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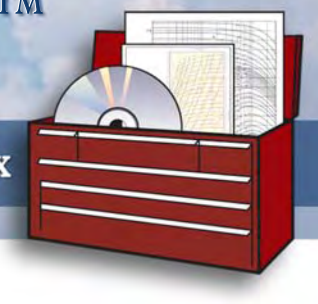
GPCALCS™

The Performance Engineer's Toolbox



Version 6.0

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Equipment Performance Workbooks

This "toolbox" of Microsoft® Excel workbook is organized for convenient data entry and report generation. Using these workbooks, the experienced performance engineer can quickly and accurately calculate equipment efficiencies consistent with industry methodology. Each workbook includes blank worksheets for your own use (test averaging, DDE links, custom reports, etc.). The following performance workbooks are provided:

- Boiler/Air Heater (Coal) Performance
- Boiler/Air Heater (Oil/Gas) Performance
- Compressor Performance
- Condenser Performance
- Controlled Extraction Turbine Performance
- Cooling Tower Performance
- Fan Performance
- Feedwater Heater Performance
- Flow Metering *(New)*
- Gas Turbine Performance *(Updated)*
- Heat Recovery Steam Generator (HRSG) Performance
- Process Compressor Performance
- Pump Performance
- Utility Steam Turbine Performance

Performance Test Protocols

A set of performance test protocols (PTPs) is included for your convenience. These generic protocols are provided in Microsoft Word format and become the basis of a comprehensive test program. Test protocols are provided for:

- Air Heater
- Boiler
- Boiler Feed Pump
- Boiler Feed Pump/Turbine Set
- Compressor
- Cooling Tower
- Feedwater Heater
- Gas Turbine Generator
- HRSG
- Motor Driven Pump
- Steam Surface Condenser
- Utility Steam Turbine Generator

GPGas™ Properties Calculator/Add-In

This tool calculates real gas properties of gases and gas mixtures. Given pressure, temperature, and composition, the calculator provides the following properties based on a user-selectable equation of state:

- Specific Volume
- Enthalpy
- Entropy
- Specific Heat
- Vapor Pressure
- Compressibility
- Isentropic Exponent (Ratio of Specific Heats)

Additionally, a second point can be entered and the calculator will calculate the polytropic head (work), exponent, and efficiency for a compression or expansion process. Available equations of state are the ideal gas, Peng-Robinson (PR), Benedict-Webb-Rubin (BWR), Starling modification of BWR (BWRS), and Soave modification of Redlich-Kwong (RKS). Gas property values are provided in Excel through the GPGas Library DLL.

GPSteam™ Properties Calculator/Add-In

GPSteam—also available as a stand-alone product—provides a convenient means of obtaining thermodynamic properties of water and steam (English or metric) over a wide range of pressures and temperatures. By entering any two state conditions (P, T, h, S, Q), the program returns ten physical properties of the fluid. The calculator provides a user-selectable "switch" to use either the 1967 or 1997 ASME Steam Property formulations. A graphical user interface also displays an active Mollier diagram and enthalpy-drop efficiency calculations for one or more expansion lines. '67 or '97 Steam Tables are provided in Excel through the GPSteam Library DLL.

GPCALCS Library Functions Add-In *(New)*

Additional GPCALCS library functions allow you to calculate the thermodynamic properties of gas turbine exhaust gas, boiler flue gas, or moist air at or near atmospheric pressure.

GP Unit Conversion Library/Add-In

Each workbook allows for automatic engineering unit conversions (both English and metric) for user inputs, as well as any calculated values, using the GP Units Conversion Utility. The Excel add-in eliminates the need to manually search through unit conversion tables.

