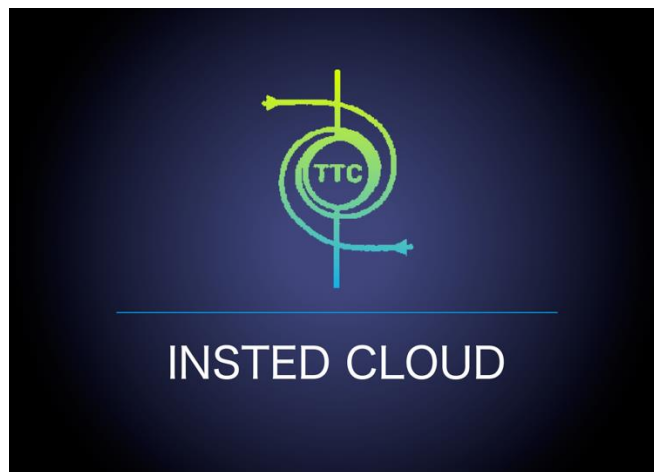


# Release Notes

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INSTED CLOUD Ver. 8.2



**TTC TECHNOLOGIES, INC.**

**August 30, 2016**

## Release Features

### INSTED CLOUD Ver. 8.2

INSTED is your one-stop software suite for empirical thermal and hydraulic analysis of engineering systems and components, with a focus on finned and un-finned heat exchangers, flow over tube banks, performance of isolated fins and fin arrays, analysis of heat conduction in composite solids, internal and external flow and heat transfer, performance analysis of flows in piping systems, design analysis of pipe flows, and power calculations for pump selection. INSTED calculations are very fast, leading to fast turnaround in the analysis cycle. The interface is easy and fun to use. With the CLOUD deployment of INSTED, you can carry out your thermal-hydraulic analysis of heat exchangers and other engineering systems/components anytime, anywhere, and even on your smartphones or tablets.

The most recent version of INSTED (Ver. 8.2) includes significant enhancements, changes, and bug fixes, to further improve your experience on INSTED CLOUD. The new features include the following:

#### *Improved Plate-Fin Solver*

- Advanced “Genetic Algorithm” (GA) has been implemented for the sizing and optimization modules, which greatly improves the calculation speed and provides more accurate results.
- Instead of returning only one design realization as in the previous version of INSTED, the plate-fin sizing calculation now provides you with a list of feasible design realizations.
- The Optimization solver now allows the fin geometries (shape, profile, fin height, and fin pitch) to be design variables when searching for optimum design.
- More objective functions and design constraints are now available for the Plate-Fin optimization task.
- Additional inputs (end plate thickness, side bar width, and height) are now allowed as part of the Plate-Fin HEX geometry.
- Additional outputs (coefficient of performance, mean stream temperature, mean fluid density, mean fluid specific heat, etc.) are now provided during Plate-Fin Rating, Multiple-Rating, Sizing, and Optimization analyses.

#### *New Features in Plate-Fin*

- In “Preference”, you can now “Turn Off” and “Turn On” the automatic unit conversion feature for all the input textboxes.
- In the previous version of INSTED, you could choose the default unit system in “Preference” to either “SI” or “British.” In this new version, an option “Custom” has been added to allow you to specify the default units for each kind of variable (temperature, length, power, etc.)
- In addition to the “ALPEMA sheet”, a new downloadable Excel file is now available for you to export more output data from Plate-Fin Rating, Multiple-Rating, and Sizing and Optimization realizations.
- Both the ALPEMA sheet and the downloadable Excel file can be generated for different unit systems (SI/British/Custom).
- You now have the option of showing the data for only one stream or for both streams when plotting the rating results.

- You now have the option of reversing the plotting direction for the data in one stream when plotting the rating results. This is especially useful for the parallel counter-flow case, where you may want to compare the hot/cold flow curves point-by-point.
- In “Preference,” you now have the option of specifying the precision and format of the output.

More details on the release features can be found in the following sections.

## New Features

Many new features have been added to INSTED in this new version.

### #1. New Plate-Fin Sizing Solver and Re-Designed Interface

- (1) A new, more powerful Plate-Fin Sizing solver based on the Genetic Algorithm (GA) has been deployed. The new solver comes with a huge performance boost (faster calculation) and is more stable and robust compared with the previous version.
- (2) The following new Plate-Fin “Sizing Criteria” have been added:
  - a. Fix or unfix the total number of plates
  - b. Fix or unfix the fin height/pitch
  - c. Fix the overall effectiveness to a value
  - d. Fix the overall coefficient of performance (COP) to a value

The screenshot shows the 'Plate-Fin: Sizing' interface. It includes a 3D model of a plate-fin heat exchanger with 'Fluid A' and 'Fluid B' flows. The interface is organized into sections: I. Project Name, II. Choose a Reference Rating Project, III. Design Target, IV. Sizing Criteria, and V. Design Parameters. A table titled 'Difference between sizing and rating' compares 'Rating' and 'Sizing' inputs and outputs. Red boxes highlight new sizing criteria in section IV, and a red arrow points to the text 'New sizing criteria'.

	Rating	Sizing
<b>Inputs</b>	Plate Length Plate Width No. of Plates No. of Flow Pass (Hot) No. of Flow Pass (Cold) Mass Flow Rate (Hot) Mass Flow Rate (Cold) Fin Shape/Profile (Hot) Fin Shape/Profile (Cold) Fin Height/Pitch (Hot) Fin Height/Pitch (Cold)	Target Heat Transfer Rate
<b>Outputs</b>	Heat Transfer Rate	Plate Length Plate Width No. of Plates No. of Flow Pass (Hot) No. of Flow Pass (Cold) Mass Flow Rate (Hot) Mass Flow Rate (Cold) Fin Shape/Profile (Hot) Fin Shape/Profile (Cold) Fin Height/Pitch (Hot) Fin Height/Pitch (Cold)

*! If not fixed for sizing calculation.*

- (3) In the previous version of INSTED, sizing results only showed one design realization. Similar to optimization, sizing results now display a list of feasible design realizations. Some of the parameters from the results of sizing are shown for each realization.

