September 27, 2017

Dear Customer,

We are pleased to release Version 27 of our software suite, with the new features and improvements summarised below. Some of the items described here were released as revisions to Version 26, optionally downloaded from our Service Center.

GT PRO / GT MASTER / PEACE

(1) Annualized Plant Financial Performance in GT PRO - GT PRO can now compute plant financial results based on annual plant performance with varying ambient conditions and including plant startup and shutdown. This feature, which has been in GT MASTER and STEAM MASTER since TFLOW22, can be used to more easily optimize designs with the MACRO/ELINK by running parametric design studies that inherently compute ROI, NPV, and levelized cost of electricity for plant operation over an annual operating cycle, including the effects of plant startup and shutdown.

(2) Steam Turbine Tuning & Output Matching in GT PRO - GT PRO has a new feature that automatically computes ST model adjustments to match desired steam turbine power, if possible. The checkbox, available on the [Main] tab of the [ST Inputs] topic, enables input of desired ST power. When checked, GT PRO computes a single correction factor, applied to the dry step efficiency for all ST groups and to the LPT Exhaust Loss curve that results in a match to specified power. The method requires the desired power to be within +/- 5% of the uncorrected power. If a larger correction would be needed to get a match, the method will fail and a message will be displayed after computation. This is intended to be a quick and simple aid to match known ST power when all other model parameters are already set to match a known result.

(3) GT MASTER – New ST and Cooling System Tuning Features & Model Adjustments - Several new model tuning features were added to GT MASTER's **Tools** menu.

1. **Single-Point** and **Multi-Point ST Tuning** - allow you to specify inlet and exit conditions from each group (after any valve losses and before any leaving losses) for up to five steam turbine operating conditions. GT MASTER finds adjustment factors to the ST group nozzle area and dry stage efficiency to match your performance data. Once defined, GT MASTER will interpolate between these factors to compute adjustments at other operating conditions. The tuning procedure finds these adjustments. These values are model inputs that you can also edit by clicking the ST Model Adjustments button on the [Main] tab of the [ST Inputs] topic.
2. **Multi-Point Condenser Tuning** - allows you to specify heat rejection and condenser pressure for up to five conditions. GT MASTER finds adjustment factors to the condenser effectiveness to match your performance data. Once tuned, GT MASTER interpolates between these factors to compute condenser effectiveness adjustments at other operating conditions. The tuning procedure finds these adjustments. These values are model inputs that you can also edit by clicking Cooling System Performance Method button on the [Main] tab of the [Cooling System] topic.
3. **Multi-Point Cooling Tower Tuning** - allows you to specify the tower's cold water exit temperature versus air inlet wet bulb temperatures. GT MASTER finds adjustments to the cooling tower effectiveness to match your data. Once tuned, GT MASTER interpolates between

these factors to compute tower effectiveness adjustments at other operating conditions. The tuning procedure finds these adjustments. These values are model inputs that you can also edit by clicking Cooling System Performance Method button on the [Main] tab of the [Cooling System] topic.

(4) GT MASTER Model Catalog - GT MASTER now allows you to store model sub-systems in a catalog. The catalog, a file available on your computer, can be used by you (and anyone with access to it) as a source of component models to be imported into other GT MASTER files. In this way the catalog can serve as a storage system for tuned component models that you wish to re-use or share with others. The [Tools] pulldown menu has entries to store items in a catalog, retrieve items from a catalog, and to manage your catalog file(s).

(5) Other Improvements to GT PRO / GT MASTER:

1. Inputs are now available to specify power and heat rate degradation over the project lifetime. This data, entered on the [Escalation] tab on the [Economics] topic, allows you to include effects of plant deterioration in the financial results including ROI, ROE, and NPV.
2. A 'Low Cost Manufacturer' switch and associated equipment cost multiplier was added to the [Equipment] tab on both the [ST Inputs] and [HRSG Inputs] topics. This is intended to help improve cost estimates as manufacturers base production in low-cost parts of the world, thereby reducing the price tags on major pieces of plant equipment.
3. User-defined shipping costs, specified as a percentage of the equipment cost itself, are available on the [Equipment] tabs for the GT, ST, HRSG, and cooling system. Previously, the shipping costs were computed using an internal value assigned to each piece of equipment.
4. GT PRO's automatic logic for condenser pressure selection for ACCs was revised. New logic suggests higher pressures resulting in smaller condensers, and higher ROI using default financial assumptions.
5. A new input that limits the HRSG duct width is available on the [Miscellaneous] tab of the [HRSG Inputs] topic in GT PRO. This can be used, for example, to constrain as-designed boiler width to fit within shipping restrictions.

