Contents

Applications Library 12
Type 514: Thermostat Controls 12
Type 515: Heating and Cooling Season Scheduler 12
Type 516: Multiple Day Scheduler 12
Type 517: Single Day Scheduler 12
Type 518: Monthly Scheduler 12
Type 519: Holiday Scheduler 12
Type 520: Multiple Thermostat Controls 13
Combined Heat and Power / CHP Library 14
Steam Properties (new in v18) 14
Type 506: Direct Evaporative Cooler 14
Type 507: Controlled Direct Evaporative Cooling (Fogging) Device 14
Type 508: Cooling Coil (Various Control Modes) 14
Type 591: Load Following Steam Turbine 14
Type 592: Flow Following Steam Turbine 15
Type 593: Steam Condenser (Known Condensing Pressure) 15
Type 594: Steam Flow Diverter 15
Type 595: Steam Mixing Valve 15
Type 596: Steam Pressure Reducing Valve (PRV) 15
Type 598: Steam Condenser (Pinch-point Model) 16
Type 597: Steam Condensate Pump 16
Type 598: Steam Condenser (Pinch-point Model) 16
Type 599: Electrical Generator 16
Type 601: Microturbine with Part-Load Performance (new in v18) 16
Type 602: Gear Box (Efficiency from Data File) 17
Type 603: Constant Efficiency Gear Box 17
Type 605: Imposed Load on a Steam Flow 17
Type 606: Load Removal from a Steam Flow (with Condensate) 17
Type 608: Condensate Preheater – Pinchpoint Method 17
Type 609: Condensate Preheater – Effectiveness Approach 18
Type 610: Steam Desuperheater 18
Type 611: Flash Tank 18
Type 612: Steam Trap or Single Inlet Steam Separator 18
Type 613: Steam Pipe 18

Type 614: Two-Inlet Steam Separator 19
Type 615: Double-Effect Steam-Fired Absorption Chiller (Four-File Format) 19
Type 616: Single-Effect Steam-Fired Absorption Chiller (Two File Data Format) 19
Type 617: Steam Superheater 19
Type 618: Condensate Pump (Flow Rate Not Set) 20
Type 619: Open Feedwater Heater / Deaerating Heater /Open Steam Heater – Steam Flow Calculated 20
Type 620: Fitting Pressure Loss 20
Type 621: Closed Feedwater Heater – Steam Flow Calculated To Achieve User-Designated Outlet Condition 20
Type 622: Closed Feedwater Heater with Drain Cooler – Steam Flow Calculated 21
Type 623: Gas Compressor 22
Type 624: Steam or Water Injection Device 22
Type 625: Gas Turbine With or Without Water Injection (Catalog Data) 22
Type 626: Heat Recovery Hot Water Generator 22
Type 627: Heat Recovery Hot Water Generator with Load Flow Calculated 22
Type 628: Performance Map Full Load Steam Turbine 23
Type 629: Air Compressor (Moist Air Calculations) 23
Type 630: Air Compressor (Dry Air) 23
Type 631: Air Preheater / Air Cooled Intercooler / Regenerator – Theoretical Gas Turbine Systems 23
Type 632: Fluid Cooled Intercooler – Theoretical Gas Turbine Systems 24
Type 633: Combustion Device – Theoretical Gas Turbine Systems 24
Type 634: Turbine Section – Theoretical Gas Turbine Systems 24
Type 635: Steam-Steam Heat Exchanger 24
Type 636: Heat Recovery Steam-Generator 25
Type 637: Heat Recovery Steam-Generator – Maximum Steam Flow 25
Type 638: Steam Boiler (Efficiency as Input) 26
Type 639: Steam Boiler (Efficiency from Data File) 26
Type 640: Feedwater Storage Tank 26
Type 659: Exhaust Gas Supplemental Firing or Proportional Hot Water Boiler 27
Type 682: Heating and Cooling Loads Imposed on a Flow Stream 27
Type 717: Double-Effect Steam-Fired Absorption Chiller (Three-File Format) 27
Type 718: Single-Effect Steam-Fired Absorption Chiller (Trane Data Format) 27
Type 719: Single-Effect Steam-Fired Absorption Chiller (York Data Format) 28
Type 722: Steam Turbine - Load Following with Max Steam Flow 28
Type 907: Internal Combustion Engine / Generator Set 28
Type 981: Steam Accumulator (new in v18) 28

Controls Library 29
Type 658: Humidistat 29
Type 661: Delayed Output Device 29
Type 698: Five Stage Room Thermostat for n Temperatures 29
Type 910: Parallel Staged-Device Controller (new in v18) 29
Type 911: Differential Controller with Lockouts 29
Type 953: Tempering Valve Controller 30
Type 970: N-Stage Differential Heating Controller with Multiple Setpoints, Multiple Deadbands and Time Delay 30
Type 971: N-Stage Differential Cooling Controller with Multiple Setpoints, Multiple Deadbands and Time Delay 30
Type 973: N-Stage Differential Controller with 1 Setpoint, 1 Deadband and Time Delay 30
Type 974: N-Stage Differential Controller with 1 Setpoint, 2 Deadbands, Minimum Run Time, and Time Delay 30
Type 975: Switched Value Holder (new in v18) 30
Type 980: On/Off Time Calculator 30
Type 1233: Thermostatic Control with Specified Run-Time 30
Type 1250: Outside Air Reset Controller 31
Type 1325: Lead/Lag Source Selector (new in v18) 31
Type 1328: Triggered Input Delay (new in v18) 31
Type 1329: Ideal Combination Selector (new in v18) 31
Type 1502: N-Stage Heating Aquastat or Simple Thermostat 31
Type 1503: N-Stage Cooling Aquastat or Simple Thermostat 31
Type 1504: Trip Timer (new in v18) 31
Type 1505: Event Counter (new in v18) 31
Type 1506: Multi-Monitoring Temperature Controller (new in v18) 31
Type 1669: Proportional Controller 32
Electrical Library 33
Type 549: Lithium-ion Battery (new in v18) 33
Type 551: Photovoltaic Array Shading 33
Type 554: Flywheel Energy Storage System (new in v18) 33
Type 560: Unglazed Combined PV/T Solar Collector 34
Type 562: Simple Glazed or Unglazed PV Panel 34
Type 563: Unglazed Combined PV/T Solar Collector (Interacts w/ Type 56) 34
Type 566: Glazed Building-Integrated PV System (Interacts w/ Zone Air Temperature) 34
Type 567: Glazed Building-Integrated PV System (Interacts w/ Type 56) 35

Type 568: Un-Glazed Building-Integrated PV System (Interfaces w/ Type 56) ... 35
Type 569: Un-Glazed Building-Integrated PV System (Interfaces w/ Zone Air Temperature) ... 35
Type 590: Simple PV Panel with PCM Layer and Embedded Heat Exchanger (new in v18) ... 36
Type 723: Inverter (new in v18) ... 36
Type 724: Power Optimizer / Voltage Converter (new in v18) ... 36
Type 726: Proportional Lighting Controller ... 36
Type 727: Continually Stepped Light Fixtures ... 36
Type 728: Multiple Power Level Lights ... 37
Type 1236: Planned and Random Down Times ... 37
Type 1340: Carnot Heat Engine (new in v18) ... 37
Type 1343: Combined PV/T Solar Collector ... 37
Ground Coupling Library ... 38
Type 653: Simple Floor Heating System ... 38
Type 714: ASHRAE Slab Heat Transfer ... 38
Type 715: ASHRAE Basement Heat Transfer ... 38
Type 957: Soil Wrapper for Buried Rectangular Storage Tank ... 38
Type 993: Detailed Radiant Floor ... 38
Type 1244: User-Mapped Slabs and Basement Model ... 39
Type 1255: Monolithic Slabs for Non-Type56 Buildings ... 39
Type 1256: Slabs, Basements, and Crawlspaces for Non-Type56 Buildings ... 39
Type 1301: Soil Wrapper for Buried Inverted Truncated Conical Storage Tank (new in v18) ... 39
Type 1302: Soil Wrapper for Buried Vertically Cylindrical Storage Tank (new in v18) ... 39
Geothermal Heat Pump Library ... 40
Type 548: Vertical Ground Heat Exchanger (multi-instance compatible) (new in v18) ... 40
Type 557: Vertical Ground Heat Exchanger ... 40
Type 951: Buried Noded Twin Pipe ... 40
Type 952: Buried Noded Pipe ... 41
Type 997: Horizontal Ground Heat Exchanger ... 41
Type 999: Horizontal Ground Heat Exchanger (multi-instance compatible) (new in v18) ... 41
Type 1330: District Loop Buried Pipe (new in v18) ... 41
High Temperature Solar Library ... 43
Type 1257: Parabolic Trough Solar Collector ... 43
Type 1258: Flow Diverter ... 43
Type 1259: Field Pipes ... 43
Type 1260: Mixing Valve ... 43