GP Handy Reference Library

In addition, a GP Handy Reference Library workbook is included that contains the following information:

- Periodic Table of Elements
- Properties of Commercial Pipe
- Typical Coal/Fuel Oil/Natural Gas Analyses
- HHV to LHV Conversion
- Psychrometric Calculator
- Gas Properties Data (over 200 gases)
- Engineering Unit Conversion Utility
- GPSteam Library Functions

Training Seminars

General Physics hopes that the time you save in developing test procedures and conducting the performance calculations can be used effectively to analyze your performance test results for the root cause(s) of any indicated performance deficiencies. We encourage your performance engineers or any of your power or process plant personnel interested in improving efficiency to increase their knowledge and diagnostic skills by attending one of our Performance Knowledge™ Series seminars. Heat rate improvement courses, including Advanced Performance Analysis and Troubleshooting for Power Plants—a case study-based seminar using GPCALCS, are offered for operations, maintenance, entry-level engineers, and experienced power plant engineers as open enrollment or onsite presentations. Visit our website at www.gpworldwide.com/fossil_fuel_courses for information about our training seminars

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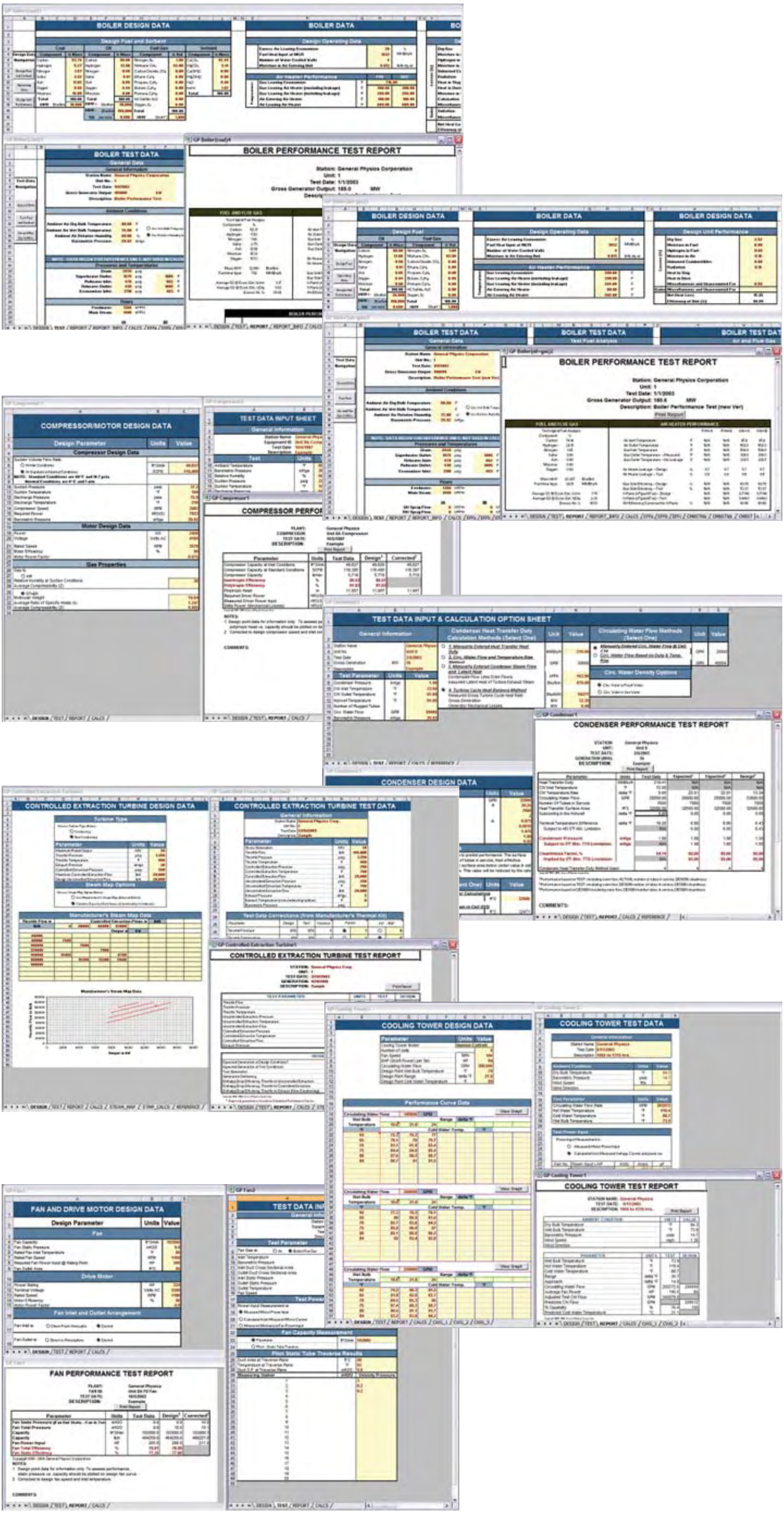
BOILER DESIGN DATA
BOILER DATA
BOILER TEST DATA
BOILER PERFORMANCE TEST REPORT
COMPRESSOR/MOTOR DESIGN DATA
TEST DATA INPUT SHEET
TEST DATA INPUT & CALCULATION OPTION SHEET
CONDENSER PERFORMANCE TEST REPORT
CONDENSER DESIGN DATA
CONTROLLED EXTRACTION TURBINE DESIGN DATA
CONTROLLED EXTRACTION TURBINE TEST DATA
CONTROLLED EXTRACTION TURBINE TEST REPORT
COOLING TOWER DESIGN DATA
COOLING TOWER TEST DATA
COOLING TOWER TEST REPORT
FAN AND DRIVE MOTOR DESIGN DATA
FAN PERFORMANCE TEST REPORT