THERMOFLEX / PEACE

(1) New Steam Turbine Icon – A new steam turbine icon is available on the [Water/Steam] tab. This icon, resembling the ST Assembly charm, provides a streamlined method to insert and interact with a complete steam turbine genset in a THERMOFLEX model. Upon adding a Steam Turbine to the flowsheet, its configuration menu is displayed where you define the casings, paths, and induction/extraction ports you need to model the turbine. This information is used to: (1) automatically create a steam turbine assembly, (2) place a single, graphically-consistent steam turbine icon on your flowsheet complete with all its inlet and outlet nodes, and (3) to add a dedicated 'Details' flowsheet to your model where all the individual ST groups, mixers, and splitters that collectively define the steam turbine in detail are located and connected together. You carry on to make connections between the Steam Turbine icon and the rest of your model. THERMOFLEX automatically makes the connections to and within the details flowsheet on your behalf. This new feature dramatically simplifies the process of creating new steam turbine models of any level of complexity.

(2) New Steam Turbine Tuning and Model Adjustments - As described above in (3) for GT MASTER, THERMOFLEX now includes steam turbine model adjustments inputs and a tuning system used to automatically find these values to match your data. In THERMOFLEX, These features are available on the Off-design input menu for the Steam Turbine Assembly, on the newly included [Model Adjustments] tab.

(3) User-defined Off-Design Performance Curves – THERMOFLEX now allows you to replace Thermoflow's well-proven, hardware-based, predictive off-design performance models for selected PEACE components with your own user-defined curves. This is primarily intended for OEMs wishing to

implant their own equipment models, and users needing to reproduce OEM-specified performance, without need to independently review that information. This feature is included for ST group efficiency and inlet pressure, ST Assembly leakage flows, WCC pressure and CW pressure drop, ACC pressure and fan power, CT basin temperature and fan power, Economiser/Superheater exit water/steam temperature or heat transfer coefficients and water/gas side pressure loss, Evaporator steam production of heat transfer coefficients, and OTB exit water/steam temperature or massflow.

(4) Model Catalog – THERMOFLEX now allows you to store portions of models you build and tune in a model catalog. The catalog, a file on your computer, can be used by you (and anyone with access to it) as a source of model items to include in other THERMOFLEX files. In this way the catalog can serve as a storage system for tuned component models that you wish to re-use or share with others. From [Edit Drawing] mode right-click the flowsheet and choose the [Import from Catalog] item to summon the catalog from which model pieces are selected for import. From [View Outputs] mode, select a single component, or a group of components, and right-click to choose the [Store in Catalog] item to place the selection into the catalog together with descriptive information you provide.

(5) Other Improvements to THERMOFLEX:

1. Smoke Tube Economiser component was added to the [Boilers / HRSGs] tab. Sometimes called a 'fire-tube' economizer, this component models water heaters where the flue gases pass through tubes submerged in water contained in a cylindrical pressure vessel. These are used in conjunction with Smoke Tube Evaporators or by themselves as stack water heaters.
2. Options were added to specify user-defined curves, instead of fixed numerical inputs, for (a) Heat Adder's heat transfer rate, (b) Logical Header's flow capacity, and (c) Fractional Header's flow fractions.
3. An integral generator option is available for the ST Assembly and the Gas Turbine. When these items drive a generator, by themselves or in a single-shaft GT+ST configuration, this method is used instead of the 'Shafts' system for defining what's driving the generator. Details for the generator is defined on, and contained within the ST Assembly or GT Icon itself. This method is used, by default, for models created by importing a GT PRO, GT MASTER, or STEAM PRO file. It is also required for models using the comprehensive PEACE cost estimate.
4. PEACE Coil component has a new input to specify the coil's application. Choices are (a) air-heating coil, (b) air-chilling coil, (c) flue gas cooler, and (d) flue gas heater. This input is used by the automatic material selection and heater tubing configuration logic. A newly included tube material, PTFE (Teflon), is automatically chosen for relatively low temperature flue gas coolers handling potentially corrosive gases.
5. The Cooling Tower and Air-Cooled Condenser have a new percent loading input parameter for cells using two-speed fans. The input is used to determine the number of fans running at full-speed, half-speed, and off. This is particularly useful in conjunction with the 'Searcher' feature which can find the optimum cooler loading at the current plant operating conditions.
6. A Power Output component was added to the [General] tab. This is useful in scripting applications where the script computes a user-defined component that generates power. An example implementation is demonstrated in '(S3-25)FuelCell with AbsorptionChiller and WaterHeater.tfx' which models a Fuel Cell together with heat recovery for chilling and hot water production.
7. It is now possible to Copy/Paste flowsheet items (icons, labels, shapes, etc.) from one file to another, just as it has always been possible to Copy/Paste flowsheet items within a model.
8. Ability to Copy/Paste Non-Flowsheet Comprehensive PEACE inputs from one file to another is now available. Likewise, ability to Copy/Paste PEACE Economics inputs from file-to-file was also added.
9. Flowsheet tabs may be reorganized using menu items on the dropdown menu shown when you right-click a tab.
10. Since 1995, THERMOFLEX has shown stream data exclusively using the order P, T, m, h. This can be now changed from the [Flowsheet] tab of the [Current Settings] and [Preferences] menus available from the [Options] pulldown.