Start Page x Plate-Fin: Sizing x **Plate-Fin: Sizing Result** x

Choose One Realization for Rating:

No.	Plates	$N_{p,hot}$	$N_{p,cold}$	L in	W in	$M_{hot}$ lb/s	$M_{cold}$ lb/s	$\Delta P_{hot}$ psi	$\Delta P_{cold}$ psi		
<input type="radio"/>	1	952	2	2	41.010628307	144.077660709	53.50094801	45.311861921	4.4029786	4.204500927	1
<input type="radio"/>	2	880	2	2	55.431298268	158.556630079	42.81759734	54.049252559	4.160612157	4.363647361	1
<input type="radio"/>	3	912	2	2	60.007544449	145.500297362	41.485190428	69.61434695	4.62982441	4.765781722	1
<input type="radio"/>	4	864	2	2	73.494174685	167.835580039	41.607610666	70.998387191	4.989606113	4.67136593	1
<input type="radio"/>	5	888	2	2	73.494174685	167.835580039	41.607610666	70.998387191	4.790505296	4.512925046	1
<input type="radio"/>	6	910	2	2	73.908308976	165.470632008	41.956567938	73.457240579	4.81939857	4.484091075	1
<input type="radio"/>	7	912	2	2	73.908308976	165.470632008	41.956567938	73.457240579	4.78802151	4.459336447	1
<input type="radio"/>	8	912	2	2	73.494174685	167.835580039	41.607610666	70.998387191	4.604395325	4.363875842	1
<input type="radio"/>	9	936	2	2	60.919692165	217.531111614	44.153045079	47.406955307	2.73007965	4.167521389	1
<input type="radio"/>	10	912	2	2	80.984238189	177.934929961	42.367251056	57.430565556	4.777989277	3.134441591	1
<input type="radio"/>	11	926	2	2	67.683026575	214.64760185	57.221413599	43.72744434	4.633300894	3.30692843	1

Rate Selected Realization      Back to the Project

Note that you can click the link-buttons in the “Fin<sub>hot</sub>” and “Fin<sub>cold</sub>” columns to view the details of the fin geometry in a realization.

Q	A	Weight	$\epsilon$	COP	Fin <sub>hot</sub>	Fin <sub>cold</sub>
Btu/h	m <sup>2</sup>	kg				
35	1.082137e+7	5.794836e+6	9700.521359594	0.974179612	2.34311861	rectangular/herringbone    rectangular/offset-strip
36	1.092846e+7	6.490619e+6	10865.257806543	0.980432836	2.517564988	rectangular/herringbone    rectangular/offset-strip
34	1.096846e+7	6.67357e+6	11171.515896817	0.957339944	2.364477016	rectangular/herringbone    rectangular/offset-strip
35	1.093873e+7	7.041709e+6	11787.779695776	0.981353902	2.83668133	rectangular/herringbone    rectangular/offset-strip
36	1.098639e+7	7.220583e+6	12087.213921147	0.958904876	2.65682603	rectangular/herringbone    rectangular/offset-strip
39	1.111576e+7	7.334074e+6	12277.196703331	0.966957432	2.492038543	rectangular/herringbone    rectangular/offset-strip
38	1.079485e+7	7.467511e+6	12500.569272916	0.986005005	2.607457087	rectangular/herringbone    rectangular/offset-strip
37	1.094739e+7	7.562183e+6	12659.050368942	0.982130629	3.148480834	rectangular/herringbone    rectangular/offset-strip
34	1.100153e+7	7.73113e+6	12941.86541052	0.960225896	2.939054223	rectangular/herringbone    rectangular/offset-strip
33	1.079871e+7	7.943878e+6	13298.003985129	0.969714079	2.886907228	rectangular/herringbone    rectangular/offset-strip
78	1.070205e+7	8.282991e+6	13865.678453262	0.992038319	2.392019775	rectangular/herringbone    rectangular/offset-strip

Fin Details

Realization #3, hot fin:

- Fin Shape: rectangular
- Fin Profile: herringbone
- Fin Height: 0.224409449 in
- Hot Fin Pitch: 0.078740157 in
- Fin Thickness: 0.005905512 in
- Hot Fin Wavelength: 0.1 in
- Fin Wave Amplitude: 0.02 in

(4) You can choose one realization and click the “Rate Selected Realization” button to view the details of this realization.

### Sizing Result:

Plate Length:	86.390634016	in
Plate Width:	267.10869122	in
Hot Flow Rate:	42.524334845	lb/s
Cold Flow Rate:	56.637630763	lb/s
Total No. of Plates:	778	
No. of Hot Passes:	2	
No. of Cold Passes:	2	
Hot Fin Shape:	rectangular	
Hot Fin Profile:	herringbone	
Hot Fin Efficiency:	0.673977058	
Hot Fin Height:	0.224409449	in
Hot Fin Pitch:	0.078740157	in
Hot Fin Thickness:	0.005905512	in
Hot Fin Wavelength:	0.1	in
Hot Fin Wave Amplitude:	0.02	in
Cold Fin Shape:	rectangular	
Cold Fin Profile:	offset-strip	
Cold Fin Efficiency:	0.633649816	
Cold Fin Height:	0.224409449	in
Cold Fin Pitch:	0.078740157	in
Cold Fin Thickness:	0.005905512	in
Cold Fin Offset Pitch:	0.03	in
Heat Transfer Rate:	1.091279e+7	Btu/h
Heat Transfer Area:	8.953367e+6	in <sup>2</sup>
Hot Pressure Loss:	3.56482239	psi
Cold Pressure Loss:	5.220433667	psi
Operating Weight:	14987.884011391	lb
Effectiveness:	0.977641181	
COP:	2.994004898	