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The **Boiler/Air Heater (Coal) Performance Workbook** calculates boiler efficiency using the ASME Loss Method. This workbook is applicable to boilers firing solid fuels singly, or with oil or gas supplemental firing. Because the boiler and air heaters are often tested together, this workbook combines performance calculations for both. Calculated values are corrected for standard or reference conditions and compared to design values. In addition, air heater gas-side efficiency and X-ratio performance values are calculated with corrections to exit gas temperature. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Boiler/Air Heater (Oil/Gas) Performance Workbook** calculates boiler efficiency using the ASME Loss Method. This workbook is applicable to boilers firing oil or natural gas or in combination. Because the boiler and air heaters are often tested together, this workbook combines performance calculations for both. Calculated values are corrected for standard or reference conditions and compared to design values. In addition, air heater gas-side efficiency and X-ratio performance values are calculated with corrections to exit gas temperature. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Compressor Performance Workbook** calculates the compressor performance indices of compressor capacity, polytropic head, isentropic and polytropic efficiencies for air or gases, and gas power required. Calculated test values are corrected to design compressor speed and inlet conditions and compared to design values.

The **Condenser Performance Workbook** calculates the expected condenser pressure for the test conditions, cleanliness factor, terminal temperature difference, and condenser heat load (duty). Expected performance is calculated using a model of the condenser based on the HEI standard. Condenser heat load is calculated using one of four different methods. Circulating water flow is either measured or calculated from condenser heat load and measured circulating water temperature rise. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Controlled Extraction Turbine Performance Workbook** calculates the performance of condensing and non-condensing steam turbines typically used in combined cycle cogeneration applications. Depending on turbine type, arrangement, and available instrumentation, performance indices of enthalpy-drop efficiency and/or steam rate are calculated and compared with design values. For controlled extraction or induction turbines, expected output and steam rate are calculated for variations in the extraction or induction flow. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Cooling Tower Performance Workbook** calculates cooling tower capability using the Performance Curve Method of the Cooling Tower Institute. Based on ambient wet bulb temperature, the expected cold water temperature for the given heat loading is predicted. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Fan Performance Workbook** calculates the fan performance indices of brake horsepower, total fan pressure, fan capacity, and static and total efficiencies. Calculated test values are compared to design values based on flow and rated speed and corrected to design fan speed and inlet temperature. These performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

