Cooling Demand

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USER GUIDE

REQUIREMENTS:
Compatible with iPad. Requires iOS 12.1 or later.

VERSION: 1.0

Description

Cooling Demand consists of a collection of three computational tools employed to determine thermal performance and cooling demand of cooling towers.

All calculations are performed employing accurate numerical techniques implementing some of the most precise mathematical models for the properties of humid air, water and steam developed for industrial purposes.

- **Demand Curves** : Calculation and graphical display of demand curves and approach data points.
- **Merkel Number** : Calculation of Merkel number using the Chebyshev numerical method.
- **Psychrometrics Calculator** : A psychrometrics calculator based on the latest mathematical models to numerically evaluate the properties of humid air, water, steam, ice and psychrometrics.

Main Features

Mathematical Models

Calculation of the properties of humid air, water and steam used for the numerical solution of the equations that describe the energy processes are based on the mathematical formulations of the following thermodynamic and transport properties:

Properties of Water and Steam

- Formulations from the IAPWS (International Association for the Properties of Water and Steam) IAPWS-IF97 Industrial formulation (Revision 2007) and related models.

Properties of Humid Air

- Thermodynamic and psychrometrics property algorithms from the ASHRAE Research Project 1485.
- Scientific Formulation IAPWS-95, IAPWS Formulation 2008 and IAPWS Formulation 2006. Properties of dry air are from the NIST Reference equation of Lemmon et al.

Applications

Demand Curves

- Numerical calculation and graphical display of demand curves following the integration of Merkel´s equation.
- Calculation and graphical display of approach data points.
- Complete validation of input variables.
- Creation of projects in a database that describe a particular set of input variables together with the calculated demand curves and approach data points for later retrieval or recalculation.
- Generation of high-quality pdf files of demand curves.
- Generation of comma-separated value (CSV) files of the approach test point calculations results.
- Supports input variables and calculation results in SI (metric) and I-P (english) system of units.

Merkel Number

- Calculation of Merkel number using the Chebyshev numerical method.
- Complete validation of input variables, informing of the correct range of variables for a valid calculation.
- Supports input variables and calculation results in both the SI (metric) and I-P (english) system of units.

Psychrometrics Calculator

- Calculation of 41 properties of humid air, water, steam, ice and psychrometrics.
  - Dry-Bub Temperature
  - Wet-Bulb Temperature
  - Dew Point Temperature
  - Humid Air Pressure
  - Water Vapor Pressure
  - Saturation Water Vapor Pressure
  - Dry Air Mole Fraction
  - Water Vapor Mole Fraction
  - Dry Air Mass Fraction
  - Water Vapor Mass Fraction
  - Humidity Ratio
  - Saturation Humidity Ratio
  - Relative Humidity
  - Absolute Humidity
  - Parts per million by weight
  - Parts per million by volume
  - Enhancement Factor
  - Specific Volume of Dry Air
  - Specific Volume of Humid Air
  - Specific Volume of Saturated Water
  - Specific Volume of Saturated Ice
  - Specific Volume of Saturated Water Vapor
  - Specific Density of Dry Air
  - Specific Density of Humid Air
  - Specific Density of Saturated Water
  - Specific Density of Saturated Ice
  - Specific Density of Saturated Water Vapor
  - Specific Enthalpy of Dry Air
  - Specific Enthalpy of Humid Air
  - Specific Enthalpy of Saturated Water
  - Specific Enthalpy of Saturated Ice
  - Specific Enthalpy of Saturated Water Vapor
  - Specific Entropy of Dry Air
  - Specific Entropy of Humid Air
  - Specific Entropy of Saturated Water
  - Specific Entropy of Saturated Ice
  - Specific Entropy of Saturated Water Vapor
  - Compressibility of Dry Air
  - Compressibility of Humid Air
  - Compressibility of Saturated Water Vapor
  - Specific Isobaric Heat Capacity of Humid Air

- Allows for 17 combinations of two thermodynamic properties to be entered as input parameters:
  - Dry-bulb Temperature / Wet-bulb Temperature
  - Dry-bulb Temperature / Dew Point Temperature
  - Dry-bulb Temperature / Relative Humidity
  - Dry-bulb Temperature / Humidity Ratio
  - Dry-bulb Temperature / Specific Enthalpy
  - Dry-bulb Temperature / Specific Volume
  - Wet-bulb Temperature / Dew Point Temperature
  - Wet-bulb Temperature / Relative Humidity
  - Wet-bulb Temperature / Humidity Ratio
  - Dew Point Temperature / Relative Humidity
  - Dew Point Temperature / Specific Enthalpy
  - Dew Point Temperature / Specific Volume
  - Relative Humidity / Humidity Ratio
  - Relative Humidity / Specific Enthalpy
  - Relative Humidity / Specific Volume
  - Humidity Ratio / Specific Enthalpy
  - Humidity Ratio / Specific Volume

- Supports input parameters and calculation results in both the SI (metric) and I-P (english) system of units.

- For each combination of input thermodynamic properties, it calculates and provides the user with information about the appropriate input values in the valid range of computations.

- Calculation points can be stored in a database for later retrieval.

- Calculation results can be sent by email in an HTML file along with a comma-separated value (CSV) file.

Limited Range of Variables

Certain limitations apply to **Cooling Demand** when the application does not have access to the Full Range of Variables. These limitations are described in Table 1.

	Full Range of Variables	Limited Range of Variables
Demand Curves		
Range of value variables for calculation of approach points	FULL RANGE	LIMITED
Range of value variables for calculation of demand curves	FULL RANGE	LIMITED
Number of approach points per project	100	10
Number of projects in database	UNLIMITED	2
Number of demand curves per project	100	1
Sending PDF files of plots or calculation results by email	ENABLED	DISABLED
Merkel Number		
Range of value variables for calculation of Merkel number	FULL RANGE	LIMITED
Psychrometrics Calculator		
Range of value variables for calculation of properties	FULL RANGE	LIMITED
Combination of variables for calculation of properties	ALL	ALL
Number of calculation points in database	UNLIMITED	3
Calculation of thermodynamic and psychrometrics properties	ALL	LIMITED
Sending calculation results by email	ENABLED	DISABLED

Table 1. Limitations applied when the application does not have access to the Full Range of Variables.

The Merkel Equation

An evaporative cooling tower is a device that is used to remove waste heat from the water used in an industrial process equipment or a machinery by rejecting that waste heat into the environment. When water is mixed with air in a cooling tower configuration, a heat transfer process takes places that involves a latent heat transfer due to the vaporization of a small amount of water and a sensible heat transfer reflecting the difference in temperatures of water and air.

Based on the theory developed by Merkel [3], the heat transfer process that take place in a cooling tower by considering the enthalpy potential difference as the driving force is described by the Merkel equation:

$$\frac{KaV}{L} = \int_{T_2}^{T_1} \frac{c_{pw} dT_w}{h' - h} \tag{1}$$

Where:

$\frac{KaV}{L}$ = Tower characteristic

T_1 = Hot water temperature (inlet)

T_2 = Cold water temperature (outlet)

h' = Enthalpy of saturated air at water temperature

h = Enthalpy of main air stream

c_{pw} = Specific heat capacity of water

dT_w = Temperature differential of water

For a specific tower, there is a characteristic curve in the form of a plot of tower characteristic, KaV/L, versus water to air flow ratio, L/G. This plot is described with an equation of the following form:

$$\frac{KaV}{L} = c\left(\frac{L}{G}\right)^{-n} \tag{2}$$

Where L = water flow rate; G = air flow rate; c = constant defined for a particular packing design, or the intercept of the characteristic curve at $L/G = 1$; n = exponent related to packing design determined from test data.

The Demand Curves application solves the equation (1) numerically using the four-point Chebyshev numerical method employing the following models for the calculation of water and humid air properties:

Properties of Water and Steam

- Formulations from the IAPWS (International Association for the Properties of Water and Steam) IAPWS-IF97 Industrial formulation (Revision 2007) and related models.

Properties of Humid Air

- Thermodynamic and psychrometric property algorithms from the ASHRAE Research Project 1485.
- Scientific Formulation IAPWS-95, IAPWS Formulation 2008 and IAPWS Formulation 2006. Properties of dry air are from the NIST Reference equation of Lemmon et al.

Input Variables

Demand Curves allows to calculate and plot in a log-log graph isolines (demand curves) resulting from the integration of equation (1) using an *approach* value as a parameter. It also calculates the approach given a pair of values determined by KaV/L and L/G, both in the SI and I-P system of units. The definition of the input variables for calculation of the demand curves is given in Table 2.

Input Variable	Definition
WET-BULB TEMPERATURE	Temperature of air wet-bulb entering the cooling tower.
COOLING RANGE	Difference between hot water temperature and cold water temperature.
PRESSURE	Total pressure referred to atmospheric.
COEFFICIENT C	Constant defined for a particular packing design.
EXPONENT N	Exponent defined for a particular packing design.

Table 2. Definition of Input Variables for Demand Curves.

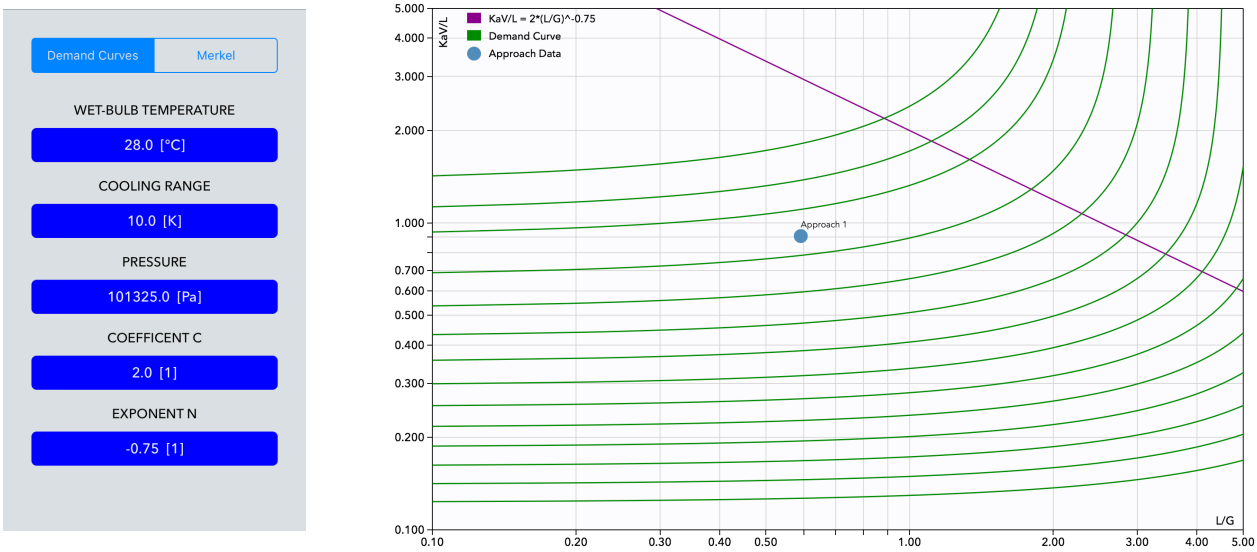

Figure1. Example of input variables in the SI system of units (left)
Demand curves plotted for several values of approach as a function of input variables (right)

Demand Curves

The Demand Curves application is accessed by tapping on the tab button **Demand**, and then on the button denoted as Demand Curves. This presents a graphical user interface as in Figure 2, where all the interaction buttons and main areas are specified.

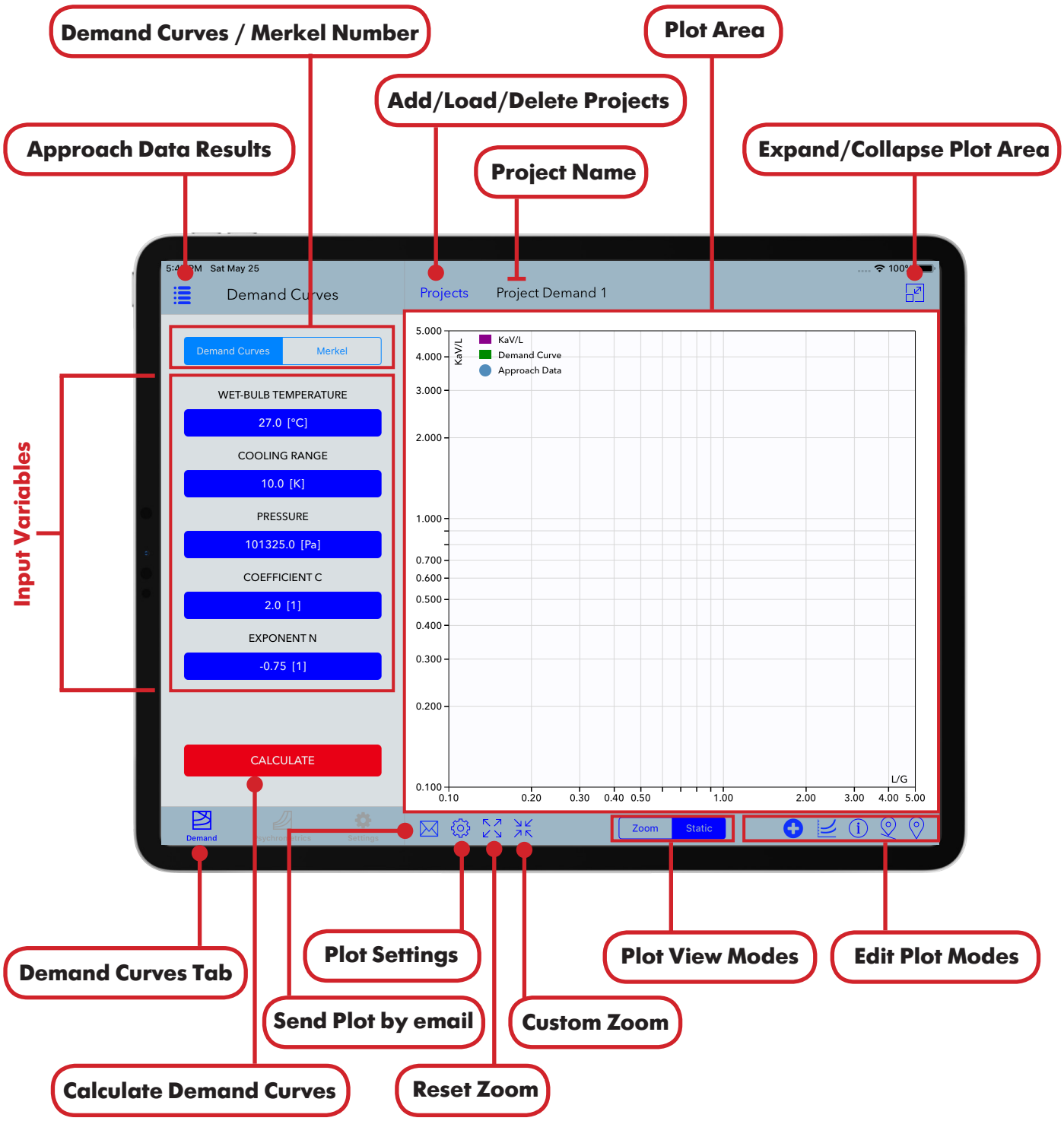

Figure 2. Graphical user interface for Demand Curves.