Save to a Regular Rating Project

### Detail Result:

Hot Flow

Cold Flow

Overall

Inlet Temperature:	860.017999931	°F
Outlet Temperature:	576.302956537	°F
Pressure Loss:	1.279794668	psi
Mass Flow Rate:	47.432502282	lb/s
Mass Flux:	0.583164922	lb/(s·ft <sup>2</sup> )
Flow Velocity:	17.298900066	ft/s
Fouling Resistance:	0.	ft <sup>2</sup> ·s·°F/btu
Equivalent Diameter:	0.109251969	in
Reynolds Number:	246.910876643	
Heat Coefficient:	39.009512094	btu/(h·ft <sup>2</sup> ·°F)
Effective hA:	7398.971823643	btu/(h·°F)
Colburn Factor j:	0.056665018	
Friction Factor f:	0.305221458	
Fin Shape:	rectangular	
Fin Profile:	herringbone	
Fin Efficiency:	0.673977058	
Fin Height:	0.0057	m
Fin Pitch:	0.078740157	in
Fin Thickness:	0.005905512	in
Fin Wavelength:	0.1	in
Fin Wave Amplitude:	0.02	in
Flow Length:	86.390634016	in
Flow Width:	133.554345591	in
Power:	1.075464e+6	Btu/h
Mean Temperature:	718.160478233	°F
Mean Density:	0.033711099	lb/ft <sup>3</sup>
Mean Specific Heat:	0.25317665	Btu/(lb·°F)
Mean Viscosity:	2.150301e-5	lb/(ft·s)
Mean Conductivity:	0.028889466	btu/(h·ft·°F)
Mean Heat Capacity:	43231.687401343	btu/(h·°F)
Mean Prandtl Number:	0.6784	
Mean Nusselt Number:	12.293894548	
Free Flow Area:	10500.467239134	in <sup>2</sup>

Download Realization Data

## #2. New Plate-Fin Optimization Solver and Re-Designed Interface

- (1) The new GA- based optimization module in INSTED shows a huge performance boost (faster calculation); it is more stable and robust compared to the previous version of the solver.
- (2) New “Objective Functions” have been added:
  - a. Minimum heat transfer area
  - b. Minimum number of plates
  - c. Maximum effectiveness
  - d. Maximum COP
- (3) Fin geometry/size is now allowed to be a design variable of the optimization task. The following are design variables in the search for an optimum solution:
  - a. Plate height
  - b. Plate width
  - c. Total number of plates
  - d. Number of flow passes (hot & cold)
  - e. Mass flow rate (hot & cold)
  - f. Fin shape (frontal) (hot & cold)
  - g. Fin profile (flow direction) (hot & cold)
  - h. Fin height/pitch (hot & cold)
- (4) The following new Plate-Fin “Optimization Constraints” have been added:
  - a. Fix or unfix the total number of plates
  - b. Fix or unfix the fin height/pitch
  - c. Fix or unfix the fin shape
  - d. Fix or unfix the fin profile
  - e. Fix the overall effectiveness to a value
  - f. Fix the overall coefficient of performance (COP) to a value

***Note that, during the optimization process, the overall heat transfer rate is implicitly fixed to the value of the reference project.***

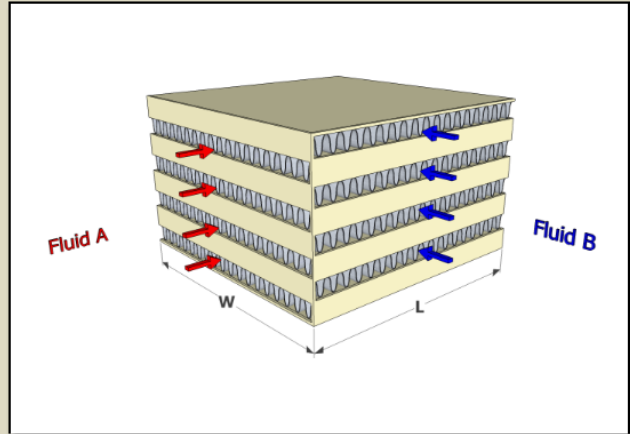
I. Project Name:

II. Choose a Reference Rating Project:

Please choose

[View Details](#)

*Single phase calculation only*



III. Optimization Objective:

- Minimum Pressure Loss?
  - Minimum Heat Transfer Area?
  - Minimum Overall Weight?
  - Minimum No. of Plates?
  - Minimum Power?
  - Maximum Effectiveness?
  - Maximum COP?
- New optimization objectives

IV. Optimization Constraints:

- Fix Plate Length?
  - Fix Plate Width?
  - Fix Hot Flow Rate?
  - Fix Cold Flow Rate?
  - Fix No. of Flow Passes?
  - Fix No. of Plates?
  - Fix Entire Hot Fin Selection?
    - Fix Hot Fin Height & Pitch?
    - Fix Hot Fin Shape (Frontal)?
    - Fix Hot Fin Profile (Flow Dir.)?
  - Fix Entire Cold Fin Selection?
    - Fix Cold Fin Height & Pitch?
    - Fix Cold Fin Shape (Frontal)?
    - Fix Cold Fin Profile (Flow Dir.)?
  - Fix Overall Effectiveness?
    - Fix to the Reference Project Value
    - Fix to a Specific Value
  - Fix Overall COP?
    - Fix to the Reference Project Value
    - Fix to a Specific Value
- New optimization constraints

V. Design Parameters:

[Set Design Parameters](#)

Note:

Outputs	
	Plate Length/Width
	No. of Plates
	No. of Flow Pass (Hot & Cold)
	Mass Flow Rate (Hot & Cold)
	Fin Shape/Profile (Hot & Cold)
	Fin Height/Pitch (Hot & Cold)

*During the optimization process, the overall heat transfer rate is implicitly fixed to the value of the reference project.*



- (5) When the calculations have been completed, a list of feasible design realizations is displayed. Note that the list is sorted consistent with the objective functions, with the “best” being on top of the list.