Type 1261: Expansion Tank 43
Type 1262: Array Shading 43
Type 1263: Variable Speed Pump 43
HVAC Library 44
Type 506: Direct Evaporative Cooler (Swamp Cooler) 44
Type 507: Controlled Direct Evaporative Cooling Device (Fogging Device) 44
Type 508: Cooling Coil with Various Control Modes 44
Type 510: Closed Circuit Cooling Tower 44
Type 511: Dry Fluid Cooler 44
Type 525: Variable Speed Compressor Air (Source) -to-Water Heat Pump (Performance Map; Humidity Effects Neglected) (new in v18) 45
Type 526: Heat Emitter / Simple Radiator (new in v18) 45
Type 527: Auxiliary Boiler with Thermal Capacitance (new in v18) 45
Type 600: Two-Pipe Fan Coil (Mass Flow Parameters) 45
Type 641: Simple Adiabatic Humidifier 45
Type 651: Residential Cooling Coil (Air Conditioner) – Performance Map Method, Separate File Format 46
Type 655: Air Cooled Chiller 46
Type 659: Auxiliary Fluid Heater with Proportional Control (Proportional Boiler) 46
Type 663: Electric Unit Heater with Variable Speed Fan and Proportional Control 46
Type 664: Electric Unit Heater with Variable Speed Fan, Proportional Control, and Damper Control 46
Type 666: Water Cooled Chiller 46
Type 667: Air To Air Heat Recovery Device 46
Type 670: Air Heating Coil (Keeps the Outlet Air Temperature below a User-Specified Setpoint) 47
Type 673: Two Pipe Console Unit in Energy Rate Control 47
Type 676: Double-Effect Steam-Fired Absorption Chiller 47
Type 677: Double-Effect Hot Water-Fired Absorption Chiller 47
Type 678: Double-Effect Direct-Fired Absorption Chiller 47
Type 679: Single-Effect Steam-Fired Absorption Chiller 47
Type 681: Single-Effect Direct-Fired Absorption Chiller 48
Type 684: Air Side Economizer 48
Type 688: Dehumidifier 48
Type 689: Heat Pipe 48
Type 692: Performance Map Fluid Cooler 48
Type 696: Air Stream Conditioning Device 48
Type 697: Performance Map Cooling Coil 48

Type 700: Simple Boiler with Efficiency Inputs 49
Type 716: Rotary Desiccant Dehumidifier 49
Type 751: Simple Boiler with Efficiency from Data File 49
Type 752: Simple Cooling Coil with Various Control Modes 49
Type 753: Heating Coil with Various Control Modes 50
Type 754: Heater/Humidifier 50
Type 757: Indirect Evaporative Cooler 50
Type 760: Air To Air Sensible Heat Exchanger 50
Type 762: Steam Humidifier (Various Control Modes) (new in v18) 50
Type 779: Active Chilled Beam (new in v18) 50
Type 781: Simple Air-Cooled Chiller Stack (new in v18) 51
Type 786: Variable Speed Compressor Air (source) to Air Heat Pump – One Indoor Unit per Outdoor Unit (new in v18) 51
Type 787: Simple Water-Cooled Chiller Stack (new in v18) 51
Type 788: Simple Boiler Stack (new in v18) 51
Type790: Multi-Rejection (Natatorium) Dehumidifier (new in v18) 51
Type 791: Simple Electric Baseboard Heater (new in v18) 51
Type 792: Hot Water Radiator (Correction Factor Method) (new in v18) 51
Type 793: Variable Speed Compressor Water (Source) to Air Heat Pump (new in v18) 52
Type 909: Adsorption Chiller (Performance Map) 52
Type 917: Air to Water Heat Pump (Air Humidity Effects Estimated) 52
Type 918: Multi-Mode Dehumidifier 52
Type 919: Water Source Heat Pump 52
Type 921: Residential Cooling Coil (Air Conditioner) – Unified File Format 53
Type 922 Two Speed Air-to-Air Heat Pump (Performance Map) 53
Type 923: Two-Speed Residential Cooling Coil (Air Conditioner) 53
Type 927: Normalized Water-to-Water Heat Pump (Performance Map) 53
Type 928: Two-Pipe Fan Coil (Volumetric Flow Parameters) 54
Type 929: Simple Gas Fired Heating Coil 54
Type 930: Simple Electric Heating Coil 54
Type 941: Air-to-Water Heat Pump (Performance Map; Humidity Effects Neglected) 54
Type 954: Air-to-Air (Air Source or Split System) Performance Map Heat Pump 54
Type 987: 4-Pipe Fan Coil (Performance Map) 54
Type 995: Performance Map Cooling Coil - Unified File Format 55
Type 996: 2-Pipe Fan Coil (Performance Map) 55

Type 1221: Two-Stage Water-to-Water Heat Pump (Performance Map) 55
Type 1225: Rotary Desiccant Dehumidifier (Performance Map) 55
Type 1231: Hydronic Heat-Distributing Unit (Radiator) 55
Type 1246: Auxiliary Cooler 55
Type 1247: Water Source Heat Pump Section of an Air Handler 56
Type 1248: Air to Air Heat Pump Section of an Air Handler 56
Type 1305: Heat Recovery Chiller (new in v18) 56
Type 1320: Water Cooled Chiller Stack (Variable Condenser Flow) (new in v18) 56
Type 1323: Variable Speed Compressor Water (Source) to Water Heat Pump (new in v18) 56
Type 1324: Heating-Only Variable Speed Compressor Water (Source) to Water Heat Pump with Flow Modulation (new in v18) 56
Type 1327: Heat Pump based on the Lorenz Cycle (new in v18) 57
Type 1332: Counter Flow HX that takes Design Conditions and Works out UA; Multiple Control Modes (new in v18) 57
Type 1333: Temperature Limiting Device / Pressure Relief Valve (new in v18) 57
Type 1337: Sensible Only Heat Exchanger; Effectiveness Input, Multiple Control Modes (new in v18) 57
Type 1338: Heat Recovery Chiller Stack (Identical Chillers) (new in v18) 57
Type 1339: Detailed Heat Recovery Chiller Stack (Non Identical Chillers) (new in v18) 57
Type 1344: Electric Thermal Storage (Ceramic Brick) – Air Version (new in v18) 58
Type 1369: Electric Thermal Storage (Ceramic Brick) – Liquid Version (new in v18) 58
Type 1716: Rotary Desiccant Dehumidifier with Process Air Humidity Control 58
Hydronics Library 60
Type 604: Bi-Directional Noded Pipe 60
Type 607: Air Duct (Thermal Model) 60
Type 642: Single Speed Fan 60
Type 643: Closely Spaced Tees (new in v18) 60
Type 644: Two Speed Fan/Blower 60
Type 646: Air Supply Plenum With Up To 100 Ports 61
Type 647: Flow Diverter With Up To 100 Ports 61
Type 648: Air Return Plenum With Up To 100 Ports 61
Type 649: Flow Mixer With Up To 100 Ports 61
Type 662: Variable Speed Fan/Blower 61
Type 695: Variable Speed Pump, Control Signal, Power from Head and Desired Flow Rate 61
Type 709: Pipe (U Value Calculated From Physical Characteristics) 61
Type 740: Constant Speed Pump, Control Signal, Power Calculated From Pressure Rise and Pump Efficiency 62