The full ranges of input variables for Demand Curves projects in the SI and I-P system of units are:

Property	Range in SI Units	SI Units	Range in I-P Units	I-P Units
Wet-Bulb Temperature	1.0 ⩽ T ⩽ 90.0	°C	33.8 ⩽ T ⩽ 194.0	°F
Cooling Range	0.1 ⩽ T ⩽ 90.0	K	0.1 ⩽ T ⩽ 162.0	°F
Pressure	60000.0 ⩽ P ⩽ 110000.0	Pa	8.702264 ⩽ P ⩽ 15.954151	psia
Coefficient C	1.0 ⩽ C ⩽ 3.0	1	1.0 ⩽ C ⩽ 3.0	1
Exponent N	-2.0 ⩽ N ⩽ -0.1	1	-2.0 ⩽ N ⩽ -0.1	1
KaV/L	0.1 ⩽ KaV/L ⩽ 5.0	1	0.1 ⩽ KaV/L ⩽ 5.0	1
L/G	0.1 ⩽ L/G ⩽ 5.0	1	0.1 ⩽ L/G ⩽ 5.0	1
Approach	1.0 ⩽ T ⩽ 60.0	°C	1.0 ⩽ T ⩽ 140.0	°F

Table 3. Full Range of Input Variables for Demand Curves.

The limited ranges of input variables for Demand Curves projects are:

Property	Range in SI Units	SI Units	Range in I-P Units	I-P Units
Wet-Bulb Temperature	25.0 ⩽ T ⩽ 28.0	°C	77.0 ⩽ T ⩽ 82.4	°F
Cooling Range	0.1 ⩽ T ⩽ 90.0	K	0.1 ⩽ Range ⩽ 162.0	°F
Pressure	99000.0 ⩽ P ⩽ 102000.0	Pa	14.358736 ⩽ P ⩽ 14.793849	psia
Coefficient C	2.0 ⩽ C ⩽ 2.1	1	2.0 ⩽ C ⩽ 2.1	1
Exponent N	-2.0 ⩽ N ⩽ -0.1	1	-2.0 ⩽ N ⩽ -0.1	1
KaV/L	0.1 ⩽ KaV/L ⩽ 5.0	1	0.1 ⩽ KaV/L ⩽ 5.0	1
L/G	0.1 ⩽ L/G ⩽ 5.0	1	0.1 ⩽ L/G ⩽ 5.0	1
Approach	1.0 ⩽ T ⩽ 60.0	°C	1.0 ⩽ T ⩽ 140.0	°F

Table 4. Limited Range of Input Variables for Demand Curves.

Add Calculation to a Project

- Tap on the Projects button to add a new project. Tap the Add button on the Projects List popup and enter an identifier for a new project.
- Tap on the input variables to introduce the desired values for the calculation.
- Select the Approach Curves category for Demand Curves in the **Settings** tab to determine isolines that will be calculated and plotted in the current project.
- Tap on the CALCULATE button to start the calculation.

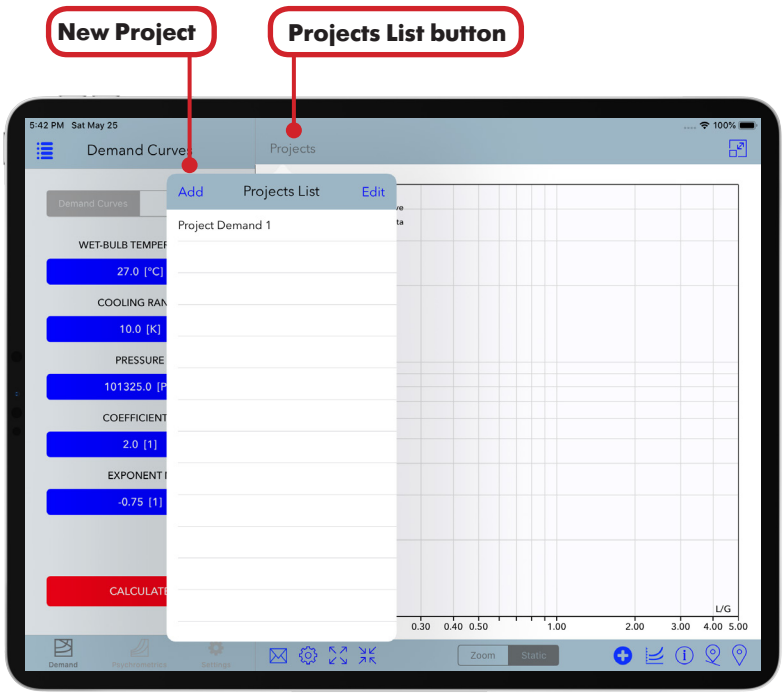

Figure 3. Add new project after tapping on the Projects button.

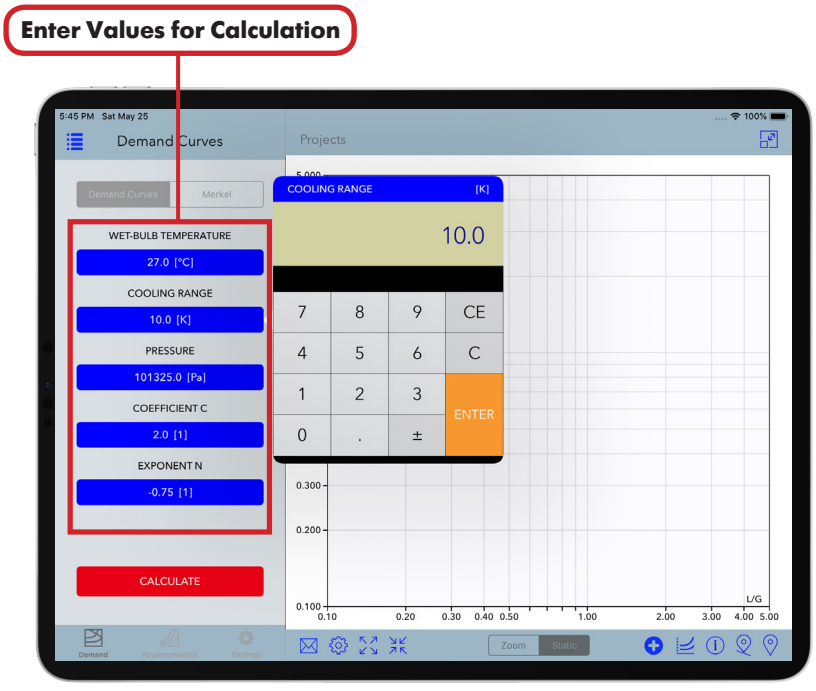

Figure 4. Entering values for Demand Curves calculation.

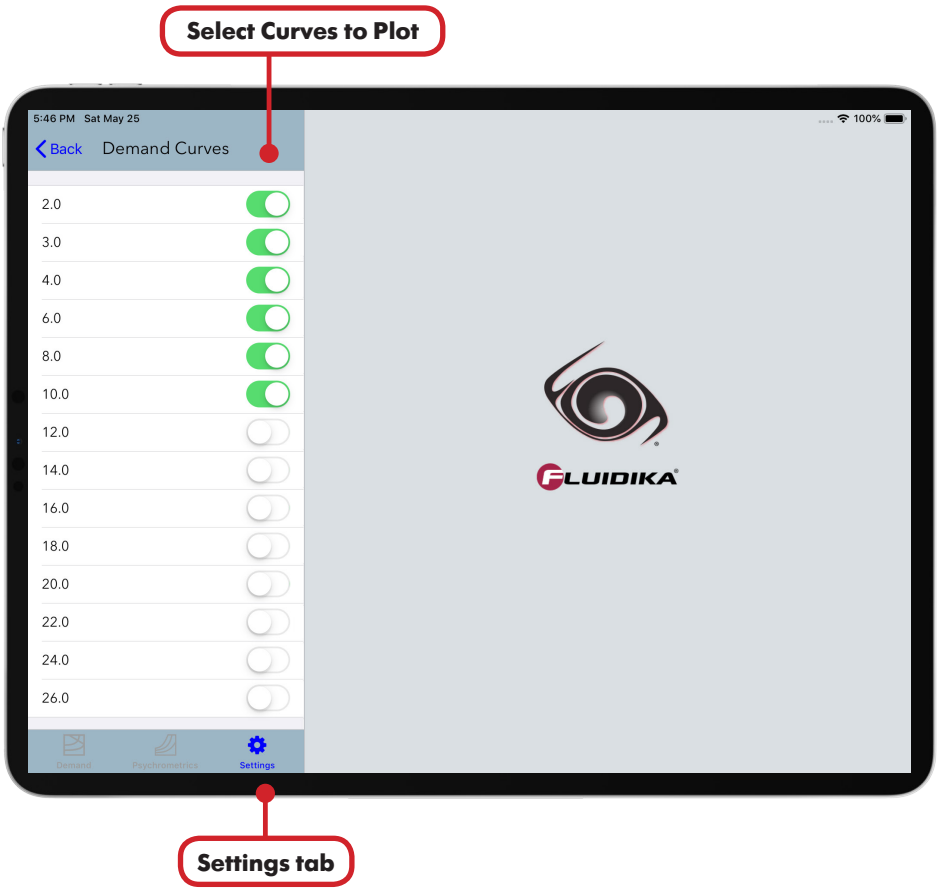

Figure 5. Select the approach curves to plot in the Settings Tab.

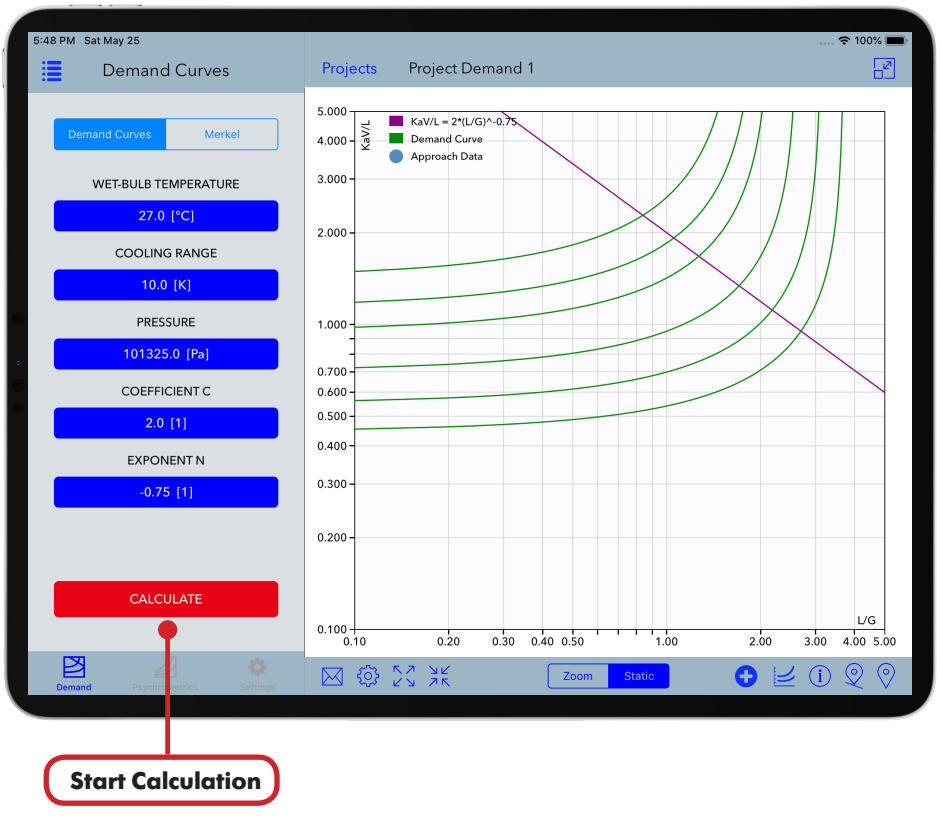

Figure 6. Plot area with Demand curves calculated in the project after tapping on CALCULATE button.