Choose One Realization for Rating:

	Plates	$N_{p,hot}$	$N_{p,cold}$	L in	W in	$M_{hot}$ lb/s	$M_{cold}$ lb/s	$\Delta P_{hot}$ psi	$\Delta P_{cold}$ psi
<input checked="" type="radio"/> 1 <b>best</b>	300	1	1	35.433070866	70.866141732	55.997414595	55.115565546	4.947965659	2.928374806
<input type="radio"/> 2	300	1	1	35.433070866	70.866141732	44.745083108	117.795160556	1.230086033	2.239712926
<input type="radio"/> 3	300	1	1	35.433070866	70.866141732	134.841759406	44.920528161	5.04324024	0.454661314
<input type="radio"/> 4	300	1	1	35.433070866	70.866141732	56.530033294	62.748596201	0.64162514	1.003774558
<input type="radio"/> 5	300	1	1	35.433070866	70.866141732	48.248281566	94.583077482	0.610361269	1.692361464
<input type="radio"/> 6	300	1	1	35.433070866	70.866141732	116.245603536	44.890449013	4.166432636	0.454183812
<input type="radio"/> 7	300	1	1	35.433070866	70.866141732	79.648883097	48.285119719	1.759718556	0.719716006
<input type="radio"/> 8	300	1	1	35.433070866	70.866141732	106.706440415	46.701473347	2.792845367	0.4832574
<input type="radio"/> 9	300	1	1	35.433070866	70.866141732	48.650016624	87.726135512	0.612668187	1.300464599
<input type="radio"/> 10	300	1	1	35.433070866	70.866141732	110.411047752	46.434287684	2.94765836	0.478926869
<input type="radio"/> 11	300	1	1	35.433070866	70.866141732	78.812274935	50.085327542	1.73063635	0.753928192

- (5) You can choose one realization and click the “Rate Selected Realization” button to view details of this design realization and carry out a rating analysis on it.

Optimization Result:

Plate Length:	35.433070866	in ▼
Plate Width:	70.866141732	in ▼
Hot Flow Rate:	55.997414595	lb/s ▼
Cold Flow Rate:	55.115565546	lb/s ▼
Total No. of Plates:	300	
No. of Hot Passes:	1	
No. of Cold Passes:	1	
Hot Fin Shape:	wavy	
Hot Fin Profile:	herringbone	
Hot Fin Height:	0.224409449	in ▼
Hot Fin Pitch:	0.078740157	in ▼
Hot Fin Thickness:	0.005905512	in ▼
Hot Fin Wavelength:	0.393700787	in ▼
Hot Fin Wave Amplitude:	0.118110236	in ▼
Cold Fin Shape:	rectangular	
Cold Fin Profile:	herringbone	
Cold Fin Height:	0.224409449	in ▼
Cold Fin Pitch:	0.078740157	in ▼
Cold Fin Thickness:	0.005905512	in ▼
Cold Fin Wavelength:	0.393700787	in ▼
Cold Fin Wave Amplitude:	0.118110236	in ▼
Heat Transfer Rate:	1.138654e+7	Btu/h ▼
Heat Transfer Area:	7.533015e+5	in <sup>2</sup> ▼
Hot Pressure Loss:	4.947965659	psi ▼
Cold Pressure Loss:	2.928374806	psi ▼
Operating Weight:	2522.04452149	lb ▼
Effectiveness:	0.787043952	
COP:	1.953180058	

Save to a Regular Rating Project

Detail Result:

Hot Flow	Cold Flow	Overall
Inlet Temperature:	860.017999931	°F ▼
Outlet Temperature:	636.918926878	°F ▼
Pressure Loss:	4.947965659	psi ▼
Mass Flow Rate:	55.997414595	lb/s ▼
Mass Flux:	3.753180203	lb/(s·ft <sup>2</sup> ) ▼
Flow Velocity:	111.333666158	ft/s ▼
Fouling Resistance:	0.	ft <sup>2</sup> ·s·°F/btu ▼
Equivalent Diameter:	0.108133307	in ▼
Reynolds Number:	1572.817586642	
Heat Coefficient:	44.628140027	btu/(h·ft <sup>2</sup> ·°F) ▼
Effective hA:	300.32110984	btu/(h·°F) ▼
Colburn Factor j:	0.010072686	
Friction Factor f:	0.054714403	
Fin Shape:	wavy	
Fin Profile:	herringbone	
Fin Efficiency:	0.651966141	
Fin Height:	0.224409449	in ▼
Fin Pitch:	0.078740157	in ▼
Fin Thickness:	0.005905512	in ▼
Fin Wavelength:	0.393700787	in ▼
Fin Wave Amplitude:	0.118110236	in ▼
Flow Length:	35.433070866	in ▼
Flow Width:	70.866141732	in ▼
Power:	5.475361e+6	Btu/h ▼
Mean Temperature:	748.468463405	°F ▼
Mean Density:	0.033711099	lb/ft <sup>3</sup> ▼
Mean Specific Heat:	0.25317665	Btu/(lb·°F) ▼
Mean Viscosity:	2.150301e-5	lb/(ft·s) ▼
Mean Conductivity:	0.028889466	btu/(h·ft·°F) ▼
Mean Heat Capacity:	51038.056238956	btu/(h·°F) ▼
Mean Prandtl Number:	0.678400083	
Mean Nusselt Number:	13.920598805	
Free Flow Area:	2148.478671957	in <sup>2</sup> ▼

Download Realization Data

### #3. Turn On/Off Automatic Unit Conversion

In the “Preference” tab, you now have the option of turning On/Off the Automatic Unit Conversion feature when entering values in INSTED.