STEAM PRO / STEAM MASTER / PEACE

(1) Annualized Plant Financial Performance in STEAM PRO – STEAM PRO can now compute plant financial results based on annual plant performance with varying ambient conditions and including plant startup and shutdown. This feature, which has been in GT MASTER and STEAM MASTER since TFLOW22, can be used to more easily optimize designs with the MACRO/ELINK by running parametric design studies that inherently compute ROI, NPV, and levelized cost of electricity for plant operation over an annual operating cycle, including the effects of plant startup and shutdown.

(2) Flue Gas Cooler – It is now possible to include a flue gas cooler downstream of the air heater to recover still more heat from the flue gas, improving the efficiency of the boiler and the plant. The low grade (low temperature) heat it provides can be used to reduce the need for low grade heat within the low pressure feedwater heating system, which otherwise draws steam from the steam turbine. This heat exchanger is included in the model and further defined on the [Flue Gas Cooler] tab of the [Boiler Thermal] topic in STEAM PRO. Detailed description of the heater's design and thermal performance is available from the [Boiler] Text Output report.

(5) Other Improvements to STEAM PRO / STEAM MASTER:

1. Inputs are now available to specify power and heat rate degradation over the project lifetime. This data, entered on the [Escalation] tab on the [Economics] topic allows you to include effects of plant deterioration in the financial results including ROI, ROE, and NPV.
2. A 'Low Cost Manufacturer' switch and associated equipment cost multiplier was added to the [Equipment] tab on both the [ST Inputs] and [HRSG Inputs] topics. This is intended to help improve cost estimates as manufacturers base production in low-cost parts of the world, thereby reducing the price tags on major pieces of plant equipment.
3. User-defined shipping costs, specified as a percentage of the equipment cost itself, are available on the [Equipment] tabs for the ST, Boiler, and cooling system. Previously, the shipping costs were computed using an internal value assigned to each piece of equipment.
4. STEAM PRO's automatic logic for condenser pressure selection for ACCs was revised. New logic suggests higher pressures resulting in smaller condensers.

COMMON OFF-DESIGN FEATURES: GT MASTER / STEAM MASTER / THERMOFLEX

(1) User-defined Cooling System Performance – Ability to replace Thermoflow's predictive off-design performance model with data you specify.

1. **Condensers (WCC, ACC)** – you may specify tables of condenser pressure versus heat rejection for different coolant supply temperatures. During computation, the program determines condenser pressure by interpolating within the dataset instead of predicting it using its hardware-based model. The data tables are edited from the [Main] tab on the [Cooling System] topic in both GT MASTER and STEAM MASTER. They are on the [Performance Method] tab on the condenser input menu in THERMOFLEX.
2. **Cooling Towers (Wet, Dry, Wet-Dry)** – you specify cold water temperature leaving the tower as a function of cooling water range at up to three different cooling water flowrates. During computation, the program finds cold water temperature by interpolating within this dataset instead of predicting it using its hardware-based model. The data tables are edited from the [Main] tab on the [Cooling System] topic in both GT MASTER and STEAM MASTER. They are available on the [Performance Method] tab on the cooling tower input menu in THERMOFLEX.

PDE

Plant Design Expert now allows for simultaneous analysis of multiple proposed systems for one set of plant requirements. This is a feature that's been in **webPDE** since it was released in 2014.

PEACE

HRSG cost estimates were revised, with particular emphasis on units sized for use with 20-60MW aero engines, and 30-60MW industrial machines. Revised HRSG cost estimates in this range will generally be lower by 10 to 20% relative to TFLOW26.

Gas turbine prices for particular engines were revised based on informal feedback we received from some OEMs. For others, where we received no input, we adjusted the specific cost ($/kW) relative to TFLOW 26. For engines with nominal output of 50 MW and above the $/kW was reduced by 10%. For engines with nominal output below 5 MW, the specific cost was left unchanged from TFLOW26. For those engines in the 5 to 50 MW range, the $/kW was reduced linearly from 0 to 10% respectively.