Add Approach Point to a Project

- Tap on the Add Point button to start the Graphical Mode. Tap on the Plot Area to show the crosshairs and drag to your desired location, or tap on the KaV/L or L/G buttons to enter the precise location.
- Select the static mode of the Plot View Mode. Tap on the Add button of the top tool bar to start the calculation of the approach point.
- Enter the Identifier of the previously calculated approach point (optional) , tap the Add button to add the point to the project. The point will be saved to the database. Tap the Done button to dismiss the popup.
- Tap on the Done button of the top toolbar to exit the Graphical Mode.

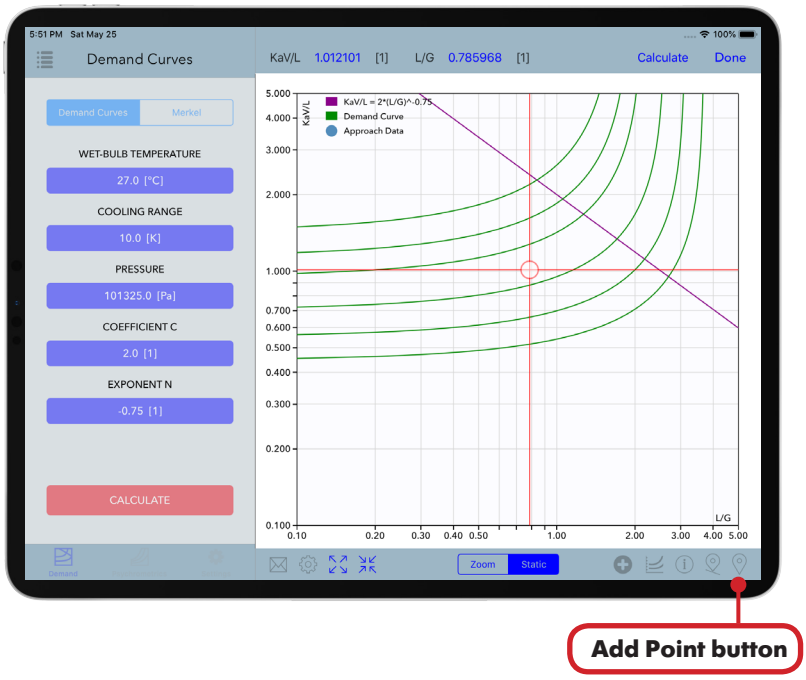

Figure 7. Graphical Mode after tapping on the Add Point button.

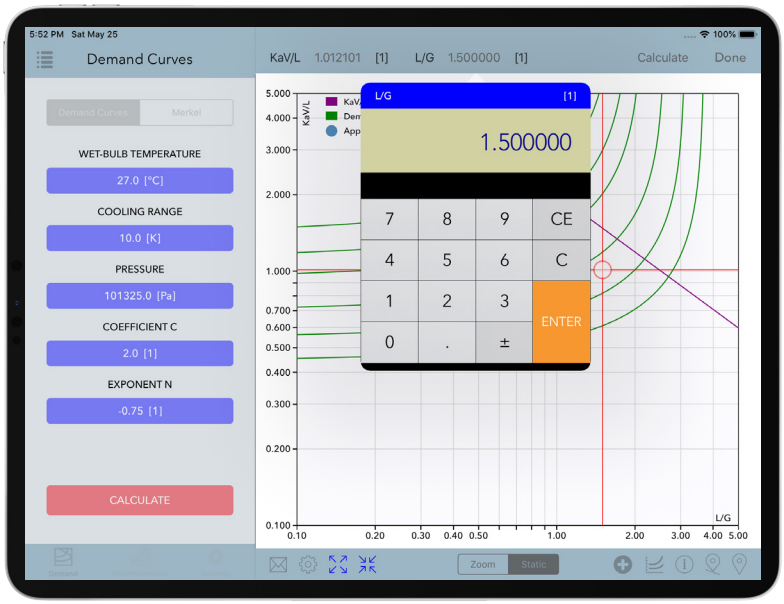

Figure 8. Enter values of KaV/L or L/G after tapping on their respective buttons.

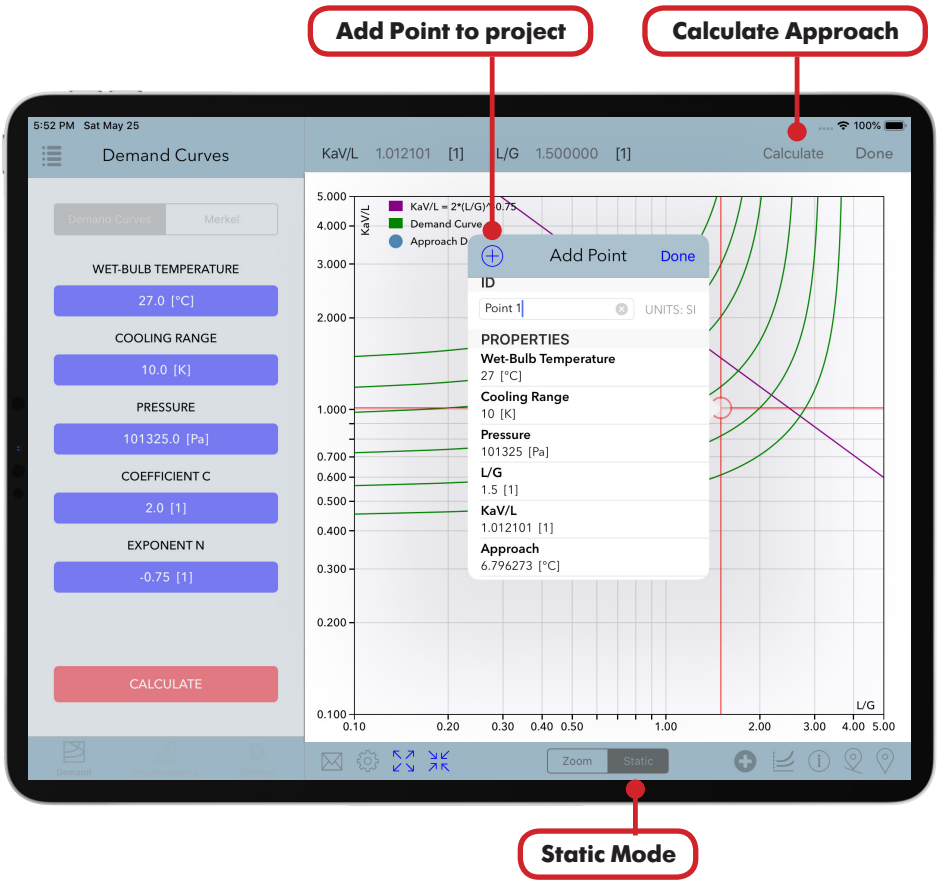

Figure 9. Approach point calculations finished after tapping on the Add button of the top toolbar.

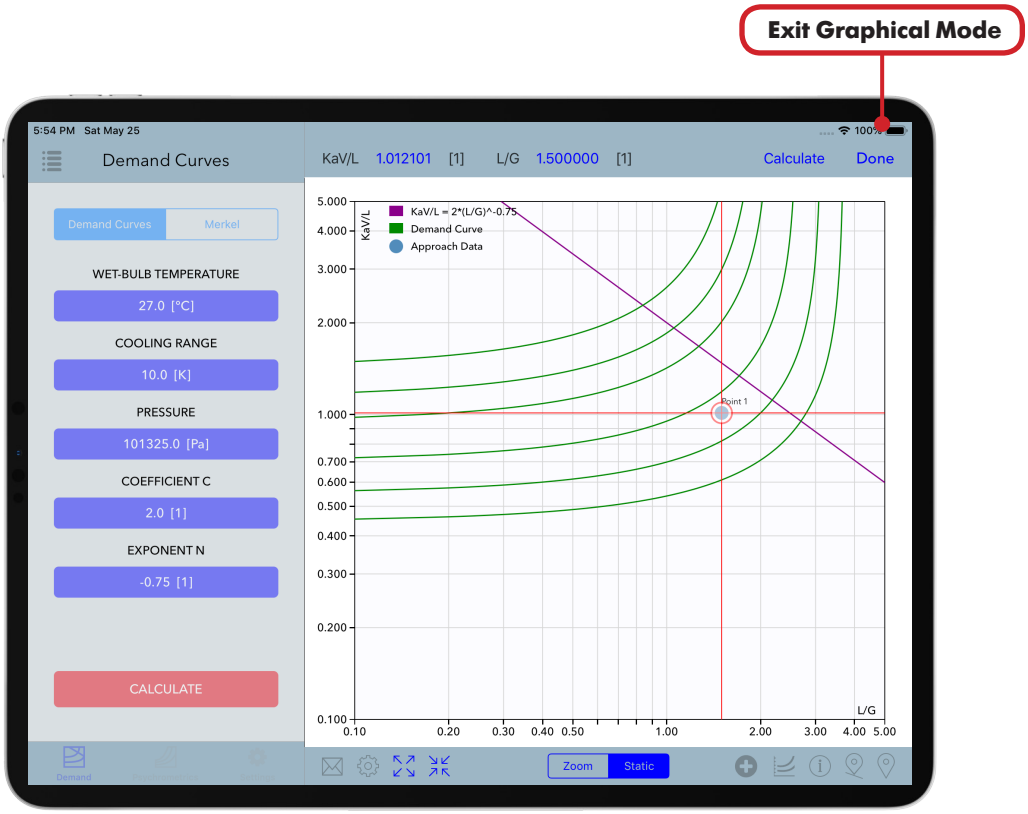

Figure 10. Point is saved to the project and the database.

Add Approach Point on KaV/L Curve to a Project

- Tap on the Add Point on KaV/L button to start the Graphical Mode. Tap on the Plot Area to show the crosshairs and drag to your desired location, or tap on the KaV/L or L/G buttons to enter the precise location. The crosshair´s movement is limited to values on the KaV/L line.
- Turn on Demand Curve on KaV/L in the **Settings** Tab to calculate and plot the demand curve result from the point calculation (in case the approach is a valid result).
- Select the static mode of the Plot View Mode. Tap on the Add button of the top tool bar to start the calculation of the approach point.
- Enter the Identifier of the previously calculated approach point, tap the Add button to add the point to the project. The point will be saved to the database. Tap the Done button to dismiss the popup.
- Tap on the Done button of the top toolbar to exit the Graphical Mode.

Figure 11. Graphical Mode after tapping on the Add Point on KaV/L button.

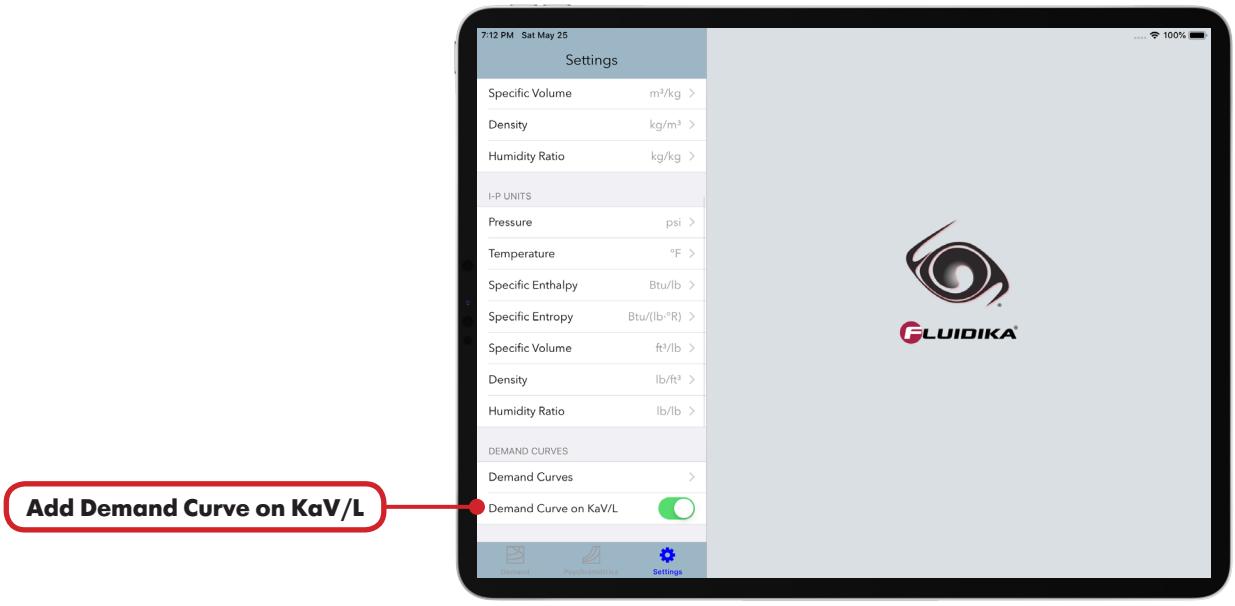

Figure 12. Turn on/off calculation of demand curve on KaV/L curve.

