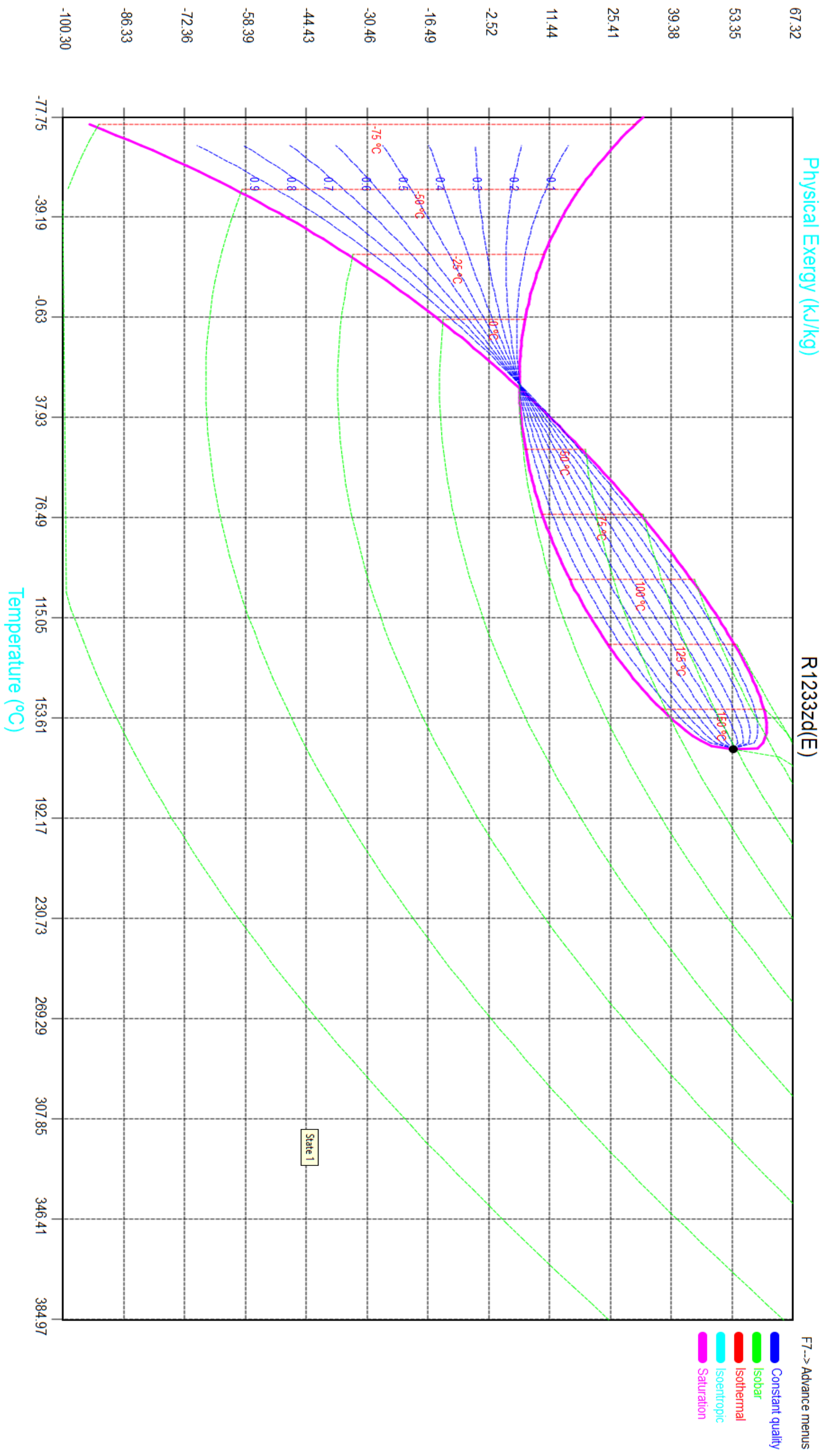
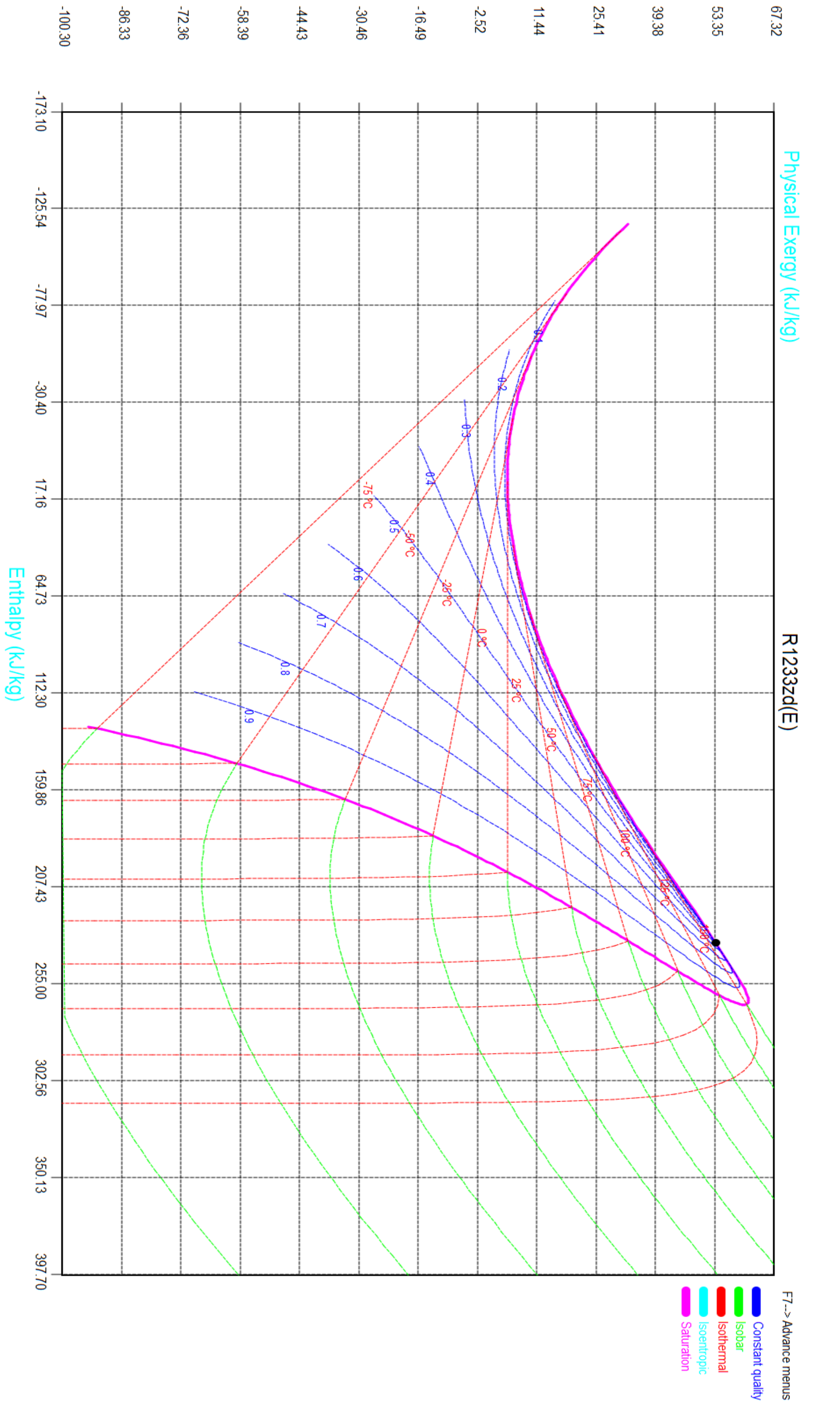
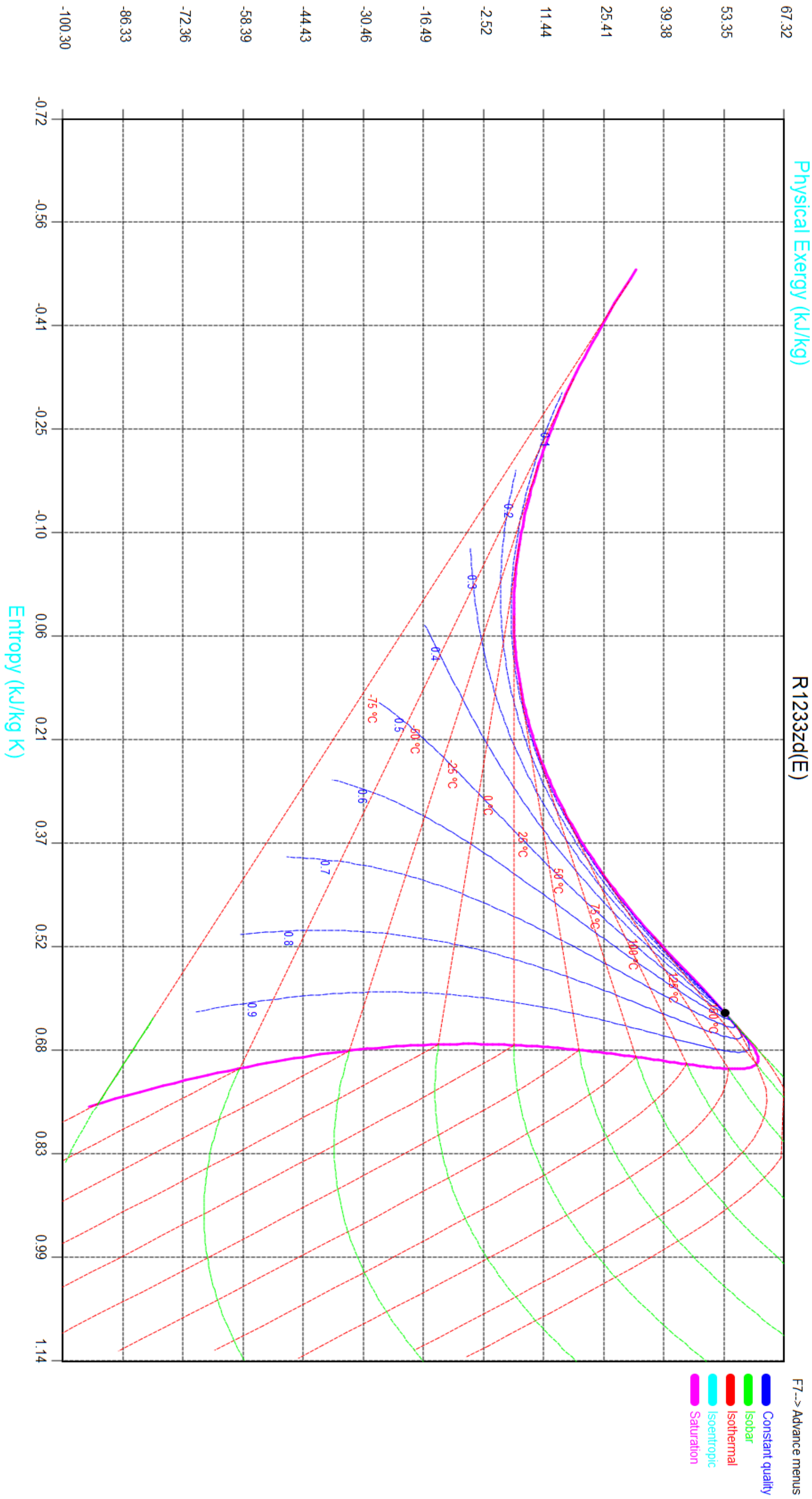



R1233zd(E)
Physical Exergy (kJ/kg)
Temperature (°C)
67.32
53.35
39.38
25.41
11.44
-2.52
-16.49
-30.46
-44.43
-58.39
-72.36
-86.33
-100.30
-77.75
-39.19
-0.63
37.93
76.49
115.05
153.61
192.17
230.73
269.29
307.85
346.41
384.97
State 1
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isoentropic
Saturation



R1233zd(E)
Physical Exergy (kJ/kg)
Enthalpy (kJ/kg)
-100.30
-86.33
-72.36
-58.39
-44.43
-30.46
-16.49
-2.52
11.44
25.41
39.38
53.35
67.32
-173.10
-125.54
-77.97
-30.40
17.16
64.73
112.30
159.86
207.43
255.00
302.56
350.13
397.70
F7--> Advance menus
Constant quality
Isobar
Isothermal
Isoentropic
Saturation


R1233zd(E)
Physical Exergy (kJ/kg)
Entropy (kJ/kg K)
-100.30
-86.33
-72.36
-58.39
-44.43
-30.46
-16.49
-2.52
11.44
25.41
39.38
53.35
67.32
-0.72
-0.56
-0.41
-0.25
-0.10
0.06
0.21
0.37
0.52
0.68
0.83
0.99
1.14
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
-75 °C
-50 °C
-25 °C
0 °C
25 °C
50 °C
75 °C
100 °C
125 °C
150 °C
F7--> Advance menus
Constant quality
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Isothermal
Isoentropic
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