Link to Siemens eTrent

Ability to use `Siemens eTrent (Industrial Trent Performance Synthesis Program)` to compute gas turbine performance from GT PRO, GT MASTER, and THERMOFLEX is now available. This feature is enabled for all Thermoflow customers who have independently acquired a license to run `eTrent`, directly from Siemens. Note, `eTrent` is not available from Thermoflow. When used, the gas turbine performance is computed by `Siemens eTrent`, and the balance of the cycle calculation and cost estimate is computed by Thermoflow.

You select `Siemens eTrent` from the GT Selection list, under the **Other GT Model Options** portion of the list. When chosen, the Configure Siemens Industrial Trent button is available to run `eTrent` to choose the particular engine configuration and define the fuel. During cycle computation, `eTrent` is called to compute engine performance at the current operating conditions supplied to `eTrent` from the whole-plant model. Engine results are reported as if it were computed as a User-Defined GT. PEACE results are computed using the equivalent engine information from Thermoflow's built-in GT library.

Gas Turbine Database

The gas turbine database was updated as shown below. Some of these engine models were included in revisions to TFLOW26 available from the Service Center.

Names used to identify certain Siemens engines were revised to reflect the current naming system used by Siemens. This affects the name listed on the [GT Selection] list for those engines formerly known as the TRENT, RB211, Avon, and Allison KB / KH series.

Engines added to the database

640 – GE J920 50Hz	652 – GE 9HA.01	658 – SIE SGT-A45 TR 50Hz
641 – GE J920 60Hz	653 – GE 9HA.02	659 – SIE SGT-A45 TR 60Hz
642 – GE LM6000 PF+G2D 50Hz		664 – SIE SGT-700-38 DLN
643 – GE LM6000 PF+G2D 60Hz	634 – SIE SGT5-2000E 41 MAC	665 – SIE SGT-800-54 DLN
644 – GE LM6000 PF+G2D SPT 50Hz	635 - SIE SGT5-2000E 33 MAC	666 – SIE SGT6-5000F
645 – GE LM6000 PF+G2D SPT 60Hz	636 - SIE SGT5-2000E 25 MAC	
646 – GE 7F.05	637 – SIE SGT5-4000F	660 – MHPS 501 GAC
647 – GE 7F.06	638 – SIE SGT-400 12.9	661 – MHPS 701 F
648 – GE 9F.05	654 – SIE SGT5-8000H	662 – MHPS 701 JAC
649 – GE 9F.06	655 – SIE SGT6-8000H	663 – MHPS 701 J
650 – GE 7HA.02	656 – SIE SGT-750	667 – MHPS 501 J
651 – GE 7HA.01	657 – SIE SGT-800-54	668 – MHPS 501 JAC

Existing engines with modified performance

403 – Sol Taurus 70 DLN	621 – SIE SGT-100 5.4 DLN	266 – SIE SGT-100 5.4 STD
424 – SIE SGT-300 7.9 DLN	265 – SIE SGT-300 7.9 STD	450 – SIE SGT-700-33 DLN
449 – SIE SGT-800-47 DLN	448 – SIE SGT-800-50 DLN	

Reciprocating Engine Database

The reciprocating engine database, used by THERMOFLEX and RECIPRO, was updated as shown below. Some of these engine models were included in revisions to TFLOW26 available from the Service Center.

390 – RR/BERGEN B35: 40V16AG2 60Hz	403 – SIE SFGLD 240	417 – JEN JMS 612GS
	404 – SIE SFGLD 360	418 – JEN JMS 616GS
391 – SIE HGM 240	405 – SIE SFGLD 360	419 – JEN JMS 620GS
392 – SIE HGM 420	406 – SIE SFGLD 480	420 – JEN JMS 624GS
393 – SIE HGM 560	407 – SIE SFGLD 480	421 – JEN JMS 208GS
394 – SIE HGM 560	408 – SIE SFGLD 560	422 – JEN JMS 312GS
395 – SIE SFGLD 180	409 – SIE SFGLD 560	423 – JEN JMS 316GS
396 – SIE SFGLD 240		424 – JEN JMS 320GS
397 – SIE SFGLD 360	410 – JEN JMS 208GS	425 – JEN JMS 412GS
398 – SIE SFGLD 480	411 – JEN JMS 312GS	426 – JEN JMS 416GS
399 – SIE SFGLD 560	412 – JEN JMS 316GS	427 – JEN JMS 420GS
400 – SIE SFGLD 180	413 – JEN JMS 320GS	428 – JEN JMS 612GS
401 – SIE SFGLD 180	414 – JEN JMS 412GS	429 – JEN JMS 616GS
402 – SIE SFGLD 240	415 – JEN JMS 416GS	430 – JEN JMS 620GS
	416 – JEN JMS 420GS	431 – JEN JMS 624GS