Type 741: Variable Speed Pump, Control Signal, Power Calculated From Pressure Rise and Pump Efficiency.. 62
Type 742: Pump with Mass Flow Input, Power from Pressure Rise and Pump Efficiency 62
Type 743: Pump with Mass Flow Input, Power from Power Curve Polynomial.. 62
Type 744: Variable Speed Fan, Mass Flow Input, Power from Power Curve Polynomial 62
Type 745: Pump with Mass Flow from Available Power, Power from Pressure Rise and Pump Efficiency........ 63
Type 746: Pump with Mass Flow from Available Power, Power Calculated from Power Curve........................ 63
Type 747: Constant Speed Pump, Mass Flow Rate from System Curve and Head Curve 63
Type 748: Variable Speed Pump, Desired Mass Flow as Input, Power from System Curve and Head Curve..... 63
Type 749: Variable Speed Pump, Power Input, Match System Curve and Head Curve 63
Type 750: Variable Speed Pump, Fraction of Rated Speed Input, Power from System Curve and Head Curve. 64
Type 784: Pipe with Heating Cable (new in v18)... 64
Type 924: Two-Speed Fan/Blower (Volumetric Flow Parameters) 64
Type 926: Variable-Speed Fan/Blower (Volumetric Flow Parameters).. 64
Type 976: Two-Speed Pump (Mass Flow) 64
Type 977: Variable Speed Pump, Volumetric Flow, Power Curve Polynomial.. 65
Type 978: Variable Speed Pump-Diverter Combo... 65
Type 983: Variable Speed Pump Bank (new in v18).. 65
Type 1336: Hydronic Hub (new in v18) 65

Loads and Structures Library.. 66

Type 660: Lumped Capacitance Multizone Building 66
Type 682: Heating and Cooling Loads Imposed on a Flow Stream 66
Type 686: Synthetic Building Loads Generator 66
Type 687: NFRC Window 66
Type 690: Energy Rate Control Loads Conversion... 66
Type 693: Loads Imposed on an Air Stream 67
Type 759: Lumped Capacitance Multizone Building with no Controls... 67
Type 780: Evapotranspiration (Penman-Monteith Algorithm) (new in v18) 67
Type 782: Adaptive Comfort Calculator (new in v18) 67
Type 912: Open Window Controller.. 67
Type 936: Refrigerator.. 67
Type 963: Lumped Capacitance.. 68
Type 1227: Stack Flow 68
Type 1367: Core/Shell Lumped Capacitance Model with Liquid Heat Exchange Core/Shell Lumped Capacitance Model with Liquid Heat Exchange (new in v18)... 68

Type 1368: Core/Shell Lumped Capacitance Model with Liquid Heat Exchange Core/Shell Lumped Capacitance Model with Air Heat Exchange (new in v18) 68
Type 2280: Latent Load Calculator 68
Optimization Library 69
Type 758: TRNOpt Printer 69
Type 778: Error Function Calculator (new in v18) 69
Type 783: RMSE Calculator / Calibration Analyzer (new in v18) 69
Solar Library 70
Type 543: Single Cover Top Loss Model 70
Type 544: Double Cover Top Loss Model 70
Type 546: Radiation Splitter 70
Type 1252: Surface Shading for Beam Radiation 70
Type 1262: Concentrating Collector Shading 70
Type 1286: Solar Collector, ISO Standard 9806:2017 (9-Parameter Eqn.), 1-D IAMs (new in v18) 71
Type 1287: Solar Collector, ISO Standard 9806:2017 (9-Parameter Eqn.), 2-D IAMs (new in v18) 71
Type 1345: Solar Collector, ISO Standard 9806:2013 (3-Parameter Eqn.) with 2-D IAMs (new in v18) 71
Type 1346: Solar Collector, ISO Standard 9806:2013 (3 Parameter Eqn.) with 1-D IAMs (new in v18) 71
Type 1347: Un-Glazed Solar Collector, 1-D IAMs, Linear/Quadratic Efficiency Equation (new in v18) 72
Type 1348: Un-Glazed Solar Collector with 1-D IAMs (new in v18) 72
Type 1349: Solar Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D IAMs (new in v18) 72
Type 1350: Solar Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D IAMs (new in v18) 73
Type 1351: Concentrating Collector, 3-Parameter Eqn., Direct Normal Radiation, 2-D IAMs (new in v18) 73
Type 1352: Concentrating Collector, 3-Parameter Eqn., Direct Normal Radiation, 1-D IAMs (new in v18) 73
Type 1353: Concentrating Collector, 3-Parameter Eqn., 2-D IAMs (new in v18) 74
Type 1354: Concentrating Collector, 3-Parameter Eqn., 1-D IAMs (new in v18) 74
Type 1355: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D IAMs (new in v18) 75
Type 1356: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D IAMs (new in v18) 75
Type 1357: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D Direct IAMs, Constant Diffuse IAMs (new in v18) 75
Type 1358: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D Direct IAMs, Constant Diffuse IAMs (new in v18) 75
Type 1359: Tubular Integral Collector Storage (ICS) System with 2-D IAMs (new in v18) 76
Type 1360: Tubular Integral Collector Storage (ICS) System with 1-D IAMs (new in v18) 76
Type 1361: Glazed Flat Plate Collector, Theoretical, Serpentine Riser Tubes (new in v18) 76
Type 1362: Glazed Flat Plate Collector, Theoretical, Simplified Top Losses (new in v18) 77
Type 1363: Glazed Flat Plate Collector, Theoretical, Standard Risers, Two Covers (new in v18) 77

Type 1364: Glazed Flat Plate Collector, Theoretical, Standard Risers, One Cover (new in v18) 77
Type 1365: Unglazed Air Heating Collector (new in v18) 78
Type 1366: Unglazed Flat Plate Collector, Theoretical (new in v18) 78
Thermal Storage Library 79
Type 529: Tank-in-Tank with Immersed Heat Exchangers (new in v18) 79
Type 938: Heat Pump Water Heater (Liquid Flow) 79
Type 940: Tankless Water Heater 79
Type 959: Heat Pump Water Heater (Storage Tank) (new in v18) 79
Type 1229: Gas Heating Device for Liquid Storage Tanks (new in v18) 79
Type 1237: Cylindrical Storage Tank with Wrap-Around Heat Exchanger and Dip Tube 79
Type 1239: Single Element Electric Heating Device for Liquid Storage Tanks (new in v18) 80
Type 1240: Dual-Element Electric Heating Device for Liquid Storage Tanks (new in v18) 80
Type 1334: Simple Ice Storage Tank with Immersed Constant Effectiveness Heat Exchanger(s) (new in v18) .. 80
Type 1531: Flat Bottom Storage Tank with Immersed Heat Exchanger 80
Type 1532: Spherical Storage Tank with Immersed Heat Exchanger 80
Type 1533: Horizontal Cylindrical Storage Tank with Immersed Heat Exchanger 81
Type 1534: Vertical Cylindrical Storage Tank with Immersed Heat Exchanger 81
Type 1535: Inverted Conical Storage Tank with Immersed Heat Exchanger (new in v18) 81
Type 1536: Inverted Truncated Rectangular Pyramid Storage Tank with Immersed Heat Exchanger (new in v18) 82
Type 1537: Horizontal Cylinder with Loss Coefficients as Inputs (new in v18) 82
Utility Library 83
Type 535: Triggered Printer 83
Type 546: Total Radiation Splitter (new in v18) 83
Type 571: Infiltration into a Conditioned Zone (K1, K2, K3 Method) 83
Type 572: Equipment Fouling 83
Type 573: Output Device for Average Day of Each Month 83
Type 574: ASHRAE Occupancy Loads 83
Type 575: Sky Temperature 84
Type 576: Two Dimensional Bin Sorter 84
Type 577: Random Number Generator (Uniform Distribution) 84
Type 578: Random Number Generator (Normal Distribution) 84
Type 579: Nested Forcing Function 84
Type 581: Multidimensional Data Interpolation 84
Type 582: Life Cycle Cost Analysis 85

Type 584: Out of Setpoint /Zone Temperature Watcher 85
Type 586: Pressure Drop Calculator 85
Type 932: Sherman Grimsrud Infiltration 85
Type 939: Running Average Calculator 86
Type 960: Lawrence Berkeley National Labs Infiltration Model 86
Type 980: On/Off Time Calculator 86
Type 1232: Flat-Plate Convection Calculator 86
Type 1236: Planned and Random Equipment Outages 86
Type 1238: Simulation Event Alert 86
Type 1243: Water Draw Profile (as Parameters) 87
Type 1251: Water Draw Profile (from Data File) 87
Type 1252: Beam Shading Calculator 87
Type 1299: Sums Inputs and Produces One Output 87
Type 1316: Component Output Summary (new in v18) 87
Type 1317: Category Aggregator 87
Type 1331: Plume Predictor (new in v18) 88
Type 1370: Min/Max Calculator with Control Signal (new in v18) 88
Type 1576: Two Dimensional Bin Sorter – Integrating 88
Type 2260: Wind Speed Converter 88

Applications Library

Type 514: Thermostat Controls

The Thermostat Controls utility program (Setpoints.exe) and the companion component Type514 are used in conjunction with one another to define a set point schedule that stays the same regardless of the day of the week. A set point schedule consists of a heating set point and setback temperature, a cooling set point and setup temperature, and the hours during which they apply. While this documentation has been written using temperature set points as an example, it should be noted that there is nothing inherent about the Setpoints programs that force it to be used only for temperatures. It should also be noted that the difference between Type520 and Type514 is that Type520 allows for differing schedules during weekdays, on Saturdays and on Sundays while Type514 applies the same schedule regardless of the day of the week.

