

September 26, 2016



Dear Customer,

We are pleased to announce the release of Version 26 of our software suite. However, we start this letter by discussing an unusual subject:

## SOFTWARE PIRACY

We have been observing software piracy in certain parts of the world where intellectual property rights tend to be abused. In the past, use of pirated copies had been limited to individuals or entities outside the industry mainstream, who would not have bought a legitimate license anyway. However, in the past two years we have observed increasing use of pirated copies by companies that are mainstream participants in the global power generation industry. These even include a few customers who have discontinued their legitimate licenses and resorted to using pirated copies.

We have consulted with legal experts and law enforcement agencies and, after gathering enough evidence, shall consider action against these illegitimate users through their international customers, projects, suppliers, affiliates, or joint ventures in countries where we find sufficient nexus and a fair legal system. We would greatly appreciate any help you can give us to accumulate evidence about illegitimate use of our software, and have posted forms on our website for this purpose at <https://www.thermoflow.com/licensing.html>.

With continuous evolution of our security protocols, pirated copies tend to be older versions. Consequently, we are asking all legitimate customers to only use the latest version, and to be aware that anyone using an old version is likely an illegitimate user. Additionally, we are introducing a policy of planned obsolescence of older versions as follows:

(1) Ability to run older versions: Starting with Version 26, you will be able to only run the latest version and its immediate predecessor. Thus, after installing Version 26 and an updated Version 25, you will be able to run Version 26 and the updated Version 25, but not Version 24 or earlier.

(2) Ability to load older files: Starting with Version 26, you will be able to only load files from the latest version and its two immediate predecessors. Thus, Version 26 will load files from Versions 26, 25, or 24; but not 23 and earlier. However, the updated version 25 will stay consistent with our previous norms, and still load old files from previous versions as before.

(3) Updating legacy files: You will be able to load a file from any old version into the updated Version 25, just like before. You can then recompute it and save it as a Version 25 file, which you can read into Version 26 (and Version 27 when it is released). This gives you a path to preserve old legacy models. Additionally, before Version 27 is released, we plan to post a utility on our website that will allow legitimate users to update any file, no matter how old, to become usable by the latest versions.

Although these changes represent a break in our traditions, they are consistent with typical software industry practice. We apologize to users who may find them inconvenient, but deem them necessary to minimize the impact of piracy. Additionally, as stated in (3) above, we are remaining faithful to our tradition of allowing customers to recover very old legacy files.

The rest of this letter focuses on the new features and improvements for Version 26, summarised below. Some of these features were released by revision to Version 25 since its original release last year.

## LICENSE MANAGEMENT

We rebuilt the website you use to get new versions, software revisions, and to refresh your license. The new Thermoflow Service Center is located at <https://www.thermoflow.com/ServiceCenter>. Starting with Version 26, this new site is where you'll go to maintain your software installation and license for all supported versions. The Service Center login uses your corporate email address as your username together with a password that's yours to choose. This same username and password are used to start the desktop software. A one-time account setup process is needed to get started with TFLOW26. After you create your new account, you'll have download access for Version 26 and ability to get a revision for Version 25, if you still need it. Versions 24 and earlier are no longer supported.

The Service Center presents you with a personalized dashboard whenever you login. It provides useful information about your license, the latest available version of our software, the most recent revisions for all active versions, and other relevant information you might find useful as a Thermoflow customer.

### GT PRO / GT MASTER / PEACE

#### (1) Scripting in GT PRO:

GT PRO now includes a full-featured scripting language, akin to that introduced in GT MASTER 24. The Script Manager input menu lets you create, define, compile, and test scripts (programs). Scripts are executed along with the model computation, and script results are available alongside other GT PRO outputs. GT PRO's new Scripting feature lets you:

1. Define logic to set one or more GT PRO model input parameters. For example, sample file (GTP\_Script1) `Different_Condensate_Return_Temperature.gtp` uses a script to compute the single condensate return temperature that results from mixing multiple condensate return streams, each returning at a different temperature. The equivalent mixed return water temperature is assigned to GT PRO's condensate return temperature input.
2. Define logic to control calculation outcome. For example, sample file (GTP\_Script3) `Script_DB_STkW.gtp` implements control logic that establishes the duct firing level needed to design the plant with steam turbine output power as a given design-point input.