The screenshot shows the 'Preferences' dialog box with the following settings:

- User Preferences:**
  - Units:**
    - Choose default unit system: Customized (dropdown) [Customize Preferred Units button]
    - Automatic input unit conversion: Off (dropdown)
  - Format Numbers:**
    - The exponent value, beneath which scientific notation occurs: 3 (dropdown)
    - The exponent value, above which scientific notation occurs: 5 (dropdown)
    - Maximum number of digits for scientific notation: 7 (dropdown)
    - Maximum number of digits for non-scientific notation: 9 (dropdown)
    - [Default Formatting button]

Buttons at the bottom: Save, Close.

#### When automatic unit conversion is on

$L = 1.0 \text{ m}$  →  $L = 39.37007874 \text{ in}$

#### When automatic unit conversion is off

$L = 1.0 \text{ m}$  →  $L = 1.0 \text{ in}$

## #4. Customizable Preferred Units


In the “Preference” tab, in addition to allowing the use of “SI” or “British” as the default unit system, you can now choose “Customized” as a new option. Click “Customize Preferred Units” to specify the preferred units for each type of variable.

**User Preferences:**

Units:

Choose default unit system: Customized ▾ Customize Preferred Units

Automatic input unit conversion: Off ▾




Start Page x Preferences x Preferred Units x

**Please set preferred units:**

**Preferred Units**

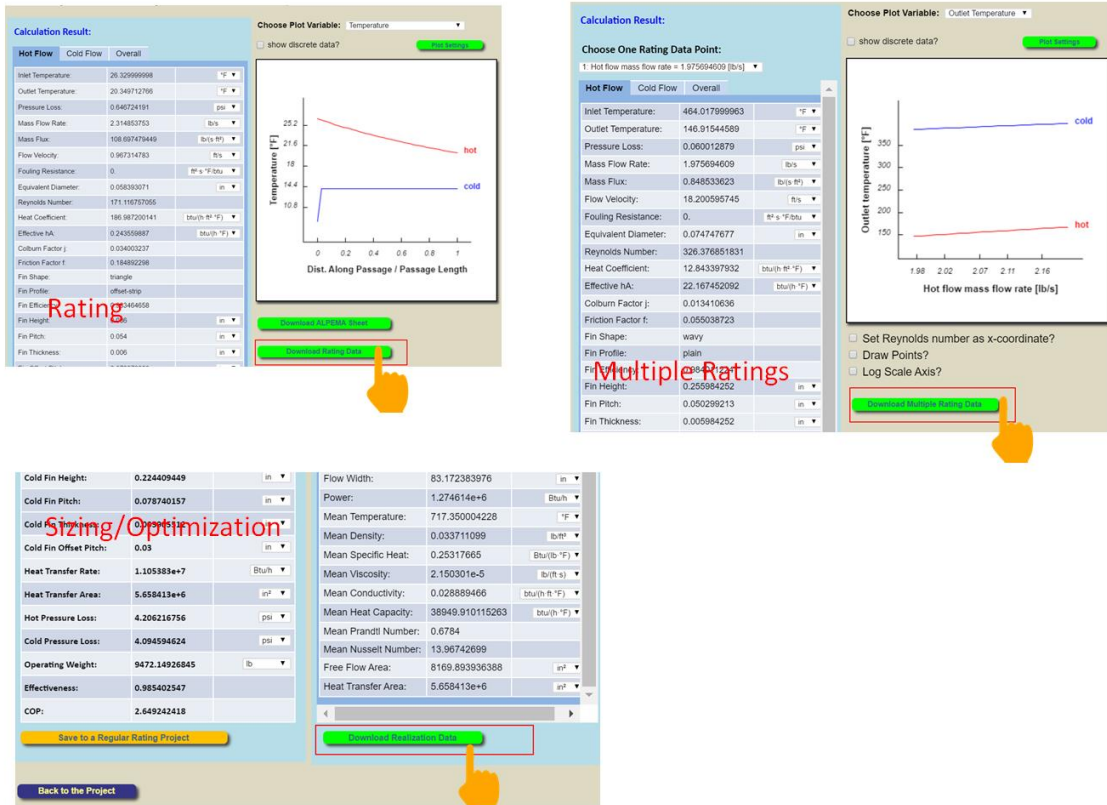
Area:	inch <sup>2</sup> ▾
Density:	lb/ft <sup>3</sup> ▾
Dynamic Viscosity:	lb/(ft·h) ▾
Effective hA, Heat Capacity:	btu/(h·°F) ▾
Energy:	lbf·in ▾
Energy Flux:	btu/(h·ft <sup>2</sup> ) ▾
Enthalpy, Specific Energy, Heat of Vaporization:	lbf·ft/lb ▾
Fouling Factor:	ft <sup>2</sup> ·s·°F/btu ▾
Heat Transfer (Film) Coefficient:	btu/(h·ft <sup>2</sup> ·°F) ▾
Length:	in ▾
Mass Flowrate:	lb/h ▾
Mass Flux:	lb/(h·ft <sup>2</sup> ) ▾
Power:	J/s ▾
Pressure:	atm ▾
Specific Heat, Entropy, Gas Constant:	Btu/(lb·°F) ▾
Surface Tension:	lbf/in ▾
Temperature:	°R ▾
Thermal Conductivity:	cal/(s·cm·°C) ▾
Thermal Expansion Coefficient:	1/°R ▾
Thermal Diffusivity, Kinetic Viscosity:	in <sup>2</sup> /s ▾
Thermal Resistance:	°F·s/btu ▾
Velocity:	mi/h ▾
Volume Flow Rate:	in <sup>3</sup> /h ▾
Fin Density, Wave Number:	1/ft ▾
Weight (Mass):	kgf·s <sup>2</sup> /m ▾