Type 515: Heating and Cooling Season Scheduler

The Heating and Cooling Season Scheduler utility program SeasonsScheduler.exe and its companion component Type515 are used in conjunction with one another to input a heating/cooling season schedule. A heating/cooling schedule denotes which portions of the year when heating or cooling (or both) equipment may be utilized.

Type 516: Multiple Day Scheduler

The Multiple Schedules utility program MultSched.exe and TRNSYS Type516 are used in conjunction with one another to input schedules with a Weekday, Saturday, and Sunday basis. It should be noted that while temperature notation is used throughout this documentation, there is no inherent reason why Type516 cannot be used to schedule any type of data desired by the user. Type516 differs from Type517 only in that it allows for different schedules to be set for weekdays, Saturdays and Sundays. Type517 applies the same schedule regardless of the day of the week.

Type 517: Single Day Scheduler

The Daily Schedule utility program Sched.exe and Type517 are used in conjunction with one another to input a 24-hour schedule. The same schedule is repeated for every day of the simulation. It should be noted that while temperature notation is used throughout this documentation, there is no inherent reason why Type517 cannot be used to schedule any type of data desired by the user. Type517 differs from Type516 only in that it does not allow for different schedules to be set for weekdays, Saturdays and Sundays. Type517 applies the same schedule regardless of the day of the week.

Type 518: Monthly Scheduler

Type518 is a forcing function that is set up to automatically provide a value for each calendar month of a simulation. It reads its monthly values from an external (text based) data file. However, it is designed to work in conjunction with an app called MonthlySchedule.exe. MonthlySchedule is a graphical interface that allows the user to set monthly values using sliders and to write the external file that Type518 requires.

Type 519: Holiday Scheduler

The Holiday Scheduler utility program Scheduler.exe and TRNSYS Type 519 are used in conjunction with one another to input and read a holiday schedule. A holiday schedule denotes which days of the year are holidays. This type of schedule is very useful when trying to match the actual operation of a building or calibrate a simulation to measured data or when switching between “occupied” and “unoccupied” building schedules.

Type 520: Multiple Thermostat Controls

The Multiple Thermostat Controls utility program MultThermoSched and its companion component Type520 are used in conjunction with one another to define a set point schedule that changes based on a weekday, Saturday, and Sunday basis. A set point schedule consists of a heating set point and setback temperatures, a cooling set point and setup temperatures, and the hours during which they apply. While this documentation has been written using temperature set points as an example, it should be noted that there is nothing inherent about that MultThermoSched program that forces it to be used only for temperatures. It should also be noted that the difference between Type520 and Type514 is that Type520 allows for differing schedules during weekdays, on Saturdays and on Sundays while Type514 applies the same schedule regardless of the day of the week.

Combined Heat and Power / CHP Library

Steam Properties (new in v18)

Many of the components in this library require steam property data. The TRNSYS Steam_Properties() routine will return steam temperature, pressure, enthalpy, entropy, quality, specific volume, and internal energy based on two of those properties. TRNSYS's native steam property routines are computationally fast but they are not always the most robust routines and at times they will return errors. The National Institute of Standards and Technology (NIST) wrote and published a set of steam routines that are much more robust than the native TRNSYS routines. With the release of the TESSLibs 18.0 users have an option as to whether TRNSYS will use its native routines or the NIST routines. The way that a given Type calls the steam properties routine does not change at all. There is, therefore, no need to modify existing components. The switch is made through the use of a TRNSYS keyword. If the following appears in the TRNSYS input file then the native TRNSYS routines will be used:

STEAM 1

If, alternatively, the following appears in the TRNSYS input file then the NIST steam routines will be used:

STEAM 2

As a side note, if no "STEAM" keyword is found in the input file then TRNSYS will use its native routines.

Type 506: Direct Evaporative Cooler

Type506 models an evaporative cooling device for which the user supplies the inlet air conditions and the saturation efficiency and the model calculates the outlet air conditions. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature. The device is not equipped with controls that monitor the conditions of the outlet air. When the device is ON (based on a user supplied control signal value), Type506 cools the air as much as it can, given the entering conditions and the device efficiency. If a controlled evaporative cooling device is more appropriate to the user's circumstances, Type507 may be used. Type507 models a similar direct evaporative cooling device but takes a target air outlet relative humidity.

Type 507: Controlled Direct Evaporative Cooling (Fogging) Device

Type507 models an evaporative cooling device for which the user supplies the inlet air conditions and a target air outlet relative humidity. The outlet air dry bulb temperature is modulated given to achieve the desired outlet relative humidity. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature.

Type 508: Cooling Coil (Various Control Modes)

Type508 models a cooling coil using one of four control modes. The cooling coil is modeled using a bypass approach in which the user specifies a fraction of the air stream that bypasses the coil. The remainder of the air stream is assumed to exit the coil at the average temperature of the fluid in the coil and at saturated conditions. The two air streams are remixed after the coil. In its unrestrained (uncontrolled) mode of operation, the coil cools and dehumidifies the air stream as much as possible given the inlet conditions of both the air and the fluid streams. The model is alternatively able to internally bypass fluid around the coil so as to maintain the outlet air dry bulb temperature above a user specified minimum, to maintain the air outlet absolute humidity ratio above a user specified minimum or to maintain the fluid outlet temperature below some user specified maximum.

Type 591: Load Following Steam Turbine

This model simulates a non-condensing steam turbine that meets a user-specified electrical load by varying the mass flow rate of steam entering the turbine. Since the model calculates the required steam flow at turbine inlet, the INPUT steam flow rate to the model is not used except as a mass balance check upon convergence at each time step. This model relies on an isentropic efficiency approach and the turbine back-pressure (pressure of exhaust steam) to calculate the performance of the steam turbine given the steam inlet conditions. Users are able to specify up to 5 injection and 5 extraction ports along the length of the turbine although by recompiling the code they are able to increase those limits. The steam conditions at these ports may be provided in any order to the model - the type will arrange them correctly based on the pressure of the streams. The turbine will automatically place the injection and extraction streams at the correct locations along the turbine to match the pressures of the streams with the local pressure of the turbine. The delivered output power from the turbine is limited by the capacity of the turbine (a parameter). Specifying a required power (as one of the inputs) greater than the capacity of the machine will cause the machine to operate at its rated capacity and report the load not met.

Type 592: Flow Following Steam Turbine

This model simulates a non-condensing steam turbine that takes a user-specified inlet steam flow and calculates the total electrical load that the turbine can meet. This model relies on an isentropic efficiency approach and the turbine back-pressure (pressure of exhaust steam) to calculate the performance of the steam turbine given the steam inlet conditions. Users are able to specify up to 5 injection and 5 extraction ports along the length of the turbine although by recompiling the code they are able to increase those limits. The steam conditions at these ports may be provided in any order to the model - the type will arrange them correctly based on the pressure of the streams. The turbine will automatically place the injection and extraction streams at the correct locations along the turbine to match the pressures of the streams with the local pressure of the turbine. The delivered output power from the turbine is limited by the capacity of the turbine (a parameter).