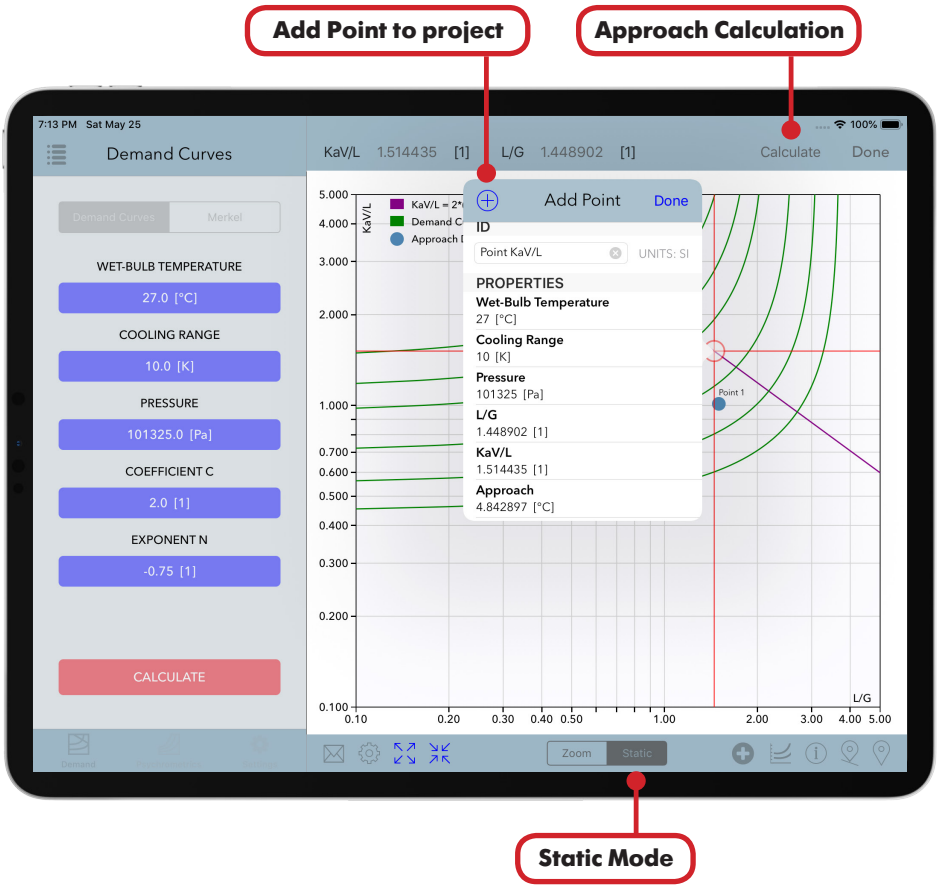

Figure 13. Approach point calculations finished after tapping on the Add button of the top toolbar.

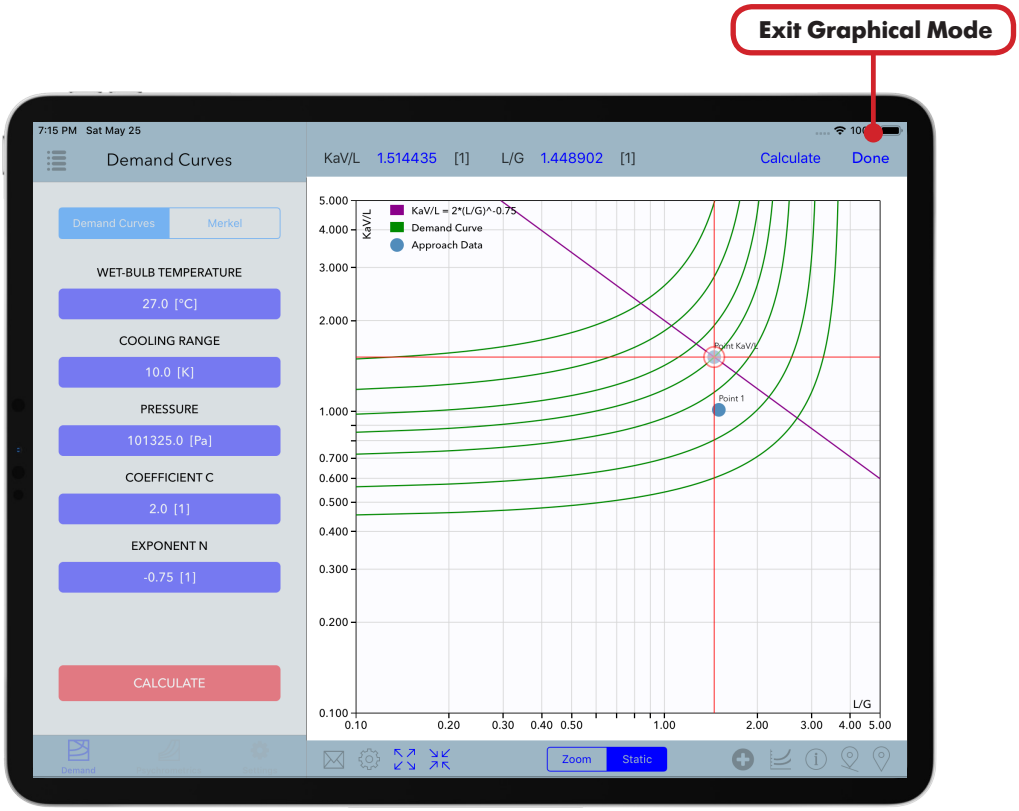

Figure 14. Calculation point and demand curve are saved to the project and the database.

Get Result from Approach Point Graphically

- Tap on the Info Point ⓘ button to start the Graphical Mode. Select the static mode of the Plot View Mode. Tap on the desired Approach Point.
- Tap on the Info button of the top tool bar to get data previously calculated for a point.
- By tapping on the Delete button of the popup the point is removed from the plot area and deleted from the database.
- Tap on the Done button of the top toolbar to exit the Graphical Mode.

Get Results from All Approach Points in a Project

- Tap on the Points Data button to show all the data calculation results for the current project.
- Tap on the Email button to send all the data by email.
- Tap the Plot Area button to return to the Plot Area.

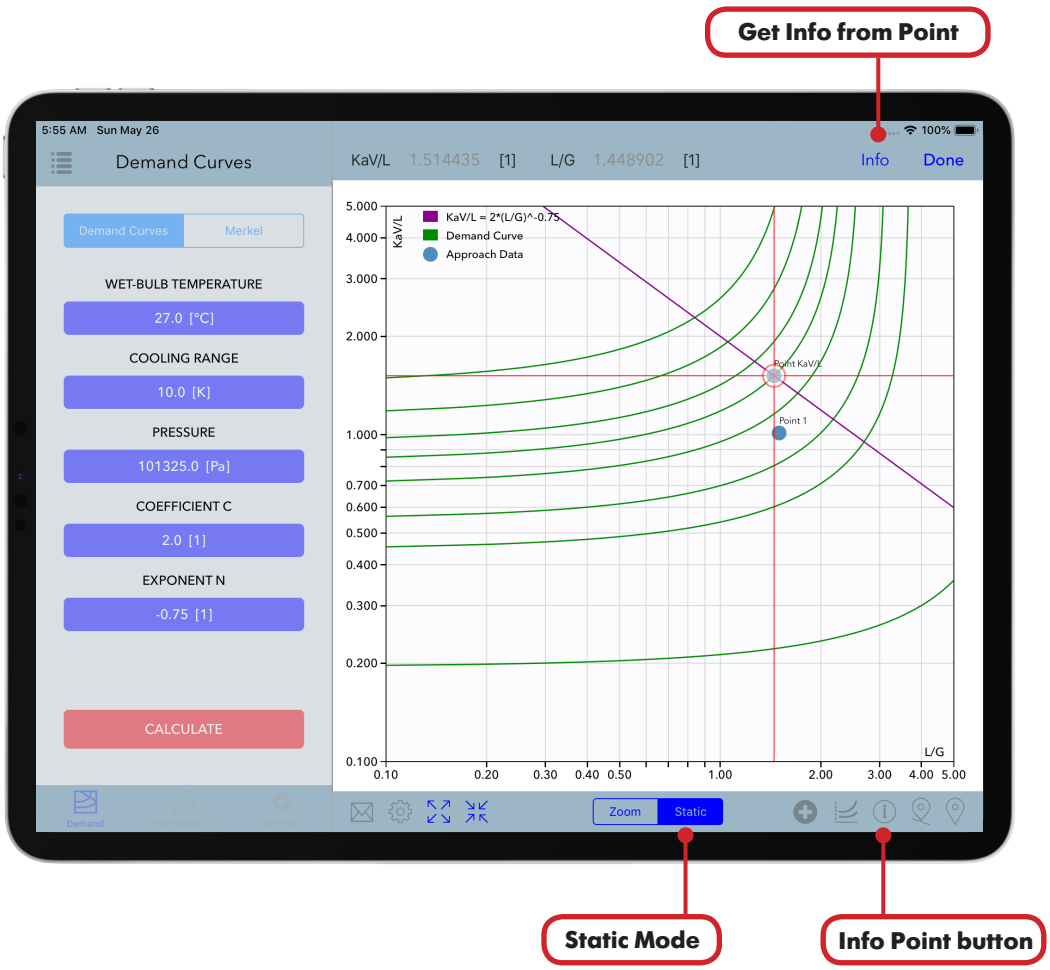

Figure 15. Graphical Mode after tapping on the Info Point ⓘ button with point selected.

Figure 16. A popup shows the data calculated for the selected point.

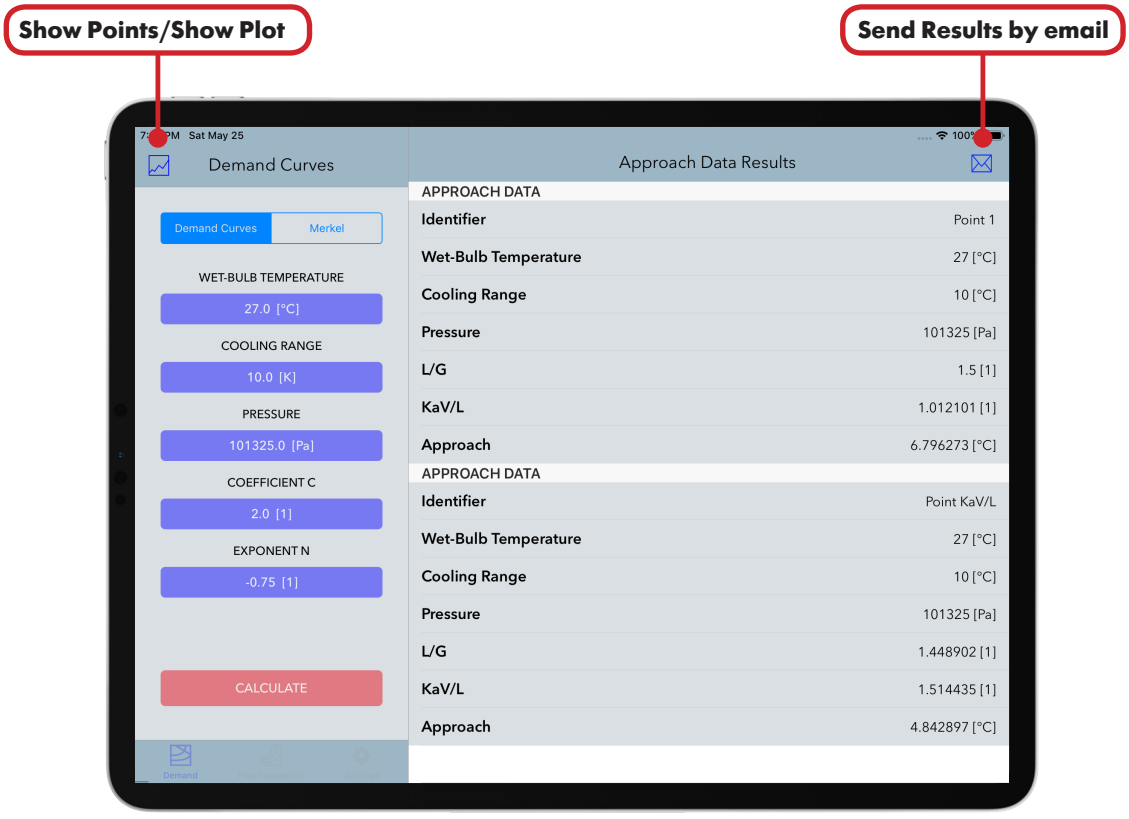

Figure 17. Calculation result points for current project.

Edit Approach Curves in a Project

- Tap on the Edit Curves button to start the Graphical Mode. This will show a list of the approach curves for the current project.
- Tap on the value of the approach curve to highlight it in the Plot Area (the curve turns red if selected).
- Tap on the Delete button to remove the curve from the plot and delete it form the database.
- Tap on the Add Label button to add a label on the Plot Area
- Tap on the Plot Area to position the label. Tap on the Angle Label button to choose an angle for the label, selecting the value by tapping on the SET button.
- Reposition the label on the Plot Area by dragging the label to its final position.
- Tap on the Accept button to save the changes to the project.

Figure 18. Graphical Mode after tapping on the Edit Curves button with approach curve selected.

Figure 19. Curve label after tapping on the Plot Area.