The LUA Scripting language is very easy to use for simple things that may require you to write only a few lines of code. However, it's powerful enough to build full-featured programs with data arrays, built-in math functions, logical branching, nested looping, subroutines, external program control, filesystem access, etc. Scripting is included in GT PRO without need for any extra license.

#### (2) Gas Turbine Inlet Chilling / Heating:

A hardware model for the cooling coil was included and is now the default for plants including heating or cooling coils. Coil characteristics such as finned tube type & geometry, and fin/tube materials are available for editing in a manner that's similar to how HRSG HX's are defined. Coil size and cost are computed based on the thermal loading in the current heat balance. Coil hardware may be resized in GT MASTER, explicitly, if needed.

#### (3) User Defined Gas Turbine:

All inputs defining the gas turbine heat balance are preserved when changing from a built-in model to the User Defined Gas Turbine model. Previously only the heat rate, power, exhaust flow, and exhaust temperature were preserved. This is important for engine models with water injected into the compressor, or steam / water injected into combustors, or those that reject heat to intercoolers or OTB's to generate steam. New inputs are available on the [Bleeds & Injections] tab to edit compressor leakage and compressor water injection for user-defined GTs.

#### (4) Custom Output Variable List:

GT PRO and GT MASTER have a new Custom Variable List menu item on the main menu bar. It's used to define and organize a list of model parameters that are reported on output in a separate table, and available for saving into CSV or XML files. This makes it easy to export calculated results in formats that can be consumed by other software for post-processing outside of Thermoflow's software.

### **(5) Other improvements to GTPRO / GTMASTER:**

(5a) Added high temperature materials Inconel 617 and Inconel 740 to the heat exchanger tube and pipe material selection lists.

(5b) For condensing non-reheat cycles in GT PRO, the IPS exit temperature will be calculated if the 'ST Pressures & Temperatures' option has been set to automatic, with the intent of ensuring the IP induction steam is reasonably close in temperature to the steam it will join.

(5c) Option to desuperheat hot reheat steam using cold reheat steam to improve cycle efficiency.

(5d) A new input is available on the [Calculation Options] tab of the [Plant Criteria] topic to automatically increase boiler pinch if needed to ensure the LMTD for each economizer is above a specified minimum value.

(5e) A new PEACE input is available in GT PRO to adjust equipment spacing on the site plan. The default is 1 which uses the automatic spacing logic that's been in PEACE since it was introduced. Larger values will increase spacing between major pieces of equipment which will, in turn, increase lengths for piping and wiring runs. This new input is located on the [Site Characteristics] tab of the [Plant Criteria] topic.

(5f) For plants with no DA or DA condenser, an option to use an integral condensate forwarding / feedwater pump for lowest pressure is available at the GT PRO [Water Circuits] topic. Previously, this had only been available for cycles using GT PRO's 'LP' circuit.

(5g) Five user-defined auxiliary load inputs are available on the [Miscellaneous] tab of the [Plant Criteria] topic. Each load has a user-defined description and power consumption.

(5h) Water recirculation from pump discharge to inlet, when throughflow hits its minimum level, is now optionally available for all fixed-speed pumps in GT MASTER.

(5i) The water-side pressure drop model for the once through boiler was modified, and may result in small differences in the heat balance results compared with the previous version.

(5j) A new font scaling factor for the Comprehensive Heat Balance diagram is available on the [Graphics] tab of the [Preferences] menu.

## **THERMOFLEX / PEACE**

### **(1) Comprehensive Cost Estimate for Gas Turbine Power Plants:**

A new comprehensive cost estimate for gas turbine plants is now available. It augments the simplified cost estimate introduced to THERMOFLEX in 2001. The new cost estimation procedure is akin to what's provided by PEACE for GT PRO and GT MASTER. A PEACE license is required to enable this feature. A number of new PEACE input menus, under **Edit Inputs** button, are included to specify items outside the heat balance, but typically included in a power plant. Equipment layout logic is built-in to automatically create a site plan for major equipment. Methods are included to size the electrical distribution system including step-up and step-down transformers, motor control centers, buswork, wiring, switchyard, etc. Additionally, methods to specify buildings, storage tanks, water treatment system, backup and emergency generators, miscellaneous pipes and pumps, etc. are available to tailor facility layout and scope.