Type 593: Steam Condenser (Known Condensing Pressure)

This component models a condenser for steam applications where the condensing pressure is known and provided to the model as an input. This model calculates the resultant heat transfer and outlet steam conditions given the desired degrees of subcooling leaving the condenser (provided by the user). The outlet steam pressure is set to the condensing pressure even when the flow rate is zero to avoid convergence problems in components that rely on this model to set the back-pressure for the steam flow loop.

Type 594: Steam Flow Diverter

Type594 models a diverting valve that splits a steam inlet mass flow into fractional outlet mass flows. One inlet flow may be split into as many as 100 individual streams. The limit of 100 inlet flows can be modified in the FORTRAN source code.

Type 595: Steam Mixing Valve

This component models a simple steam mixing valve which can have up to 100 separate inlet ports. The outlet fluid properties are set by an overall energy balance on the inlet flow streams, assuming that each of the inlet streams adiabatically expands to the pressure of the lowest pressure inlet fluid (ports with flow only). The outlet mass flow rate is simply the sum of the inlet flow rates.

Type 596: Steam Pressure Reducing Valve (PRV)

This component models a steam pressure-reducing valve. The steam entering the valve adiabatically expands to the user-specified outlet pressure. If the desired outlet pressure is above the inlet steam pressure the steam passes through the device without a change in state.

Type 598: Steam Condenser (Pinch-point Model)

This component models a steam condenser for which the condensing pressure is not known but the pinch-point temperature difference is known. The component relies on the pinch-point temperature difference approach to solve for the heat transfer between the condensing steam and the cooling liquid. The saturation pressure of the steam is calculated such that the pinch-point temperature is just reached at the critical location in the condenser. For parallel flow applications, the pinch-point occurs at the outlet of the steam (and therefore at the outlet of the cooling fluid) stream. For counter-flow applications, the pinch-point can occur at one of four locations; the steam inlet (and cooling fluid outlet), the steam saturated vapor point, the steam saturated liquid point, or the steam outlet (cooling fluid inlet). The pinch-point is defined as the smallest temperature difference between the steam and the cooling fluid stream.

Type 597: Steam Condensate Pump

This component models a steam condensate pump. The user specifies the inlet steam condensate conditions and the desired outlet pressure and the model calculates the theoretical power from a compressed liquid calculation. The actual power is found by dividing the theoretical power by the pump efficiency. A user-supplied fraction of the actual pump power is assumed to be lost from the pump shell to the surroundings while the remaining energy ends up as an energy gain to the fluid. This model sets the flow rate for a steam loop by multiplying the rated pump flow rate (a parameter) by the input control signal (an input). The input flow rate to this model is used only for convergence checking.

Type 598: Steam Condenser (Pinch-point Model)

This component models a steam condenser for which the condensing pressure is not known but the pinch-point temperature difference is known. The component relies on the pinch-point temperature difference approach to solve for the heat transfer between the condensing steam and the cooling liquid. The saturation pressure of the steam is calculated such that the pinch-point temperature is just reached at the critical location in the condenser. For parallel flow applications, the pinch-point occurs at the outlet of the steam (and therefore at the outlet of the cooling fluid) stream. For counter-flow applications, the pinch-point can occur at one of four locations; the steam inlet (and cooling fluid outlet), the steam saturated vapor point, the steam saturated liquid point, or the steam outlet (cooling fluid inlet). The pinch-point is defined as the smallest temperature difference between the steam and the cooling fluid stream.

Type 599: Electrical Generator

This component models an electrical generator; a device that creates electrical power from the rotational motion of a spinning input shaft. The efficiency of the device is read from a data file as a function of the load on the device at the current time.

Type 601: Microturbine with Part-Load Performance (new in v18)

A microturbine is a small combustion turbine that produces both heat and electricity on a relatively small scale, typically on the order of 25 to 500 kW of electricity at rated load. This component models the part-load performance of a microturbine.

The model relies on the following parameters at rated conditions: electric power, turbine inlet and outlet temperature, compressor pressure ratio, recuperator effectiveness (if a recuperator is used), and isentropic efficiency of the compressor. Turbine and compressor part-load performance are characterized by a set of dimensionless coefficients; values for these coefficients may be optimized by comparing the model to part-load data. The model is driven by the desired electrical output of the microturbine, as well as the ambient temperature and pressure supplied at the microturbine inlet. Outputs of the model include pressure and temperature at all state points of the microturbine, as well as microturbine electrical efficiency, isentropic efficiency of the turbine and compressor at part load, recuperator effectiveness (if a recuperator is used) at part load, and air and fuel mass flowrates through the microturbine at part load.

This is a steady-state (equilibrium) model; there is no thermal capacitance modeled in any component of the microturbine.

Type 602: Gear Box (Efficiency from Data File)

This component models a mechanical gearbox. The user provides the rated rotational speed, the input rotational speed and the input power and the model calculates the efficiency of the gear box by interpolating from a user-supplied data file of gearbox efficiency as a function of the fraction of the rated speed.

Type 603: Constant Efficiency Gear Box

This component models a mechanical gear box. The user provides the input power and the gearbox efficiency from which the output power and thermal losses can be found. The outlet rotational speed is found by dividing the inlet rotational speed by the gear ratio. The gear box efficiency is assumed to be constant in this model; Type602 may be used to model a gear box whose efficiency is a function of the input shaft speed

Type 605: Imposed Load on a Steam Flow

This component models a heating load imposed on a flow of steam. The user must specify the inlet steam conditions, the load to be imposed, and the outlet steam pressure. The model will remove the specified amount of energy from the steam flow, checking to make sure that the outlet steam temperature is above the minimum user-specified temperature (for pinch-point calculations etc.). If the calculated outlet temperature falls below the user-specified minimum temperature, the steam exits at the user-specified minimum temperature and the load-met and load-not-met are calculated by the model. This component is commonly used to model a steam load device where the physics of the device are not important to the simulation and only the removal of the correct amount of energy from the system is important.

Type 606: Load Removal from a Steam Flow (with Condensate)

This component models a simple steam end-use device. The user must specify the inlet steam conditions, the outlet steam conditions, and the fraction of steam flow (usually condensate) that will be returned by the system. This component is useful for modeling a complicated device like a steam absorption chiller or a detailed building steam heating and distribution system without having to model the physics of the detailed heat transfer in the device. The model calculates the amount of useful energy consumed by the load, the amount of energy that is dumped to the environment by the failure to return a fraction of the steam (usually condensate), and the total energy removal from the steam flow (sum of useful energy and dumped energy).

Type 608: Condensate Preheater – Pinchpoint Method

This component models a pre-heater for steam condensate using the pinch-point temperature difference approach. In typical applications waste heat is used to elevate the temperature of a condensate stream before it enters the heat recovery steam generator. In this model the inlet hot-side fluid attempts to heat a flow of steam condensate to a user-specified temperature just below the condensate saturation temperature. The model may operate in one of two heat exchanger configuration modes: parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model attempts to elevate the steam condensate to the user-specified condition by checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered the outlet condensate conditions are re-calculated to alleviate the problem and the outlet condensate leaves the heat exchanger cooler than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet condensate temperature, or if the inlet condensate temperature is already above the desired condensate outlet temperature.

Type 609: Condensate Preheater – Effectiveness Approach

This component models a pre-heater for steam condensate using the heat exchanger effectiveness approach. The effectiveness is the ratio of the heat transfer at the inlet fluid conditions to the maximum possible heat transfer given the fluid inlet conditions. Refer to the documentation for Type91 in the 04-MathematicalReference guide in the TRNSYS documentation set for additional information about the effectiveness concept. In typical applications waste heat is used to elevate the temperature of a condensate stream before it enters a heat recovery steam generator. In this model the inlet hot-side fluid attempts to heat a flow of steam condensate to a user-specified temperature just below the condensate's saturation temperature. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet condensate temperature, or if the inlet condensate temperature is already above the desired condensate outlet temperature.

Type 610: Steam Desuperheater

This component models a steam desuperheater using the pinch-point temperature difference approach. In typical applications, a low-temperature fluid (usually water) is used to desuperheat a steam flow before entering a steam load device. In this model, the inlet cold-side fluid attempts to cool a flow of steam to just above the steam saturation temperature. The model may operate in one of two heat exchanger configuration modes: parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model will attempt to lower the steam temperature to the user-specified condition, checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered, the outlet steam conditions are re-calculated to alleviate the problem and the outlet steam flow leaves the heat exchanger warmer than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet cold-side fluid temperature is above the inlet steam temperature, or if the inlet steam temperature is already below the desired steam outlet temperature.