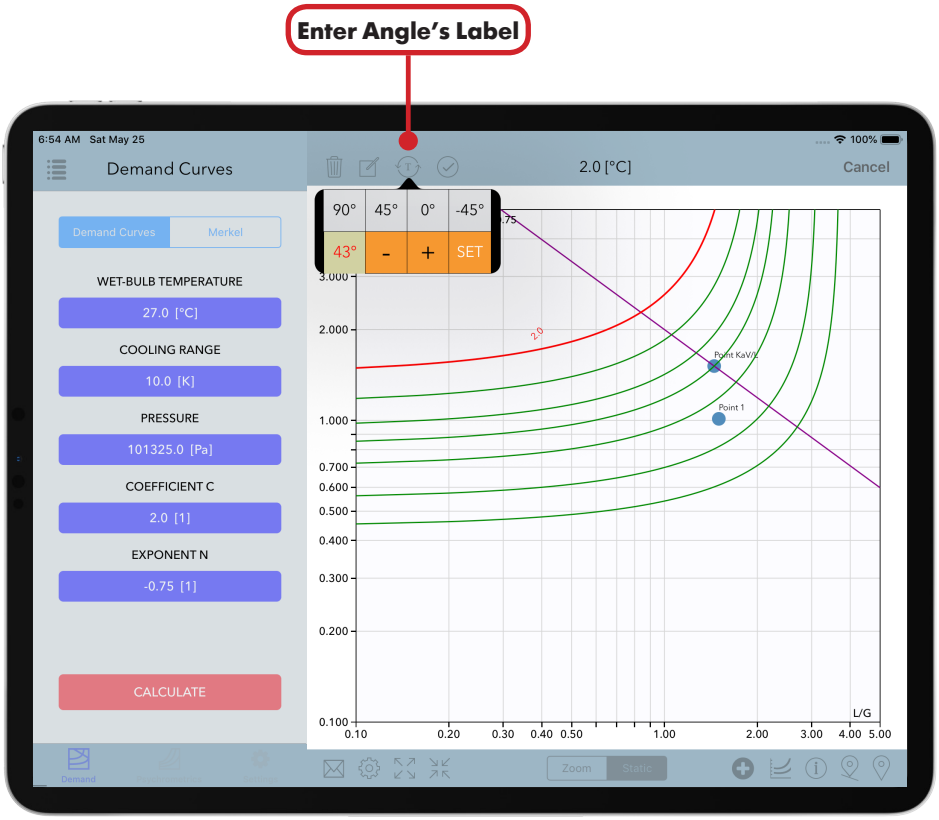

Figure 20. Set the angle by modifying the popup.

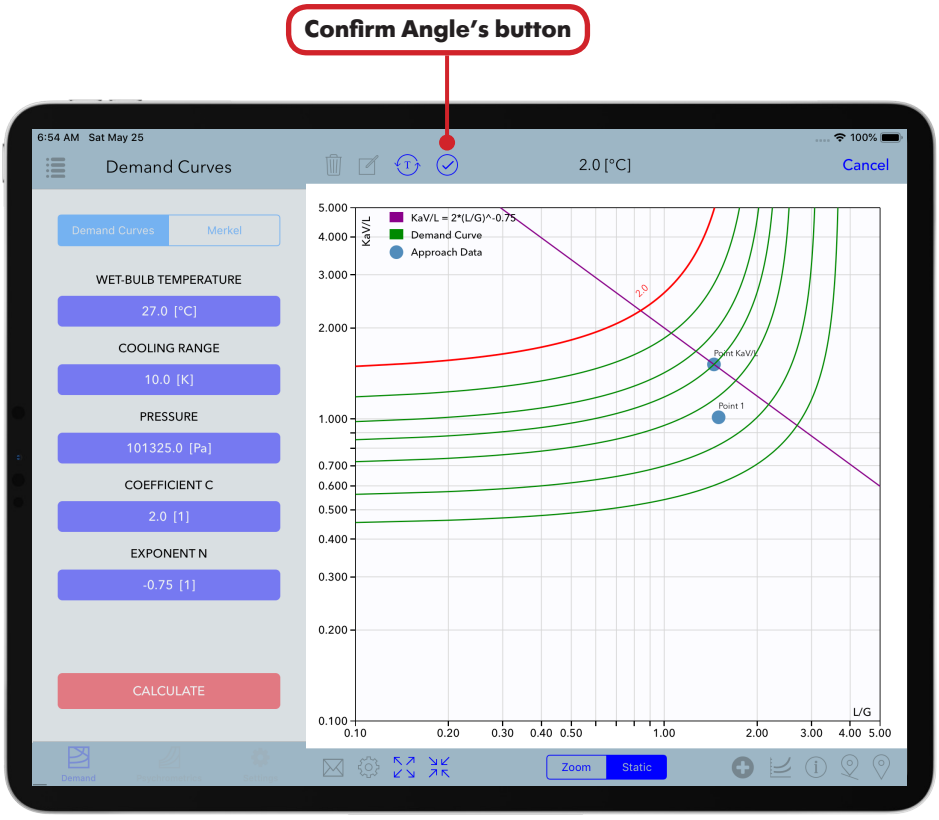

Figure 21. Position of the label after dragging it to its final position.

Add Demand Curves to a Project

- Tap on the Add Curve ⊕ button that shows the keyboard popup that enables to introduce an approach value for the calculation of the demand curve.
- Tap on the popup keyboard to introduce the desired value for the curve´s approach.
- Tap on the ENTER button to start the calculation of the demand curve.

Notes:

- A message will inform if the curve has been previously calculated.
- A message will appear if the curve can not be calculated.

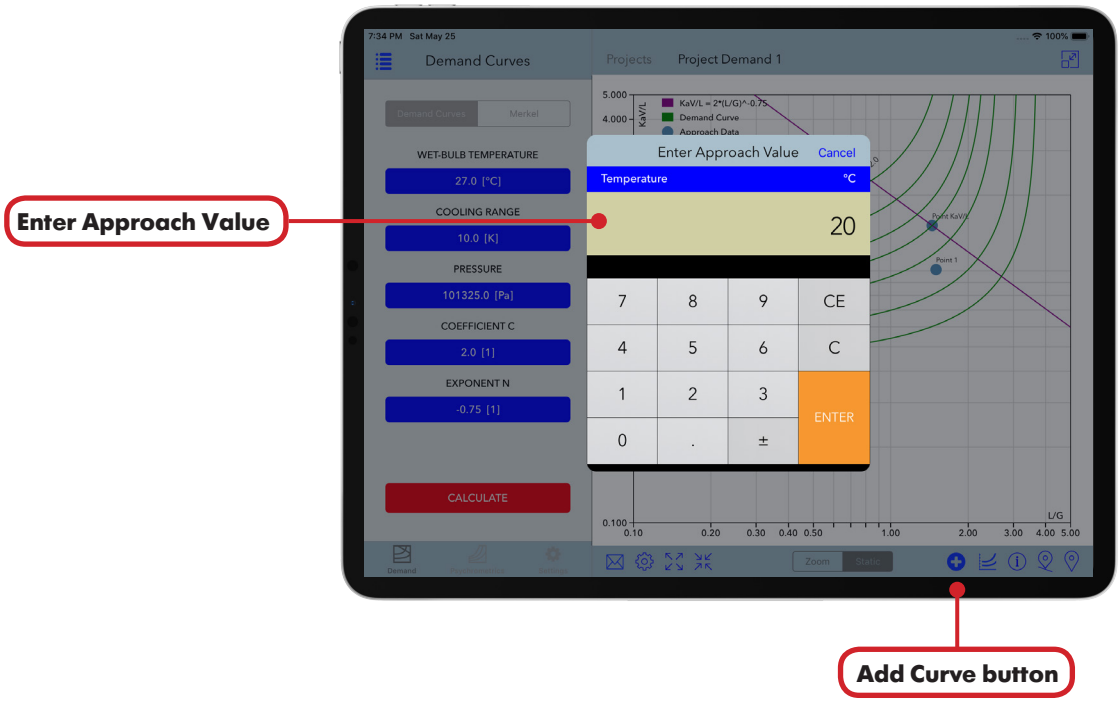

Figure 22. Keyboard popup to enter the approach value for a new demand curve.

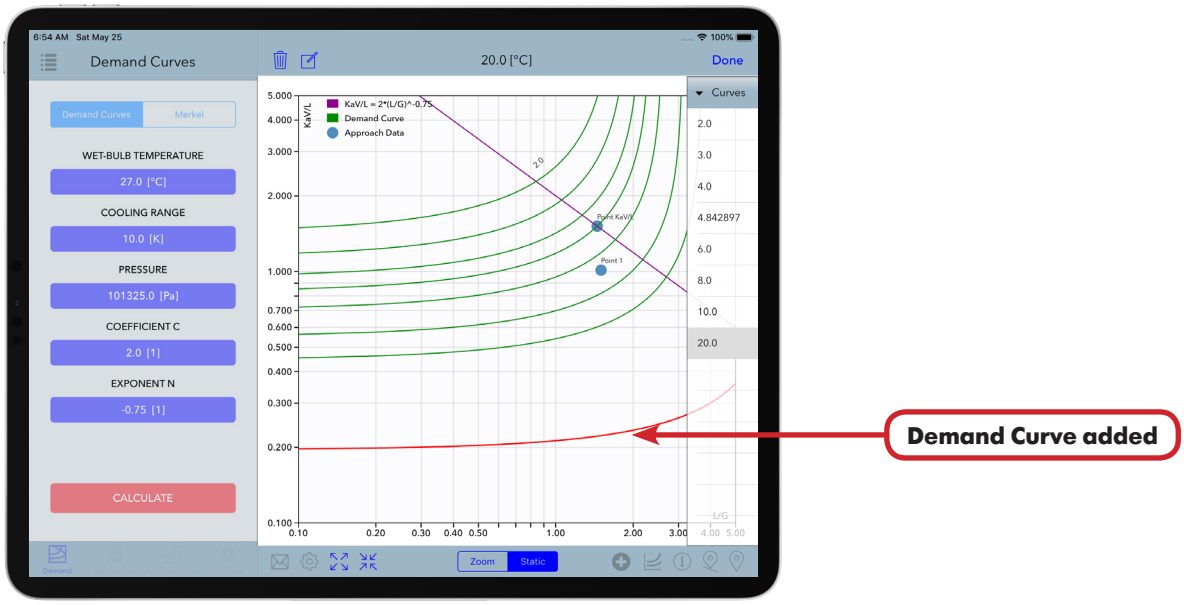

Figure 23. List of demand curves with the added demand curve.

Project Settings

- Tap on the Plot Settings button to show the visual settings for a particular project.
- Change the desired settings for the current project. These are applied instantly.

Notes:

- When a project is loaded, all changes in the settings popup are automatically saved.
- Tap on the button to expand / collapse the Plot Area at anytime.

Zoom into Plot Area

- Select the zoom mode of the Plot View Modes.
- Touch and drag a square to select the zoom over the Plot Area.
- Tap the Reset Zoom button to reset the Plot Area to its default view.

Figure 24. Settings window for the current project.

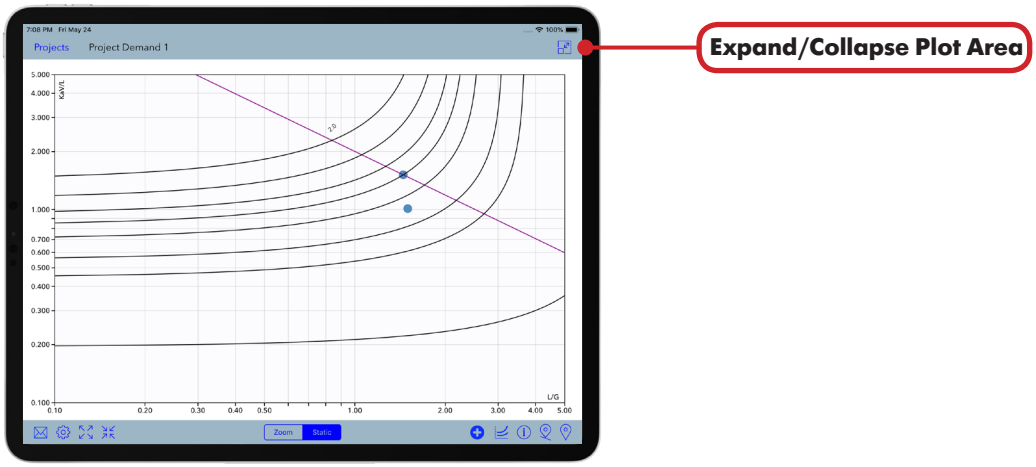

Figure 25. Settings applied for project and Plot Area expanded.