Workbook Summary

The **Feedwater Heater Performance Workbook** calculates feedwater heater terminal temperature difference, drain cooler approach, and feedwater temperature rise. These values, along with extraction flow, are compared to expected values predicted using a detailed model of the feedwater heater. The number of plugged tubes can be readily entered into the original design data to obtain expected performance values for off-design operations. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Flow Metering Workbook** calculates the rate of flow of water or steam from measurements of static pressure, temperature, and differential pressure. It only applies to pressure difference devices in which the flow remains turbulent and subsonic throughout the measuring section, is steady or varies only slowly with time, and the fluid is considered single-phased. Calculations are provided for orifice plates, flow nozzles, and Venturi tubes. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and calculated values.

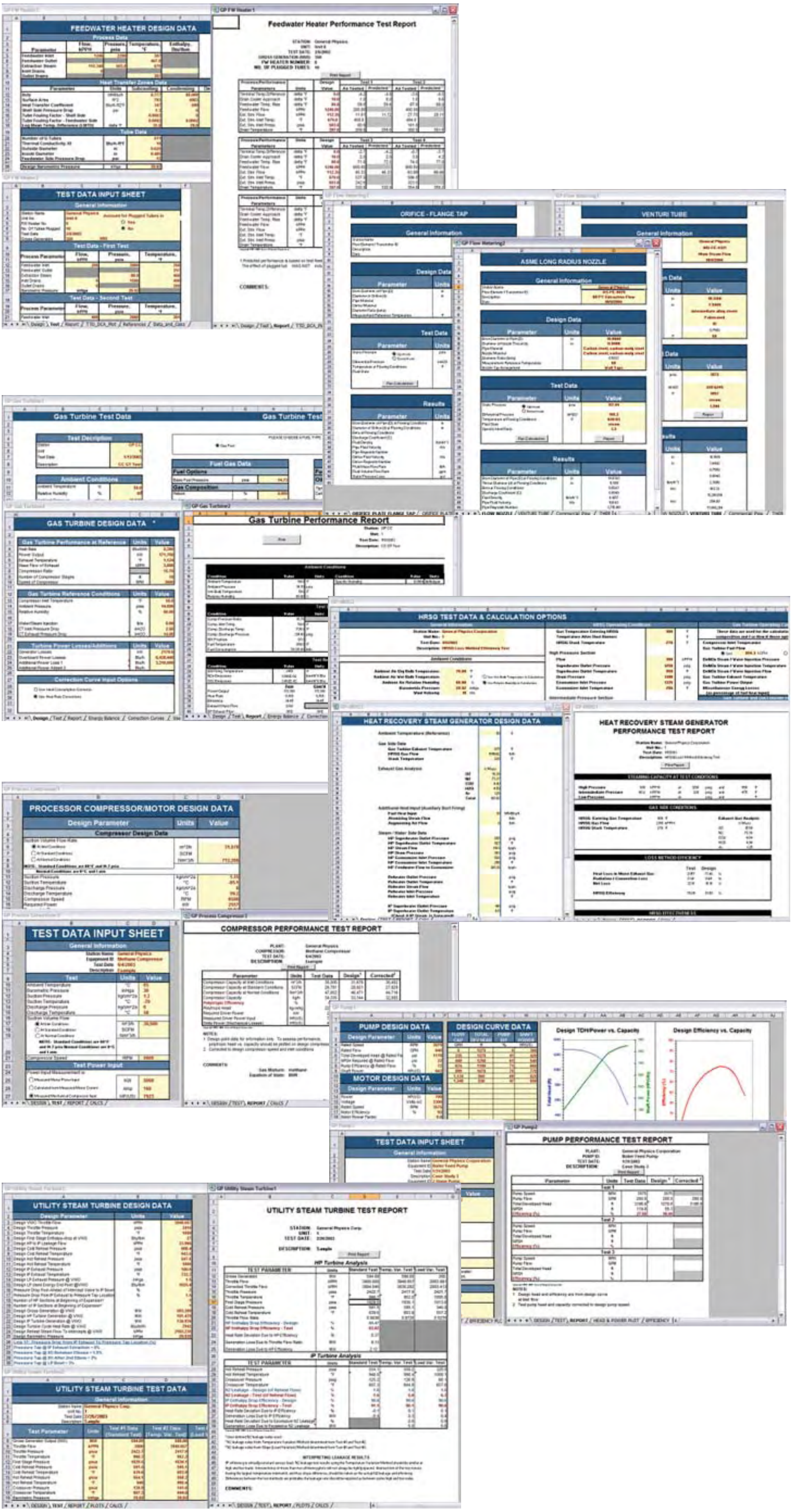
The **Gas Turbine Performance Workbook** calculates gas turbine heat rate, capacity (power output), exhaust mass flow, ISO firing temperature, and compressor isentropic and polytropic efficiencies. Additionally, the workbook calculates flue gas properties, based on the entered gas composition. Calculated test values are corrected to user-defined reference conditions and compared to design values. These performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Heat Recovery Steam Generator (HRSG) Performance Workbook** calculates efficiency using the ASME Thermal Loss Method, along with HRSG effectiveness and steaming capacity. Depending on instrumentation available, performance of individual sections, as well as overall performance, is calculated. Exhaust gas flow is determined using one of four methods. Three options are given for entering the exhaust gas composition used to determine gas enthalpy. Radiation loss used in the Loss Method is calculated using one of three different methods. This workbook can accommodate HRSGs with up to three pressure levels plus a reheater, with or without auxiliary duct firing. Important performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Process Gas Compressor Workbook** calculates the compressor performance indices of compressor capacity, polytropic head, polytropic efficiency for real gases, and gas power required. Real gas properties are calculated using the GPGas Properties Calculator/Add-In. Calculated values are corrected for standard or reference conditions and compared to design values.