Type 611: Flash Tank

This component models a steam flash tank; a device used to make higher quality saturated steam or superheated steam from lower quality or condensed steam by expanding the steam into a low-pressure vessel. The steam entering this device instantaneously expands from the higher inlet pressure to the user-specified lower outlet pressure. The steam in the vessel then loses energy to the surroundings (environment) as it flows through the device before exiting. This component operates with a steady-state steady-flow assumption. The capacitance of the device and the steam are not accounted for in the model. The device has two outlet streams, one for steam condensate (liquid) and one for steam vapor.

Type 612: Steam Trap or Single Inlet Steam Separator

This component models a steam trap or single-port steam separator; a device used for removing any liquid in a steam flow from the system. The device has two outlet streams; one for liquid that is drained from the system and one for the remaining vapor. The device is assumed to be perfectly insulated but allows the user to specify a pressure drop.

Type 613: Steam Pipe

This component models a steam pipe where the steam loses heat and pressure as it travels along the pipe. The user must break this pipe up into N segments (from 1 to 50). The greater the number of segments the more accurate the thermal loss calculations but the more slowly the simulation will run. This pipe model is unlike the standard TRNSYS Type 31 pipe model that operates in plug flow fashion. Rather this pipe operates under the steady-state steady-flow approach and the assumption made is that the outlet fluid state at the current time-step is simply the result of the inlet fluid state flowing along this pipe at the current time step with no residue (no mass left over) from previous time steps. There is no heat transfer between nodes along the length of the pipe and each node is assumed to be isothermal. This pipe is intended to model the physics of heat transfer in a pipe and should not be used for capacitance purposes like other pipe models in TRNSYS.

Type 614: Two-Inlet Steam Separator

This component models a two-port steam separator; a device used for separating the liquid steam from the steam vapor after two steam flows have been mixed together. The device is assumed to be perfectly insulated such that an adiabatic mixing of the two fluids occurs. The higher pressure steam instantaneously and adiabatically expands to the outlet pressure provided that the lower pressure steam port has a non-zero flow rate. The two fluids are then mixed together and the resultant steam state found. Any liquid from the mixed steam condition is drained via the liquid outlet port while any steam vapor exits the device from the vapor outlet port.

Type 615: Double-Effect Steam-Fired Absorption Chiller (Four-File Format)

Type615 uses a normalized catalog data lookup approach to model a double-effect steam-fired absorption chiller. “Steam-Fired” indicates that the energy supplied to the machine’s generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided in the .\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\ directory. If the manufacturer’s performance data that you have been provided does not conform well to the structure of the three files required by Type615, consider the use of either Type717 (also in the TESS CHP Library) as it uses the same methodology as Type615 but requires a different data file format (one that is commonly used by certain manufacturers).

Type 616: Single-Effect Steam-Fired Absorption Chiller (Two File Data Format)

Type616 uses a normalized catalog data lookup approach to model a single-effect steam-fired absorption chiller. “Steam-Fired” indicates that the energy supplied to the machine’s generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided in the .\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Steam-Fired\ directory. If the manufacturer’s performance data that you have been provided does not conform well to the structure of the files required by Type616, consider the use of either Type718 or Type719 (both in the TESS CHP Library) or Type679 (in the TESS HVAC Library). These alternate models use the same methodology as Type616 but require different data file formats.

Type 617: Steam Superheater

A steam superheater is a device that adds energy to a flow of steam and dries it out. This component models a steam superheater using the pinch-point temperature difference approach. In typical applications, high-temperature waste heat is used to superheat a steam flow before entering a steam turbine or other high-temperature steam load device. In this model, the inlet hot-side liquid attempts to heat a flow of steam to a user-specified number of degrees of superheat. The model may operate in one of two heat exchanger configuration modes: parallel flow or counter flow. The pinch-point represents the location in the heat exchanger where the two fluids are closest in temperature. The location of the pinch-point depends on the flow rates of the hot and cold streams and the configuration of the heat exchanger. The model will attempt to elevate the steam condensate to the user-specified condition, checking the pinch-point at several critical locations in the device. If a pinch-point problem is encountered, the outlet condensate conditions are re-calculated to alleviate the problem and the outlet steam flow leaves the heat exchanger cooler than desired. The device is assumed to be off if either of the flow rates is zero, if the inlet hot-side fluid temperature is below the inlet steam temperature, or if the inlet steam temperature is already above the desired steam outlet temperature.

Type 618: Condensate Pump (Flow Rate Not Set)

This component models a steam condensate pump. The user specifies the inlet steam condensate conditions and the desired outlet pressure and the model calculates the theoretical power from a compressed liquid calculation (specific volume times pressure differential). The actual power is found by dividing the theoretical power by the pump efficiency. A user-supplied fraction of the actual pump power is assumed to be lost from the pump shell to the surroundings while the remaining energy ends up as an energy gain to the fluid. Unlike other TRNSYS pump models that set the flow rate for the steam loop by multiplying the rated pump flow rate by an input control signal, this pump simply sets the outlet flow rate to the inlet flow rate. The pump is assumed to be off if the input control signal is less than 0.5 or if the inlet steam flow rate is zero.

Type 619: Open Feedwater Heater / Deaerating Heater /Open Steam Heater – Steam Flow Calculated

This component models an open steam heater in which high-temperature steam at a variable flow-rate is mixed with low-temperature steam at a known flow-rate in order to elevate the low-temperature steam to a user-specified outlet condition. This component calculates the flow rate of high-temperature steam required to meet the desired outlet conditions bounded by a user-defined maximum high-temperature steam flow rate. This component also models an open feedwater heater in which saturated or superheated steam is mixed with sub-cooled condensate in order to bring the temperature of the condensate at or near its saturation temperature. This component will calculate the required steam flow rate in order to meet the user-specified outlet condition. The inlet high-temperature steam flow rate inputs used strictly for convergence checking at each time step. The high-temperature steam flow rate is set to zero if the low-temperature steam enthalpy is already above the desired outlet enthalpy or if the high-temperature steam is at a lower enthalpy than the low-temperature steam inlet. The high-temperature steam flow rate is set to the user-defined maximum mixing flow rate if the enthalpy of the high-temperature steam is above the inlet low-temperature steam enthalpy and below the desired outlet enthalpy. The outlet pressure from the device is the lower of the two inlet pressures with the high-pressure steam flow instantaneously and adiabatically expanding to the lower pressure. This device is assumed to be perfectly insulated

Type 620: Fitting Pressure Loss

This component models a pressure drop in a steam component. It takes inlet pressure, enthalpy temperature and mass flow rate as well as the desired pressure drop across the fitting. The model calculates the outlet steam conditions after the pressure has dropped isenthalpically. The component can be used to determine outlet conditions if the steam comes in as condensate, or condenses due to the pressure drop. An error will be detected if the specified pressure drop across the fitting is greater than the inlet pressure. This device is assumed to be perfectly insulated.

Type 621: Closed Feedwater Heater – Steam Flow Calculated To Achieve User-Designated Outlet Condition

This component models a closed feedwater heater; a device in which higher-temperature steam is mixed with sub-cooled steam condensate in order to bring the temperature of the condensate at or near its saturation temperature. This device operates with a counter-flow configuration. Closed feedwater heaters do not mix the flow streams. This device is not equipped with a drain cooler; a device used to sub-cool the higher-temperature steam flow and transfer additional heat to the condensate flow stream. In devices without drain coolers, the higher-temperature steam flow may only exit at the saturated liquid point or above. Type622 offers a version of the model with a drain cooler. This model uses the terminal temperature difference (TTD) approach to model the heat transfer in the device. The terminal temperature difference is defined as the saturation temperature of the higher-temperature steam minus the desired outlet temperature of the condensate flow. The terminal temperature difference may be negative if the higher-temperature steam flow enters in a superheated condition. Care should be taken to specify proper values of the TTD as poor values of the TTD may result in a pinch-point problem at the saturated vapor point of the higher-temperature steam. For this reason the pinch-point temperature difference at both outlets and at the saturated vapor point of the higher-temperature steam is reported by the model and should be checked by the user for reasonableness. The outlet temperature of the condensate flow is set to the minimum of either the condensate saturation temperature or the saturated steam temperature minus the terminal temperature difference. The outlet temperature of the steam flow is set to the saturated steam. If the calculated steam flow required to make the desired outlet condensate condition is greater than the maximum steam flow rate parameter, the heat transfer will be re-calculated with the steam flow at its maximum flow rate and the outlet conditions reset. The device is assumed to be off if the condensate flow rate is zero or if the inlet steam enthalpy is less than the enthalpy of the condensate at the inlet.