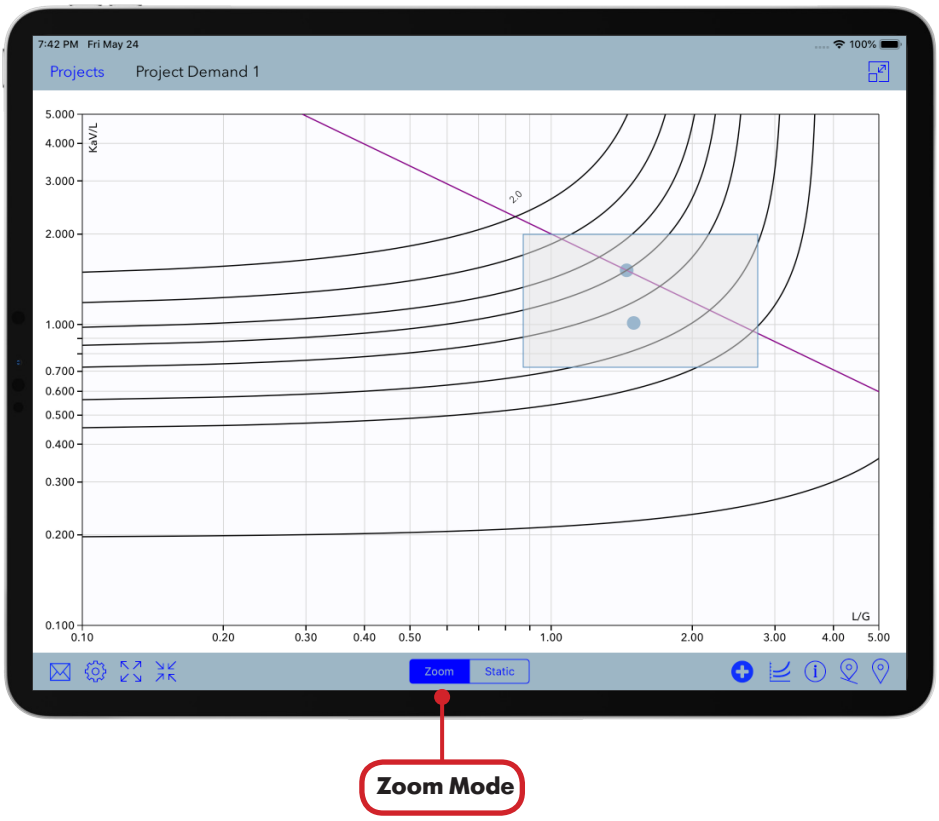

Figure 26. Zoom square dragged over the Plot Area.

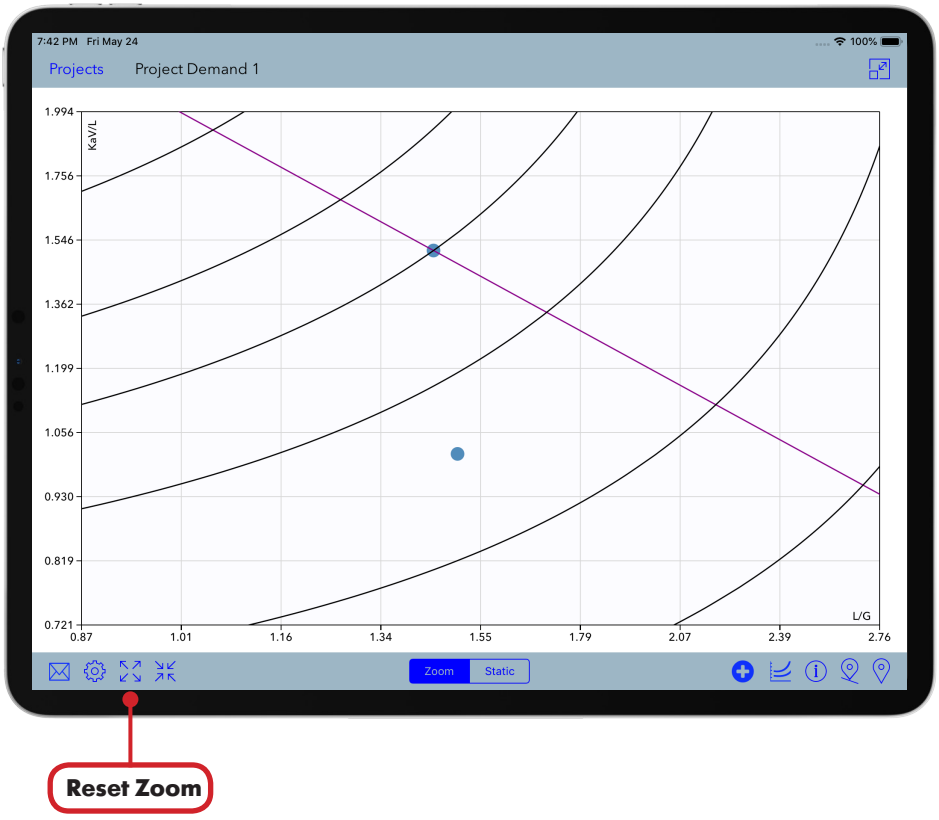

Figure 27. Area selected for zoom on the Plot Area.

Calculation of Merkel Number

- Select the Merkel button in the **Demand** tab.
- Enter the desired values for the calculation.
- Tap on the CALCULATE button to start the calculation.

Notes:

- A message will inform of the correct values for a valid calculation if the calculation can not proceed.

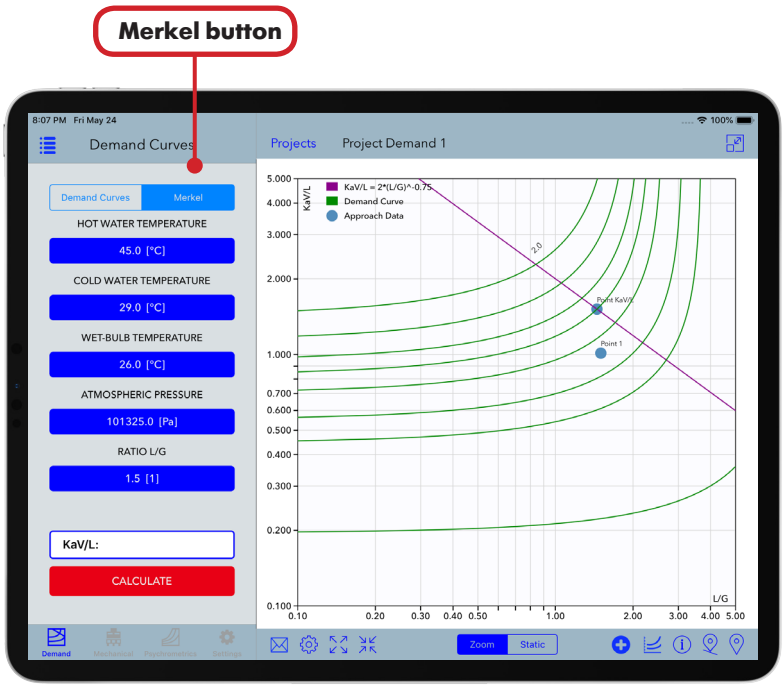

Figure 28. **Demand** tab with Merkel button selected.

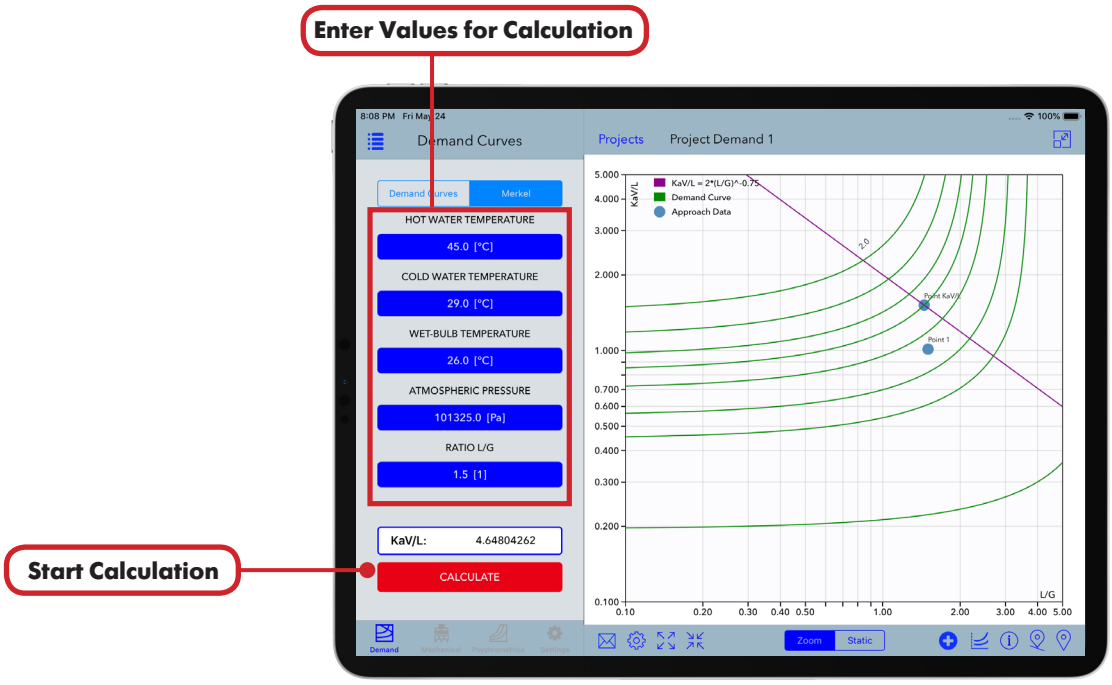

Figure 29. Merkel number result after calculation.

The full ranges of input variables for calculation of the Merkel Number in the SI and I-P system of units are:

Hot Water Temperature	$1.0 \leqslant T \leqslant 90.0$	°C	$33.8 \leqslant T \leqslant 194.0$	°F
Cold Water Temperature	$1.0 \leqslant T \leqslant 90.0$	°C	$33.8 \leqslant T \leqslant 194.0$	°F
Wet-Bulb Temperature	$1.0 \leqslant T \leqslant 90.0$	°C	$33.8 \leqslant T \leqslant 194.0$	°F
Pressure	$60000 \leqslant P \leqslant 110000$	Pa	$8.702264 \leqslant P \leqslant 15.954151$	psia
Ratio L/G	$0.01 \leqslant L/G \leqslant 5.0$	1	$0.01 \leqslant L/G \leqslant 5.0$	1

Table 5. Full Range of Input Variables for the Calculation of the Merkel Number.

The limited range of input variables for calculation of the Merkel Number:

Hot Water Temperature	$44.0 \leqslant T \leqslant 53.0$	°C	$111.2 \leqslant T \leqslant 127.4$	°F
Cold Water Temperature	$28.0 \leqslant T \leqslant 31.0$	°C	$82.4 \leqslant T \leqslant 87.8$	°F
Wet-Bulb Temperature	$25.0 \leqslant T \leqslant 28.0$	°C	$77.0 \leqslant T \leqslant 82.4$	°F
Pressure	$99000.0 \leqslant P \leqslant 102000.0$	Pa	$14.358736 \leqslant P \leqslant 14.793849$	psia
Ratio L/G	$0.01 \leqslant L/G \leqslant 5.0$	1	$0.01 \leqslant L/G \leqslant 5.0$	1

Table 6. Limited Range of Input Variables for the Calculation of the Merkel Number.

Psychrometrics

The Psychrometrics Calculator application is accessed by tapping on the tab button **Psychrometrics.** Property input variables are introduced by tapping on the currently selected combination of variables. This presents a graphical user interface as in Figure 30, where all the interaction buttons and main areas are specified.

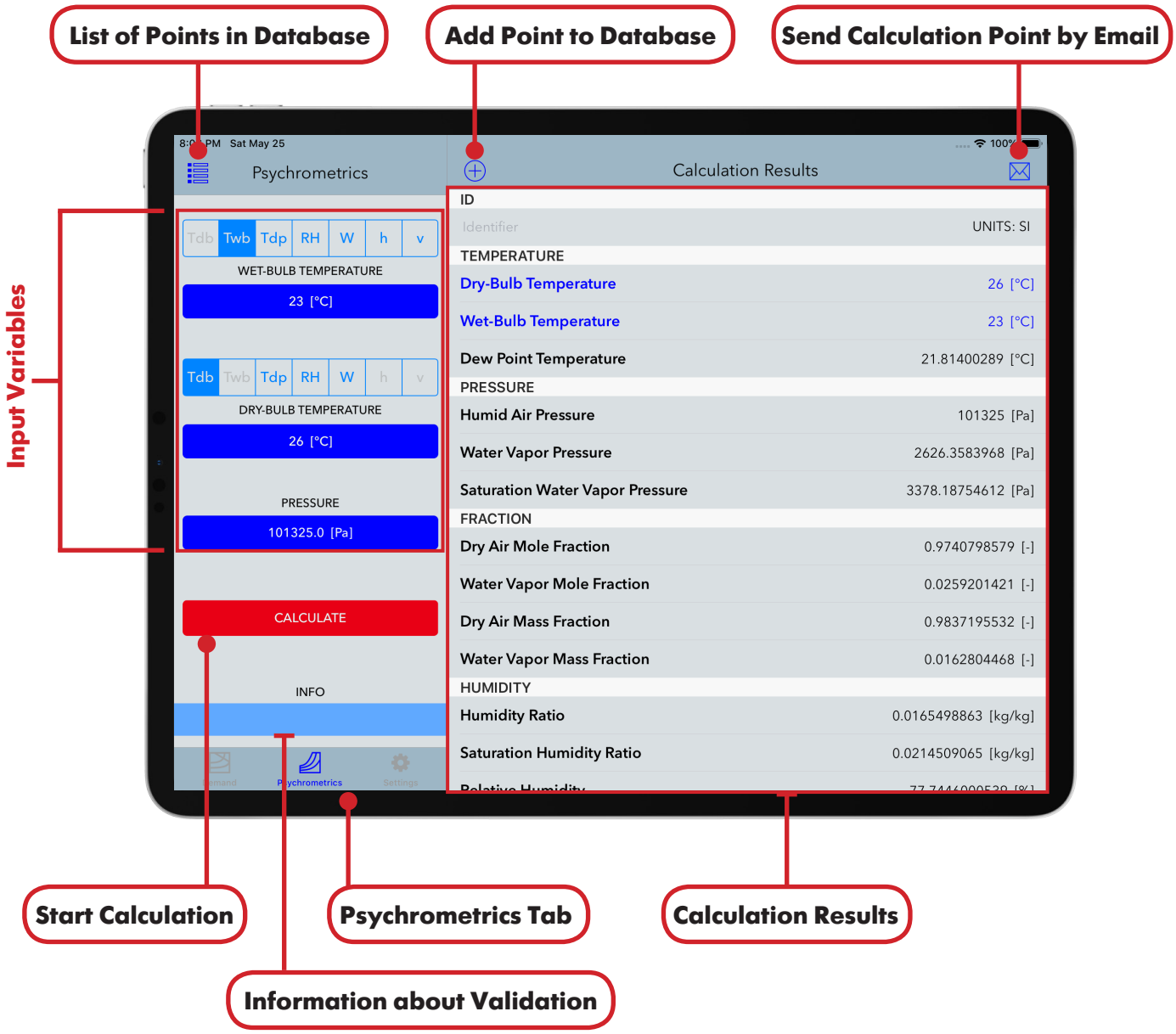

Figure 30. Graphical User interface for the Psychrometrics Calculator.