The **Pump Performance Workbook** calculates pump total developed head (static + velocity + gravity), net positive suction head (NPSH), and efficiency. Calculated test values are compared to design values based on flow and rated speed, corrected to pump speed and inlet temperature. These performance parameters are automatically displayed and printed in a concise report that compares test, design, and corrected values.

The **Utility Steam Turbine Performance Workbook** calculates the steam turbine performance indices of HP and IP turbine section enthalpy-drop efficiencies. Calculations include the determination of HP to IP steam leakage flow rate for common casing turbines using both the Temperature Variation and Constant Slope Methods. IP section efficiency is calculated and reported with and without the leakage flow. Calculated test values are compared to design values and the effects of any deviations on turbine cycle heat rate and generator capacity are estimated.


FEEDWATER HEATER DESIGN DATA
Feedwater Heater Performance Test Report
TEST DATA INPUT SHEET
ORIFICE - FLANGE TAP
VENTURI TUBE
ASME LONG RADIUS NOZZLE
Gas Turbine Test Data
GAS TURBINE DESIGN DATA
Gas Turbine Performance Report
HRSG TEST DATA & CALCULATION OPTIONS
HEAT RECOVERY STEAM GENERATOR DESIGN DATA
HEAT RECOVERY STEAM GENERATOR PERFORMANCE TEST REPORT
PROCESSOR COMPRESSOR/MOTOR DESIGN DATA
TEST DATA INPUT SHEET
COMPRESSOR PERFORMANCE TEST REPORT
PUMP DESIGN DATA
DESIGN CURVE DATA
MOTOR DESIGN DATA
Design TDH/Power vs. Capacity
Design Efficiency vs. Capacity
TEST DATA INPUT SHEET
PUMP PERFORMANCE TEST REPORT
UTILITY STEAM TURBINE DESIGN DATA
UTILITY STEAM TURBINE TEST REPORT
UTILITY STEAM TURBINE TEST DATA