This component calculates the required high-temperature steam flow rate in order to meet the user -specified condensate outlet condition. The inlet steam flow rate input is just used for convergence checking in the model.

Type 622: Closed Feedwater Heater with Drain Cooler – Steam Flow Calculated

This component models a closed feedwater heater; a device in which higher-temperature steam is mixed with sub-cooled steam condensate in order to bring the temperature of the condensate to or near to its saturation temperature. This device operates with a counter-flow configuration. Closed feedwater heaters do not mix the flow streams. This device is equipped with a drain cooler; a device used to sub-cool the higher-temperature steam flow and transfer additional heat to the condensate flow stream. In devices without drain coolers, the higher-temperature steam flow may only exit at the saturated liquid point or above. This model uses the terminal temperature difference (TTD) and drain cooler temperature difference (DCTD) approach to model the heat transfer in the device. The terminal temperature difference is defined as the saturation temperature of the higher-temperature steam minus the desired outlet temperature of the condensate flow. The terminal temperature difference may be negative if the higher-temperature steam flow enters in a superheated condition. The drain cooler temperature difference is defined as the outlet steam temperature minus the inlet condensate temperature and must always be greater than zero. The TTD and DCTD define the heat transfer and outlet conditions from the model, but care should be taken to specify proper values of these INPUTs. Poor values of the TTD and DCDT may result in a pinch-point problem at the saturated vapor point of the higher-temperature steam. For this reason the pinch-point temperature difference at both outlets and at the saturated vapor point of the higher-temperature steam is reported by the model and should be checked by the user for reasonableness. The outlet temperature of the condensate flow is set to the minimum of either the condensate saturation temperature or the saturated steam temperature minus the terminal temperature difference. The outlet temperature of the steam flow is set to the minimum of either the saturated steam temperature or the inlet condensate temperature plus the drain cooler temperature difference. If the calculated steam flow required to make the desired outlet condensate condition is greater than the maximum steam flow rate (Parameter 1), the heat transfer will be re-calculated with the steam flow at its maximum flow rate and the outlet conditions reset. The device is assumed

to be off if the condensate flow rate is zero or if the inlet steam enthalpy is less than the enthalpy of the condensate at the inlet.
This component calculates the required high-temperature steam flow rate in order to meet the user -specified condensate outlet condition. The inlet steam flow rate input is just used for convergence checking in the model.

Type 623: Gas Compressor

This component models a gas compressor. The user specifies the inlet gas conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant properties. The theoretical power is calculated using ideal gas relationships and then the actual power is found using the provided efficiency. With the actual power known, the outlet gas conditions are calculated. The device is assumed to be off if either the control signal indicates it is off (< 0.5), if the inlet flow rate is zero, or if the inlet pressure is above the desired outlet pressure.

Type 624: Steam or Water Injection Device

This component models a steam or water injection device used to humidify an air stream. These systems are typically used to increase the mass flow rate entering a gas turbine in order to boost its power output. This component is similar to the evaporative cooling models in the TESS HVAC library but does not rely on the standard TRNSYS moist air properties subroutine due to pressure limitations that are commonly encountered in gas turbine simulations. The user specifies the inlet air and steam (water) conditions and the desired outlet RH for the air and the model solves the heat and mass balance equations to determine the outlet states of the air and steam streams. The steam that is not consumed by the device exits at the same temperature, pressure, and enthalpy with which it entered the device.

Type 625: Gas Turbine With or Without Water Injection (Catalog Data)

This component models a gas turbine based on a user-supplied performance data file. The performance data file supplied to this model should be specific to the desired capacity, site elevation, and fuel-type for the application. The data file should contain the full load capacity (kW), air inlet flow rate (kg/h), heat rate (kJ/kWh), exhaust flow rate (kg/h), exhaust temperature (C), exhaust heat (GJ/h), and water injection ratio (kgH2O/kgfuel) as a function of the current part-load ratio, water injection ratio, and ambient temperature. Example files are provided.
The turbine will attempt to deliver the user-specified load power (an input), but may be limited by the operating capacity of the machine based on the current inlet conditions.

Type 626: Heat Recovery Hot Water Generator

This component models a heat recovery hot water generator; a device which uses the waste heat (usually from a gas turbine or a reciprocating engine) to make hot water. This model relies on an effectiveness approach to calculate the heat exchange between the two fluids. The device is internally controlled to bypass a portion of the hot-side fluid in order to keep the cold side at or below a user-specified temperature. The model also makes sure that the non-bypassed portion of the hot-side fluid remains above a user-specified minimum temperature (minimum stack temperature for example) and that the mixed hot-side temperature (bypasses plus non-bypassed flows) is also above a minimum temperature specified by the user.

Type 627: Heat Recovery Hot Water Generator with Load Flow Calculated

This component models a heat recovery hot water generator; a device which uses the waste heat (usually from a gas turbine or a reciprocating engine) to make hot water. This model relies on an effectiveness approach to calculate the heat exchange between the two fluids. If the device is running at its maximum load side flow rate

(par 1) and the outlet load-side temperature is still above the desired outlet temperature, the device provides internal control to bypass a portion of the hot-side fluid in order to keep the cold side at or below its setpoint.
This model calculates the flow rate of load-side fluid that may be raised to its set point temperature based on the inlet source conditions- the input flow rate is not used!!

Type 628: Performance Map Full Load Steam Turbine

This model uses an external data file to compute the power produced from a steam turbine given the inlet steam conditions, the turbine back pressure, and the required rotational speed. The turbine operates at its rated capacity at all times. The model calculates the steam inlet flow rate required - the steam flow rate INPUT to this model is NOT used except to check whether continuity is maintained. The external data file contains the full-load capacity and corresponding turbine efficiency as a function of the rotational speed, the inlet steam pressure and the turbine back pressure. A sample data file is provided for the user.

Type 629: Air Compressor (Moist Air Calculations)

This component models an air compressor. The user specifies the inlet air conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant but average properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The ideal outlet temperature is calculated using ideal gas relationships and then the actual outlet temperature is found using the provided efficiency. With the outlet temperature known, the remaining moist air properties can be calculated and the required power found. The device is assumed to be off if either the control signals indicates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet air pressure is above the desired outlet air pressure.

Type 630: Air Compressor (Dry Air)

This component models an air compressor. The user specifies the inlet air conditions, the desired outlet pressure, and the efficiency and the model calculates the power required and the outlet conditions. The model assumes that the gas behaves like an ideal gas with constant but average properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The ideal outlet temperature is calculated using ideal gas relationships and then the actual outlet temperature is found using the provided efficiency. With the outlet temperature known, the required power can be found. The device is assumed to be off if either the control signals indicates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet air pressure is above the desired outlet air pressure.

Type 631: Air Preheater / Air Cooled Intercooler / Regenerator – Theoretical Gas Turbine Systems

This component has the ability to model several similar gas turbine components; an air-to-air regenerator device, an air-cooled intercooler, and an air pre-heater. A regenerator is a device that preheats the air after the compression process (and before the combustion process) by using the hot exhaust gases from a gas turbine. An air-cooled intercooler is a device that uses cooler supply air to cool an air stream between multiple compression steps. An air preheater is a device that exchanges waste heat from one air stream in order to elevate the temperature of a second air stream.
This model is basically an air-to-air heat exchanger where the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The intercooler heat transfer is calculated using the heat exchanger effectiveness approach – refer to the

documentation for the Type 5 heat exchanger in Volume 1 of the TRNYS Manual for more information on the effectiveness concept.