[Go Back](#)

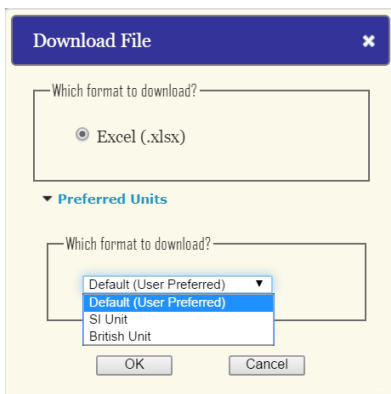
## #5. Export Rating/Multiple-Rating/Sizing/Optimization Data into Excel

Selected Plate-Fin Rating, Multiple-Rating, and Sizing and Optimization realization data can now be exported into an Excel file by clicking

- “Download Rating Data” in Plate-Fin rating
- “Download Multiple Rating Data” in Plate-Fin multiple-ratings
- “Download Realization Data” in Plate-Fin sizing and optimization



After these buttons have been clicked, a new window will pop-up in which you can choose the units you prefer when exporting data to Excel.



Excel file for plate-fin rating:

INSTED Output for HX Sizing and Rating Simulations- Last Rev. [08/29/2016]																
Design #	Description (for example, flow arrangement, multipassing, single/two phase flow etc.)	Performance Requirement			Operating conditions -Hot			Operating conditions -Cold			HX core design input					
		Q	Δp-hot	Δp-cold	Fluid type	Flow rate	Tin	Pin	Fluid type	Flow rate	Tin	Pin	t-sp			
		[kW]	[kPa]	[kPa]	[-]	[lb/s]	[°F]	[psi]	[-]	[lb/s]	[°F]	[psi]	[in]			
1	cross-flow/counter-current, single banking, 2 hot flow passes, 4 cold flow passes, Boiling					2.31485	26.33	14.5038	(Sample) R1	0.04409	8.33	29.008	0.016			

HX core design input																
HX core dimensions							Hot side									
P-L	P-W	L-NF/S	Np-h	Np-c	W	Type	N-fin or channel	H	t-fin	l or λ	Za	dh	Ac	A	Type	
[in]	[in]	[in]	[-]	[-]	[lb]	[-]	[1/in]	[in]	[in]	[in]	[in]	[in]	[in <sup>2</sup> ]	[in <sup>2</sup> ]	[-]	
2.25	9	2.056	11	10	0.4028	triangle/offset-strip	18.519	0.086	0.006	0.0781		0.0584	3.0667	194.06	triangle/offset	

HX Size, Weight and Performance- Output																							
Cold side							Hot Side																
A	Type	N-fin or channel	H	t	l or λ	Za	dh	Ac	A	Tout	Tmean	Δp	αΔP	P <sub>mean</sub>	μ <sub>mean</sub>	C <sub>p,mean</sub>	K <sub>mean</sub>	Re	Pr	Nu	ηhA	P	Tou
[in <sup>2</sup> ]	[-]	[1/in]	[in]	[in]	[in]	[in]	[in]	[in <sup>2</sup> ]	[in <sup>2</sup> ]	[°F]	[°F]	[psi]	[kPa]	[lb/ft <sup>2</sup> ]	[lb/(ft <sup>3</sup> ·s)]	[btu/(h <sup>2</sup> ·ft <sup>2</sup> ·°F)]	[lb/ft <sup>2</sup> ·°F]	[-]	[-]	[-]	[btu/(h <sup>2</sup> ·°F)]	[Btu/h]	[°F]
194.06	triangle/offset-strip	18.519	0.086	0.006	0.0781		0.0584	0.2889	146.25	20.35	23.074	0.6467		112.37	0.0031	0.2102	0.0404	171.12	57.829	22.498	0.2436	8.8753	14.0

HX Size, Weight and Performance- Output																								
Hot Side							Cold Side																	
A	Tout	Tmean	Δp	αΔP	P <sub>mean</sub>	μ <sub>mean</sub>	C <sub>p,mean</sub>	K <sub>mean</sub>	Re	Pr	Nu	ηhA	P	Tout	Tmean	Δp	αΔP	P <sub>mean</sub>	μ <sub>mean</sub>	C <sub>p,mean</sub>	K <sub>mean</sub>	Re	Pr	Nu
[in <sup>2</sup> ]	[°F]	[°F]	[psi]	[kPa]	[lb/ft <sup>2</sup> ]	[lb/(ft <sup>3</sup> ·s)]	[btu/(h <sup>2</sup> ·ft <sup>2</sup> ·°F)]	[-]	[-]	[-]	[-]	[btu/(h <sup>2</sup> ·°F)]	[Btu/h]	[°F]	[°F]	[psi]	[kPa]	[lb/ft <sup>2</sup> ]	[lb/(ft <sup>3</sup> ·s)]	[btu/(h <sup>2</sup> ·ft <sup>2</sup> ·°F)]	[-]	[-]	[-]	
146.25	20.35	23.074	0.6467		112.37	0.0031	0.2102	0.0404	171.12	57.829	22.498	0.2436	8.8753	14.018	13.901	5.1807		14.52308	0.0001	0.2629	0.0327	556.37	3.2571	384.5