The output thermodynamic and psychrometric properties calculated with their units:

Result Property	SI Units	I-P Units
Dry-Bub Temperature	°C, K	°F, °R
Wet-Bulb Temperature	°C, K	°F, °R
Dew Point Temperature	°C, K	°F, °R
Humid Air Pressure	Pa, kPa, bar, mmHg	psia, inHg, inH2O, atm
Water Vapor Pressure	Pa, kPa, bar, mmHg	psia, inHg, inH2O, atm
Saturation Water Vapor Pressure	Pa, kPa, bar, mmHg	psia, inHg, inH2O, atm
Dry Air Mole Fraction	[-]	[-]
Water Mole Fraction	[-]	[-]
Dry Air Mass Fraction	[-]	[-]
Water Vapor Mass Fraction	[-]	[-]
Humidity Ratio	kg(w)/kg)(da), g(w)/kg(da)	lb(w)/lb(da), gr(w)/lb(da)
Saturation Humidity Ratio	kg(w)/kg)(da), g(w)/kg(da)	lb(w)/lb(da), gr(w)/lb(da)
Relative Humidity	[%]	[%]
Absolute Humidity	kg(w)/m³	lb(w)/ft³
Parts per million by weight	ppmw	ppmw
Parts per million by volume	ppmv	ppmv
Enhancement Factor	[-]	[-]
Specific Volume of Dry Air	m³/kg	ft³/lb
Specific Volume of Humid Air	m³/kg(da)	ft³/lb(da)
Specific Volume of Saturated Water	m³/kg	ft³/lb
Specific Volume of Saturated Ice	m³/kg	ft³/lb
Specific Volume of Saturated Water Vapor	m³/kg	ft³/lb
Density of Dry Air	kg/m³	lb/ft³
Density of Humid Air	kg/m³	lb/ft³
Density of Saturated Water	kg/m³	lb/ft³
Density of Saturated Ice	kg/m³	lb/ft³
Density of Saturated Water Vapor	kg/m³	lb/ft³
Specific Enthalpy of Dry Air	kJ/kg	Btu/lb
Specific Enthalpy of Humid Air	kJ/kg(da)	Btu/lb(da)
Specific Enthalpy of Saturated Water	kJ/kg	Btu/lb
Specific Enthalpy of Saturatd Ice	kJ/kg	Btu/lb
Specific Enthalpy of Saturated Water Vapor	kJ/kg	Btu/lb
Specific Entropy of Dry Air	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Humid Air	kJ/(kg(da)·K)	Btu/(lb(da)·°R)
Specific Entropy of Saturated Water	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Ice	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Water Vapor	kJ/(kg·K)	Btu/(lb·°R)
Compressibility of Dry Air	[-]	[-]
Compressibility of Humid Air	[-]	[-]
Compressibility of Saturated Water Vapor	[-]	[-]
Specific Isobaric Heat Capacity of Humid Air	kJ/(kg·K)	Btu/(lb·°R)

Table 7. Result Output Variables of Psychrometrics.

The full ranges of input variables for the psychrometrics calculator in the SI and I-P system of units are:

Property		Range in SI Units	SI Units	Range in I-P Units	I-P Units
Dry-bulb Temperature	(Tdb)	-143.15 ≤ Tdb ≤ 350	°C	-225.67 ≤ Tdb ≤ 662.0	°F
Wet-bulb Temperature	(Twb)	-143.15 ≤ Twb ≤ 350	°C	-225.67 ≤ Twb ≤ 662.0	°F
Dew Point Temperature	(Tdp)	-143.15 ≤ Tdp ≤ 350	°C	-225.67 ≤ Tdp ≤ 662.0	°F
Relative Humidity	(RH)	0 ≤ RH ≤ 100.0	[%]	0 ≤ RH ≤ 100.0	[%]
Humidity Ratio	(W)	0 ≤ W ≤ 10.0	kg/kg	0 ≤ W ≤ 10.0	lb/lb
Specific Enthalpy	(h)	-311.357 ≤ h ≤ 32135.848	kJ/kg	-126.174 ≤ h ≤ 13823.61	Btu/lb
Specific Volume	(v)	1.469E-3 ≤ v ≤ 3.055E5	m^3/kg	2.353E-2 ≤ v ≤ 4.893E6	ft^3/lb
Pressure	(P)	10 ≤ P ≤ 10.0E6	Pa	0.00145 ≤ P ≤ 1450.4	psia

Table 8. Full Range of Input Variables of Psychrometrics.

The limited ranges of input variables for the Psychrometrics Calculator are:

Property		Range in SI Units	SI Units	Range in I-P Units	I-P Units
Dry-bulb Temperature	(Tdb)	-143.15 ≤ Tdb ≤ 350	°C	-225.67 ≤ Tdb ≤ 662.0	°F
Wet-bulb Temperature	(Twb)	-143.15 ≤ Twb ≤ 350	°C	-225.67 ≤ Twb ≤ 662.0	°F
Dew Point Temperature	(Tdp)	-143.15 ≤ Tdp ≤ 350	°C	-225.67 ≤ Tdp ≤ 662.0	°F
Relative Humidity	(RH)	0 ≤ RH ≤ 100.0	[%]	0 ≤ RH ≤ 100.0	[%]
Humidity Ratio	(W)	0 ≤ W ≤ 10.0	kg/kg	0 ≤ W ≤ 10.0	lb/lb
Specific Enthalpy	(h)	-311.357 ≤ h ≤ 32135.848	kJ/kg	-126.174 ≤ h ≤ 13823.61	Btu/lb
Specific Volume	(v)	1.469E-3 ≤ v ≤ 3.055E5	m^3/kg	2.353E-2 ≤ v ≤ 4.893E6	ft^3/lb
Pressure	(P)	P = 700000.0	Pa	P =101.52641641	psia

Table 9. Limited Range of Input Variables of Psychrometrics.

Start New Calculation

- Select the system of units and variable units from the **Settings** tab. Input variables and calculation results will be displayed and saved using those units selected.
- Select a combination of variables by tapping on each of the two segmented controls.
- Tap on the button that corresponds to each variable selected to introduce its value.
- Tap on the CALCULATE button to start the calculation.

Notes:

- If the calculation is invalid, the INFO area will display information about the condition that must be met for the calculation can proceed.
- If the calculation is valid, the variables that were used for the combination will be colored blue in the Calculation Results **area.**

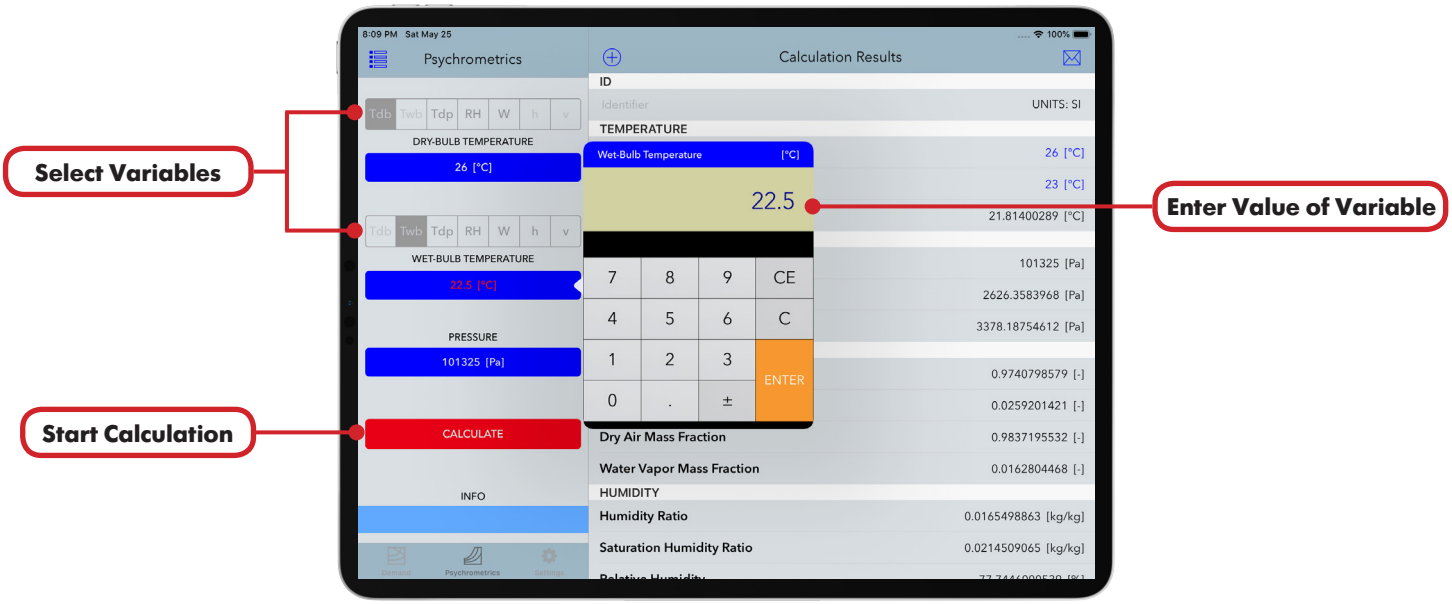

Figure 31. Input variables for a new Psychrometrics Calculation.

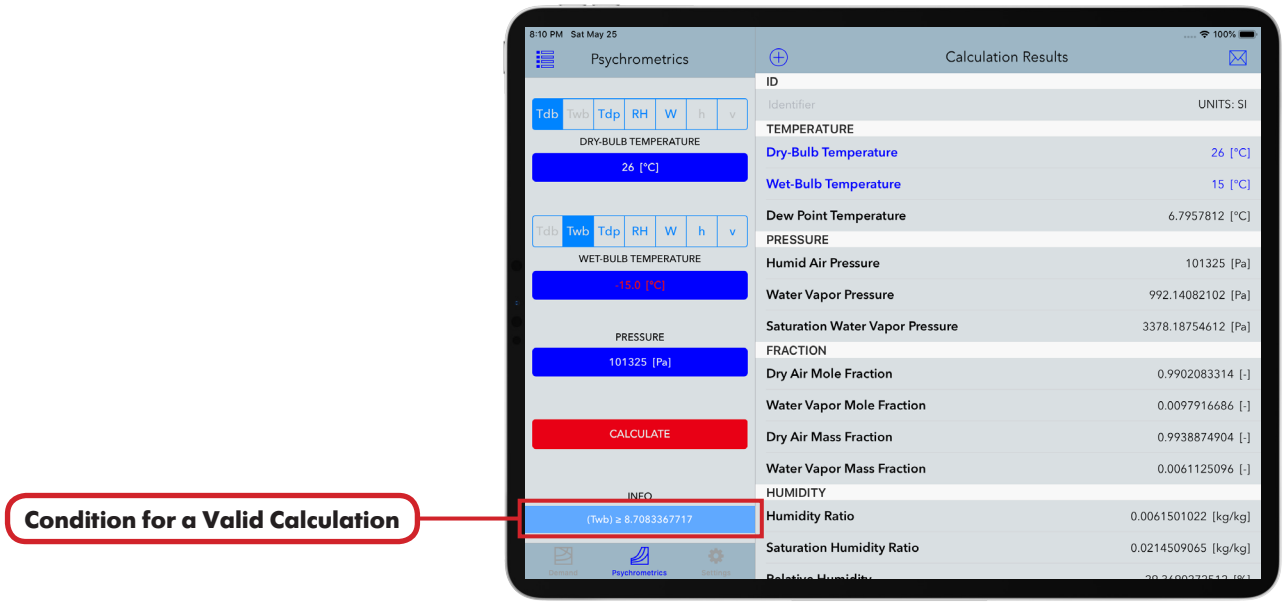

Figure 32. Example of an invalid calculation with the condition for a valid calculation displayed.

Save Points to Database

- Once a calculation has been validate and the results are displayed in the Calculation Results area, enter an identifier in the Calculation Results (optional).
- Tap on the Add Point to Database ⊕ button to add it to the database.

Load Points from Database

- Tap on the Points List ☰ button to show all the point calculations saved to the database.
- Tap on a selected row in the points list to load the calculation previously saved.