Users familiar with PEACE output reports in GT PRO & GT MASTER will find similar details available in a familiar presentation for THERMOFLEX models computed using the Comprehensive Method. Results include an automatically arranged Site Plan illustrating placement of major equipment and systems showing required land area. A collection of equipment tables is included to show details for plant equipment included for cost purposes only. A motor list is included to show motor counts, aux loads, and

voltage levels. The total plant cost is presented on a summary table with detailed breakdowns for equipment, material, and labor for all included components plus soft costs.

## **(2) Solar PV Component:**

This new icon is located on the **General** tab, beside the Solar Tower icon. It models a field of photovoltaic panels affixed to mounting hardware arranged in rows. The model provides performance as a function of solar conditions together with estimated field size and installed cost. It defaults to a user-defined PV panel, but includes a small library of commercially available panels. Outputs provide snapshot performance at a single condition and also estimated annual yield using irradiance data from an internal solar database comprised of over 1000 locations in the US and Canada. The sample file (S5-22) SolarPV with Gas Turbine Backup using Scripting.tfx illustrates an example use of this component where a solar field is backed up by a gas turbine generator.

## **(3) Wind Farm Component:**

This new icon is located on the **General** tab, beside the Solar PV icon. It models one or more wind turbines. Model output includes power generation at user-defined wind conditions together with estimated wind farm land area and estimated installed plant cost. It includes a user-defined wind turbine with an editable power curve and wind speed limits. Outputs provide snapshot performance at a single condition together with estimated annual yield using wind data that you supply. The sample file (S5-23) WindFarm with Gas Turbine Backup using Scripting.tfx illustrates an example use of this component where a wind farm is backed up by a gas turbine generator.

## **(4) Plate Heat Exchanger Component:**

This new icon is located on the **General** tab, beside the General HX icon. This icon can be used with liquid water and heat transfer fluids. It models a plate heat exchanger comprised of a number of corrugated plates, spaced close together, to provide a large surface area in a relatively compact package that's readily extendable by addition of extra plates. The model computes heat transfer, heater size and weight, and estimated heater equipment cost. The sample file (S2-38) Modeling GTCC Cooling Water Loop Using Plate Heat Exchanger.tfx illustrates an example where this component is used as an isolation heat exchanger in a typical plant cooling loop.

## **(5) Boiler Assembly:**

THERMOFLEX now has ability to define a Boiler Assembly for fired boilers. The assembly unites the collection of components that model the boiler and provides a centralized set of output reports, akin to what the HRSG Assembly provides for HRSGs. Outputs include the Specification report including weights, dimensions and installed cost estimate, an ASME Heat Balance, Gas & Water data summaries, Plan & Elevation views, TQ diagram, and fired boiler component output reports. A Boiler Assembly is created automatically when a STEAM PRO file is imported to THERMOFLEX. The sample file (S1-10) Rankine\_900MW STassembly.tfx includes a Boiler Assembly.

## **(6) LNG Fuel Specification:**

THERMOFLEX has had the ability to define and use liquefied natural gas since the mid 1990's, using data you provide. This version includes a new automated method to define natural gas properties for a fuel with user-defined composition. The new method uses the REFPROP (NIST) property database to establish the thermodynamic and thermophysical properties for the fuel composition you provide as input. LNG fuels may now be used with PEACE components such as pipes and heat exchangers. LNG fuels may be saved in fuel files for use with other models. A small library of benchmark LNG fuels is now included in PROFUEL. The sample file (S2-21) LNG\_Chill.tfx demonstrates use of a user-defined LNG fuel in a gas turbine inlet air chilling scheme. The built-in help, Volume IV, describes the process for defining the fuel composition and creating its property database.

## **(7) Other Improvements to THERMOFLEX:**

(7a) The Once-Through Boiler (OTB) component can now be used in parallel flow arrangements in horizontal and vertical boilers alike. This configuration is used in some boilers with heavy supplemental firing. It is available as an alternate visage for the OTB that's located on the **Boilers / HRSGs** tab.

(7b) An Aux Power icon was added to the **General** tab, beside the Tank icon. Any number of these nodeless icons can be added to the flowsheet to graphically display user-defined auxiliary loads. The auxiliary load can be specified directly as power or as a percent of plant gross power. This icon makes it easier to account for separate aux loads, and can be useful when calculating auxiliary loads using scripts.