Overall HX core performance									
Nu	ηhA	P	EB	C*	ε	Q	NTU	UA	COP
[-]	[btu/(h <sup>2</sup> ·°F)]	[Btu/h]	[%]	[-]	[-]	[Btu/h]	[-]	[btu/(h <sup>2</sup> ·°F)]	[-]
384.51	0.2441	550.1		0.0238	0.7126	10469	33.849	1196.7	18.7288

Excel file for plate-fin Multiple-Rating:

Design #	Description (for example, flow arrangement, multipassing, single/two)	Performance Requirement			Operating conditions -Hot			Operating conditions -Cold			HX core design input						
		Q	Δp-hot	Δp-cold	Fluid type	Flow rate	Tin	Pin	Fluid type	Flow rate	Tin	Pin	t-sp	t-ep	w-sb-hot	h-sb-hot	w-sb-cold
		[kW]	[kPa]	[kPa]	[-]	[lb/s]	[°F]	[psi]	[-]	[lb/s]	[°F]	[psi]	[in]	[in]	[in]	[in]	[in]
#1: Hot flow mass flow rate = 1.975694609 [lb/s]	cross-flow, single banking				1.97569	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#2: Hot flow mass flow rate = 1.9867177221 [lb/s]	cross-flow, single banking				1.98672	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#3: Hot flow mass flow rate = 1.9977408352 [lb/s]	cross-flow, single banking				1.99774	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#4: Hot flow mass flow rate = 2.0087639483 [lb/s]	cross-flow, single banking				2.00876	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#5: Hot flow mass flow rate = 2.0197870614 [lb/s]	cross-flow, single banking				2.01979	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#6: Hot flow mass flow rate = 2.0308101745 [lb/s]	cross-flow, single banking				2.03081	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#7: Hot flow mass flow rate = 2.0418332876 [lb/s]	cross-flow, single banking				2.04183	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#8: Hot flow mass flow rate = 2.0528564007 [lb/s]	cross-flow, single banking				2.05286	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#9: Hot flow mass flow rate = 2.0638795138 [lb/s]	cross-flow, single banking				2.06388	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#10: Hot flow mass flow rate = 2.0749026269 [lb/s]	cross-flow, single banking				2.0749	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#11: Hot flow mass flow rate = 2.08592574 [lb/s]	cross-flow, single banking				2.08593	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#12: Hot flow mass flow rate = 2.0969488531 [lb/s]	cross-flow, single banking				2.09695	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#13: Hot flow mass flow rate = 2.1079719662 [lb/s]	cross-flow, single banking				2.10797	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#14: Hot flow mass flow rate = 2.1189950793 [lb/s]	cross-flow, single banking				2.119	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#15: Hot flow mass flow rate = 2.1300181924 [lb/s]	cross-flow, single banking				2.13002	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#16: Hot flow mass flow rate = 2.1410413055 [lb/s]	cross-flow, single banking				2.14104	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#17: Hot flow mass flow rate = 2.1520644186 [lb/s]	cross-flow, single banking				2.15206	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#18: Hot flow mass flow rate = 2.1630875317 [lb/s]	cross-flow, single banking				2.16309	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#19: Hot flow mass flow rate = 2.1741106448 [lb/s]	cross-flow, single banking				2.17411	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#20: Hot flow mass flow rate = 2.1851337579 [lb/s]	cross-flow, single banking				2.18513	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	
#21: Hot flow mass flow rate = 2.196156871 [lb/s]	cross-flow, single banking				2.19616	464.02	14.6959		1.829	39.218	14.696	0.0157	0.0157	0.1	0.1	0.25	

## #6. New Inputs for Plate-Fin Geometry

- The “Bar Thickness” in the old version has been removed
- “End Plate Thickness” has been added. This value will affect the stack height and weight of the HEX
- “Bar Width” and “Bar Height” have been added into “Fin Properties”, this allows you to set different values of side/separator bar width and height for different streams
- The value of “Bar Height” is allowed to be slightly different from the value of “Fin Height.” If zero is input for “Bar Height,” its value will automatically be set to be equal to “Fin Height.”
- The value of “Bar Width” can be set to zero if the width of the side/separator bar is negligible.

### Old version

VI. Plate Properties:

Plate Thickness:  ft

Bar Thickness:  ft

Plate Conductivity:  btu/(h-ft<sup>2</sup>-F)

Plate Density:  lb/ft<sup>3</sup>

III. Fin Properties:

Fin Height ( $h'$ ):  ft

Fin Thickness ( $t$ ):  ft

Fin Pitch ( $p$ ):  ft

Fin Conductivity:  btu/(h-ft<sup>2</sup>-F)

Fin Density:  lb/ft<sup>3</sup>

Custom j/f data

Use user-defined j/f data?

### New version

VI. Plate Properties:

Plate Thickness:  in

End Plate Thickness:  in

Plate Conductivity:  btu/(h-ft<sup>2</sup>-F)

Plate Density:  lb/ft<sup>3</sup>

III. Fin Properties:

Fin Height ( $h'$ ):  in

Fin Thickness ( $t$ ):  in

Fin Pitch ( $p$ ):  in

Fin Conductivity:  btu/(h-ft<sup>2</sup>-F)

Fin Density:  lb/ft<sup>3</sup>

Bar Width ( $w_{sb}$ ):  in

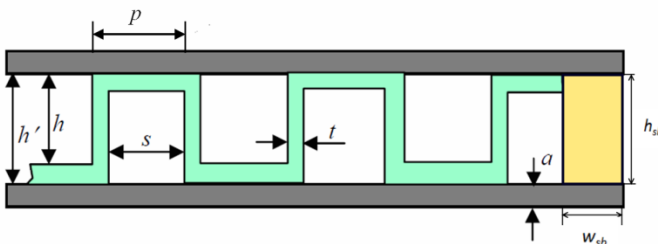
Bar Height ( $h_{sb}$ ):  in

Custom j/f data

Use user-defined j/f data?