Notes:

- Points can be deleted from the database by tapping on the Edit button of the Points List.
- Points can be sent by email by tapping on the Send Results by email ✉ button.

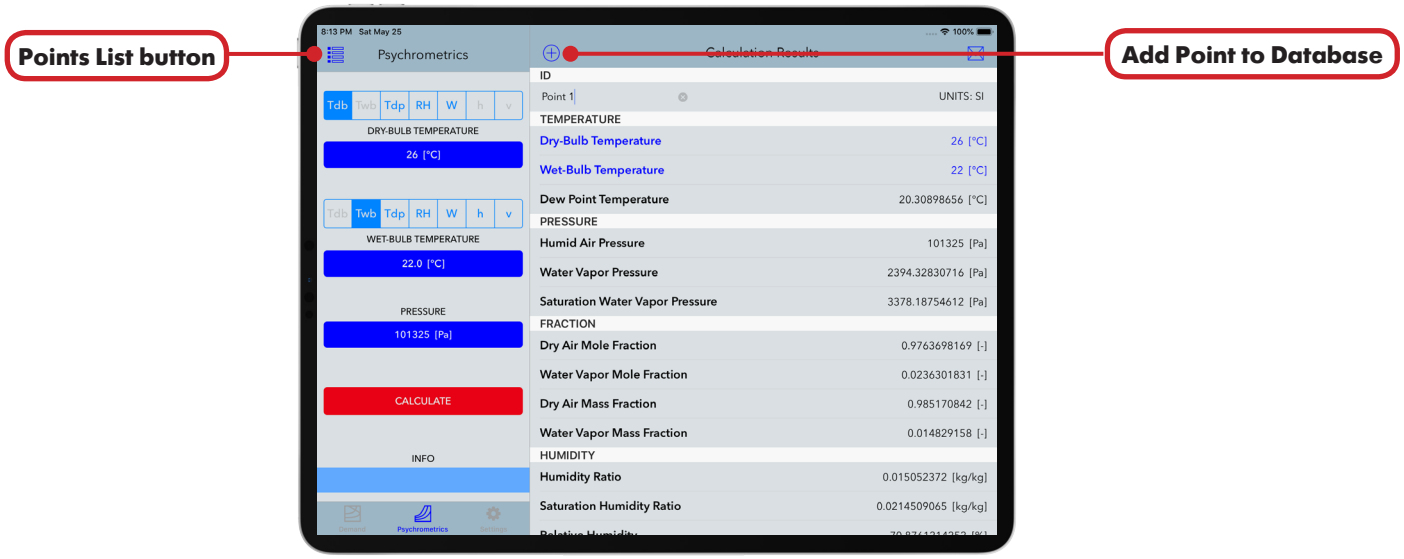

Figure 33. Psychrometrics calculation results being saved to the database.

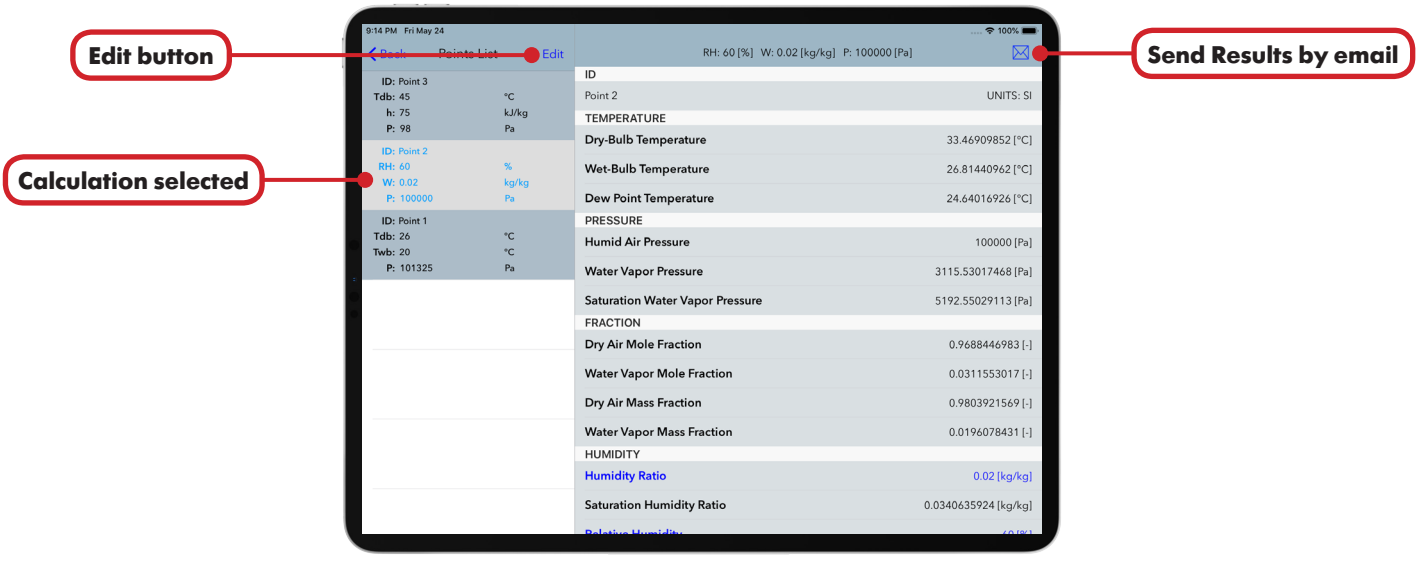

Figure 34. Points list with selected calculation point loaded.

Settings

In order to set the system of units used for calculations across all the applications, as well as the individual units for input properties and results, go to the **Settings** tab and set the desired configuration. Changes to units and results are propagated instantly, and the configuration is preserved among calls to the application.

Previous calculation results in the database are not modified when changes are applied. Table 10 shows an explanation of each of the options offered in **Settings**.

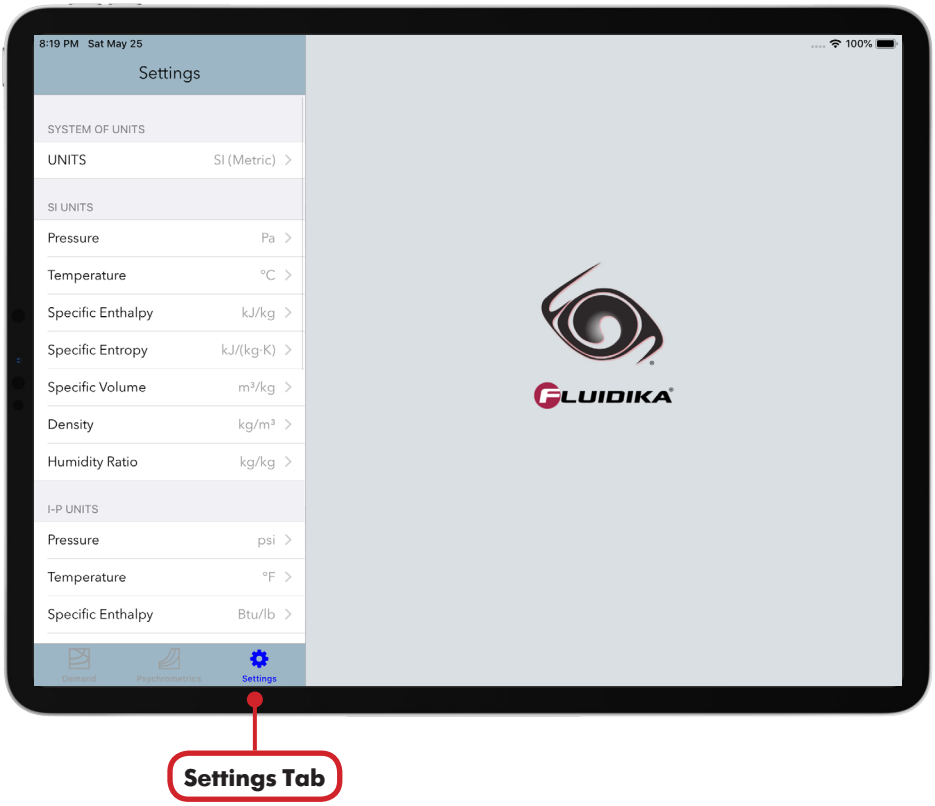

Figure 35. **Settings** tab of Cooling Tower.

Setting Option	Explanation
UNITS	Change the current system of units for all input and result variables across all applications.
Properties (SI or I-P)	Sets the individual units for each particular property in the SI or I-P system of units.
Demand Curves	Sets the approach value of demand curves to be calculated and plotted for Demand Curve projects
Demand Curve on KaV/L	When this switch is ON, a demand curve will be calculated and plotted in a Demand Project when an approach point added is the result of a calculation using the Add Point on KaV/L button.

Table 10. Explanation of the application settings of Cooling Tower.

Purchase / Restore full range of variables

Purchase access to the full range of variables

- In order to access the full range of variables for the application, tap on the **Settings** tab, and then tap on the Purchase full range of variables button. An internet connection and credentials for the iTunes Store are required to complete the transaction.

Restore purchase to access the full range of variables

- Information of your purchase is stored in the iTunes Store if you have previously purchased access to the full range of variables, or a prior version of the application. If you require to reactivate full access once again (when for example, reinstalling the application), tap on the **Settings** tab and then tap on the Restore your purchase button. If the restore transaction is successful, access to the full range of variables will be activated. An internet connection and credentials for the iTunes Store are required to complete the restore transaction.

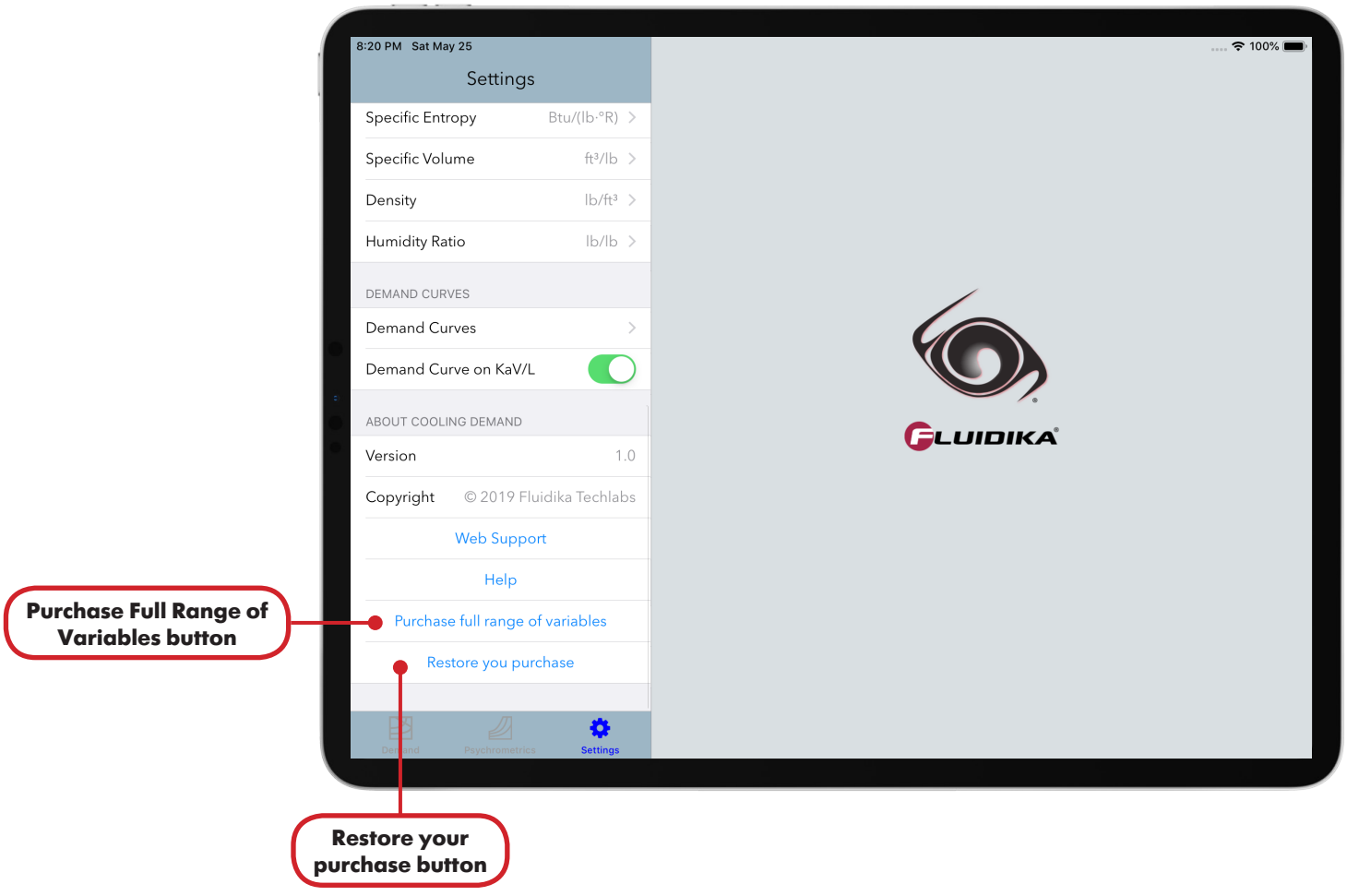

Figure 36 . Purchase full range of variables and Restore your purchase buttons on the **Settings** tab.

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