(7c) In previous versions the fuel price was defined on the **Economics** tab. This input was applied to all fuel heat inputs, regardless of fuel type or grade. Now, each fuel has its own price defined on the fuel source input menu, so plants burning multiple fuels can more easily specify fuel-specific pricing. Likewise, in previous versions all heat exported from the model was accounted for using a single heat export price, defined on the **Economics** tab. Starting with this version, each process icon has its own unique price, editable on its input menu. Similarly, sources and sinks declared to be included as process heat input or output on the Energy Accounting menu, also have individual prices defined on the component's input menu.

(7d) Scripts may now be exported from a model and imported into another model to make it easier to reuse scripts. This feature is available from the Script Manager menu.

(7e) Other improvements include the following. The moisture separator icon (**General** tab) can now handle ammonia water mixtures. The water/steam moisture separator can now control exit quality of main outlet stream. The CFB has new steam addition and water extraction nodes connected to the steam drum. The CFB now has a user-editable curve to specify furnace exit temperature versus boiler operating load, at off-design. Likewise, the BFB now has a user-editable curve to define bed temperature versus load, at off-design.

## PEACE

Some PEACE cost functions and automated sizing procedures used for GT PRO and GT MASTER were revised for compatibility with the comprehensive cost estimate in THERMOFLEX. This may cause small cost differences for some models relative to the previous version.

The labor hour estimation procedure for large foundations, those with more than 300 cu.yd. of concrete, was modified. This change reduces estimated hours for large foundations, and consequently reduces the foundation installed cost. Overall plant cost estimates for large GTCC may be lower by as much as 1 to 2% as a result.

Gas turbine prices for particular engines were revised based on informal feedback we received from some OEMs. For engines where we received no guidance, the prices are unchanged from Version 25. We have been observing modest inflation or modest deflation in many other components of plant cost. Thus, aside from certain gas turbines we have decided to leave the default cost estimates unchanged from Version 25.

## Gas Turbine Database

Corporate cooperation and consolidation involving a number of turbine OEMs has resulted in the rebranding of some engines in the gas turbine library. To track these changes the database list was modified as follows:

1. Currently available gas turbine specs previously listed under ALSTOM are now listed under GE or Ansaldo. The ALSTOM manufacturer category was retained to list old engine specs that are not offered by either successor company.
2. Engines previously listed under Hitachi are now listed under Mitsubishi Hitachi Power Systems. The Hitachi OEM category was removed.
3. Engines previously listed under Rolls Royce are now listed under Siemens. The Rolls Royce category was eliminated. The RR specs that are no longer available new are now listed under Siemens.

The gas turbine database was updated as shown below. Some of these engine models have been previously released in revisions to TFLOW25.

### Engines added to the database

591 - GE Nova LT16	592 - SIE TRENT 60	593 - SIE TRENT 60 DLE ISI
594 - SIE TRENT 60 DLE	595 - SIE TRENT 60	596 - SIE TRENT 60 WLE
597 - SIE TRENT 60 ISI	598 - ANSALDO GT26 (2006)	599 - GE 7HA.02
601 - SIE SGT6-5000F	602 - GE 7HA.02	603 - GE 7HA.01
604 - GE 9HA.01	605 - GE 9HA.02	606 - GE 9E.04 DLN15
607 - GE 9E.03 DIFF	608 - GE 9E.03 DLN15	609 - GE 7E.03 DLN9
610 - GE 7E.03 MNQC	611 - 7F.05 DLN9	612 - 7F.04 DLN9
613 - GE 9F.04 DLN15	614 - GE 6F.03 DLN15	615 - GE 6B.03 DLN15
616 - MHPS H-100 (100)	617 - MHPS H25 (42)	618 - GE Nova LT5-1
619 - GE MS50002E	620 - MAN GT 6100	621 - SIE SGT-100-1S DLE
622 - SIE TRENT 60WLE	623 - SIE TRENT 60WLE	624 - ANSALDO GT26 (2011)
625 - ANSALDO GT36-S5	626 - ANSALDO GT36-S6	627 - ANSALDO GT26 (2011 High Fog)
628 - SIE SGT5-4000F	629 - SIE SGT5-2000E (41MAC)	630 - SIE SGT5-2000E (33MAC)
631 - SIE SGT5-2000E (25MAC)	632 - SIE SGT5-8000H	633 - SIE SGT6-8000H

### Existing engines with modified performance

280 - MHPS H25 (28)	523 - GE 9F.03 DLN15	266 - SIE SGT-100-1S
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Engines are added to the database as we receive information throughout the year. When new or revised data are available we include it in the revision available from the Service Center.