The dimensions of bar width ( $w_{sb}$ ) and bar height ( $h_{sb}$ ) are shown in the illustration of a fin below.



## #7. Additional Outputs for Plate-Fin Calculations

The following data have been added to the Plate-Fin rating output results:

- Mean temperature (hot/cold)
- Mean density (hot/cold)
- Mean viscosity (hot/cold)
- Mean specific heat (hot/cold)
- Mean thermal conductivity (hot/cold)
- Mean Prandtl number (hot/cold)
- Mean Nusselt number (hot/cold)
- Heat transfer surface area (hot/cold)
- Free flow area (hot/cold)
- Coefficient of performance (COP)

Note that COP is defined as  $COP = \frac{\text{Overall Heat Transfer Rate}}{\text{Power}_{\text{hot}} + \text{Power}_{\text{cold}}}$

Fin Height:	0.086	in
Fin Pitch:	0.054	in
Fin Thickness:	0.006	in
Fin Offset Pitch:	0.078070866	in
Flow Length:	2.25	in
Flow Width:	4.3125	in
Power:	8.875277345	Btu/h
Mean Temperature:	23.074265811	°F
Mean Density:	112.370329037	lb/ft³
Mean Specific Heat:	0.210184389	Btu/(lb·°F)
Mean Viscosity:	0.003091057	lb/(ft·s)
Mean Conductivity:	0.040445252	btu/(h·ft·°F)
Mean Heat Capacity:	1751.566039145	btu/(h·°F)
Mean Prandtl Number:	57.828566331	
Mean Nusselt Number:	22.497531161	
Free Flow Area:	3.066667183	in²
Heat Transfer Area:	194.062500775	in²

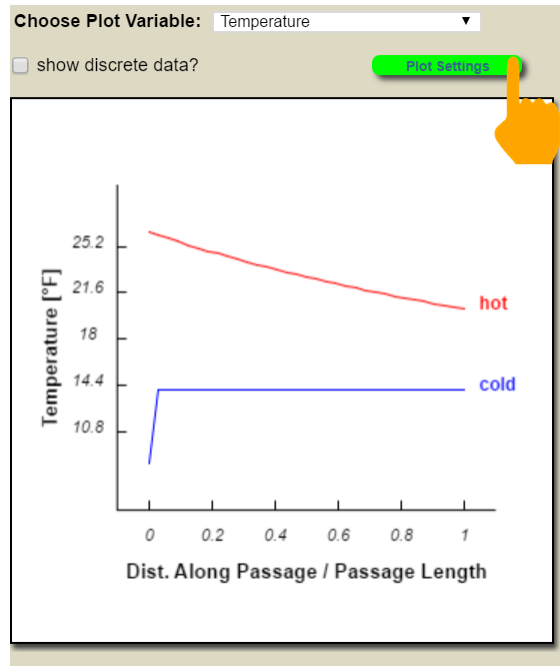
Heat Transfer Area:	194.062500775	in²
U:	425.473316688	btu/(h·ft²·°F)
UA:	1196.672503537	btu/(h·°F)
Heat Flow Rate:	10468.929550324	Btu/h
Ratio of Heat Capacity:	0.023829074	
Effectiveness:	0.712632467	
NTU:	33.848869	
COP:	18.728760058	
Empty Weight:	0.40281829	lb
Operating Weight:	0.873371113	lb



## #8. More Controls on Plotting the Curves of Rating Results

By clicking the “Plot Setting” button, you can

- Set units of the variables to be plotted
- Indicate whether to plot the graph for one or two streams
- Indicate the plotting direction for the streams



Plot Settings
✕

Set Units of Plotting Variables

Unit for Temperature: °F

---

Choose Plotting Curves

Plot Lines for : hot & cold

---

Choose Plotting Direction

Reverse plotting direction? cold only

Close

Note that, by default, the curves are plotted along the respective flow directions. “Reversing” the plotting direction is especially useful for parallel counter-flow HEX. By reversing the plotting direction of one stream, you can compare the data for the two streams point-by-point.

## #9. Set the Precision and Formats of the Outputs

You can specify the precision and formats of the outputs in “Preference.” The meaning of the settings is self-explanatory.

The screenshot shows a software interface with two tabs: 'Start Page' and 'Preferences'. The 'Preferences' tab is active. Under the heading 'User Preferences:', there are two sections: 'Units:' and 'Format Numbers:'. The 'Units:' section includes 'Choose default unit system:' set to 'Customized' and 'Automatic input unit conversion:' set to 'Off'. The 'Format Numbers:' section includes four settings: 'The exponent value, beneath which scientific notation occurs:' (3), 'The exponent value, above which scientific notation occurs:' (5), 'Maximum number of digits for scientific notation:' (7), and 'Maximum number of digits for non-scientific notation:' (9). A red box highlights these four settings. Buttons for 'Customize Preferred Units', 'Default Formatting', 'Save', and 'Close' are also visible.

Section	Setting	Value
Units:	Choose default unit system:	Customized
	Automatic input unit conversion:	Off
Format Numbers:	The exponent value, beneath which scientific notation occurs:	3
	The exponent value, above which scientific notation occurs:	5
	Maximum number of digits for scientific notation:	7
	Maximum number of digits for non-scientific notation:	9