Type 632: Fluid Cooled Intercooler – Theoretical Gas Turbine Systems

This component models a fluid-cooled intercooler; a device that uses a cooler supply fluid to cool an air stream between multiple compression steps. This model is basically a fluid-to-air heat exchanger where the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. Although it is described as a fluid-cooled intercooler, this model could also be used to heat an air stream using a warm inlet fluid. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The intercooler heat transfer is calculated using the heat exchanger effectiveness approach – refer to the documentation for the Type 5 heat exchanger in Volume 1 of the TRNYS Manual for more information on the effectiveness concept.

Type 633: Combustion Device – Theoretical Gas Turbine Systems

This component models a simple heat addition device for a gas-turbine system. The combustion process is simply modeled as a heat gain to the air with a user-defined efficiency. The products of combustion are ignored in this model. The air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The outlet temperature is set to the desired set-point temperature if the capacity of the machine is not exceeded in doing so. If the capacity of the machine is reached, the device will run at its capacity and the resultant outlet temperature calculated. The device is assumed to be off if either the control signals dictates it is off (< 0.5), if the inlet flow rate is zero, or if the inlet temperature is above the set-point temperature.

Type 634: Turbine Section – Theoretical Gas Turbine Systems

This component models a turbine section for a gas turbine application. The user specifies the inlet air conditions and the outlet pressure and efficiency and the model calculates the power produced and the outlet air conditions. In this model, the moist-air calculations are not considered and the air is assumed to act like an ideal gas with constant (but average) properties. The average specific heat of the air stream is calculated from an integrated correlation based on the inlet and outlet temperatures of the air stream. The theoretical power produced is calculated from an ideal gas relationship using the inlet and outlet pressures. The actual power is then found by multiplying the theoretical power by the user-supplied efficiency and the outlet air conditions then found. The device is assumed to be off if either the control signals dictates it is off (< 0.5), if the inlet air flow rate is zero, or if the inlet pressure is below the desired outlet pressure.

Type 635: Steam-Steam Heat Exchanger

This component models a steam-to-steam heat exchanger; transferring heat from the inlet hot-side steam flow to the inlet cold-side steam flow. The model includes internal controls to keep the cold-side outlet fluid at or below a user-specified maximum enthalpy condition and to keep the hot-side outlet fluid at or above a user-specified maximum enthalpy condition. If either of the outlet conditions are to be free floating (not controlled), simply set the corresponding desired outlet enthalpy less than zero and the controls for that outlet will be disabled. This feature is useful if the user wishes to keep the hot-side in a saturated condition or keep the cold side below saturation for example. The device is controlled to be off if either the hot side or cold-side flow rates are zero, or if heat transfer from the hot-side to the cold-side is not physically possible. The component relies on both an effectiveness approach and a pinch-point approach to model the complex heat transfer between the two steam flows. The effectiveness (Input 11) is used to set the maximum possible heat transfer between the flow streams based on the inlet temperatures. For this model, the maximum possible heat transfer (ignoring pinch-point effects) is when the outlet temperature of the cold-side flow rate is equal to the inlet temperature of the hot-side flow stream. With this maximum heat transfer rate known, the temperatures of the steam flows at several critical points are calculated to make sure that the pinch-point temperature difference (Parameter 1) is not encountered. If a pinch-point problem is encountered, the outlet steam conditions are re-calculated to avoid the pinch-point problem and the effectiveness is re-calculated. While having the user designate both an effectiveness and a pinch-point temperature difference is somewhat redundant, it does increase the flexibility of the model.

For parallel flow configurations, the pinch-point temperature difference is checked at the outlet of the device. For counter-flow configurations, the pinch-point temperature difference is checked at the outlet of the hot-side flow (the inlet of the cold-side flow), the outlet of the cold-side flow (the inlet of the hot-side flow), the saturated liquid points of both streams, and the saturated vapor points of both streams.

With the provided flexibility of this component, it can model a closed feedwater heater (with or without a drain cooler), a steam pre-heater, a steam economizer, a superheater, a desuperheater etc. Basically any steam-to-steam or steam-to-water, or water-to-water heat exchanger.

Type 636: Heat Recovery Steam-Generator

This component models a heat recovery steam generator (HSRG); a device which uses high-temperature waste heat (usually from a gas turbine) to heat a steam flow. This component can also model a steam super-heater, or a condensate pre-heater. This model will attempt to meet the user-specified steam outlet condition but may be limited by the entering hot-side temperatures and flow rate. This device may operate in either a counter-flow or parallel-flow configuration. The model relies on the pinch-point temperature difference approach to check for impossible (or unrealistic) heat exchange conditions. The pinch-point temperature difference is defined to be the minimum temperature difference between the hot-source fluid and the steam that allows for heat transfer between the fluids. In parallel-flow mode the pinch-point is checked only at the outlet of the device (the outlet of the steam and the outlet of the hot source fluid) as this represents the minimum temperature difference between the two fluids. In counter-flow mode, the pinch-point is checked at the outlet of the steam flow (inlet of the hot source flow), the outlet of the hot source flow (the steam inlet), at the steam saturated liquid point, and at the steam saturated vapor point. If the temperature difference at these points is less than the pinch-point temperature difference, the heat transfer is re-calculated such that the pinch-point problem is not encountered. The device is assumed to be off if either of the flow rate inlets is zero, or if the inlet steam enthalpy is already at or above the desired outlet steam enthalpy.

Type 637: Heat Recovery Steam-Generator – Maximum Steam Flow

This component models a heat recovery steam generator (HSRG); a device which uses high-temperature waste heat (usually from a gas turbine) to heat a steam flow. This component can also model a steam super-heater, or a condensate pre-heater. This model will attempt to meet the user-specified steam outlet condition but may be limited by the entering hot-side temperatures and flow rate. This device may operate in either a counter-flow or parallel-flow configuration. The model relies on the pinch-point temperature difference approach to check for impossible (or unrealistic) heat exchange conditions. The pinch-point temperature difference is defined to be the minimum temperature difference between the hot-source fluid and the steam that allows for heat transfer between the fluids. In parallel-flow mode the pinch-point is checked only at the outlet of the device (the outlet of the steam and the outlet of the hot source fluid) as this represents the minimum temperature difference between the two fluids. In counter-flow mode, the pinch-point is checked at the outlet of the steam flow (inlet of the hot source flow), the outlet of the hot source flow (the steam inlet), at the steam saturated liquid point, and at the steam saturated vapor point. If the temperature difference at these points is less than the pinch-point temperature difference, the heat transfer is re-calculated such that the pinch-point problem is not encountered. The device is assumed to be off if either of the flow rate inlets is zero, or if the inlet steam enthalpy is already at or above the desired outlet steam enthalpy.

This version of the heat recovery steam generator calculates the maximum steam flow rate which can be produced given the inlet hot-side source conditions and the desired steam outlet enthalpy; constrained by the specified pinch-point. In this model, the inlet steam flow rate is not used and is just provided for continuity.

Type 638: Steam Boiler (Efficiency as Input)

This component models a steam boiler. This model will attempt to meet the user-specified steam outlet condition but may be limited by capacity restraints. The available capacity is calculated by multiplying the rated capacity (Parameter 1) by the input control signal (Input 5). The capacity refers to the heat input to the fluid and not the gross capacity of the device. In this model, the user enters the boiler efficiency (Input 6) which is then divided into the required steam input energy to calculate the required fuel input to the model. The user also provides the combustion efficiency (Input 7) which is used to calculate the boiler thermal losses. Overall efficiency is lower than the combustion efficiency due to boiler thermal losses and any cycling effects. This model accepts, condensate, saturated or superheated steam. The boiler is assumed to be off if the inlet steam flow rate is zero, the input control signal is zero, or if the inlet steam enthalpy is greater than or equal to the desired outlet steam enthalpy. If the desired outlet steam conditions cannot be met due to capacity limitations, the machine will run at its available capacity and the outlet steam state calculated.

This model is based on ASHRAE's definition of boiler efficiencies as published in 2000 ASHRAE Systems and Equipment Handbook

Type 639: Steam Boiler (Efficiency from Data File)

This component models a steam boiler. This model will attempt to meet the user-specified steam outlet condition but may be limited by capacity restraints. The available capacity is calculated by multiplying the rated capacity (Parameter 1) by the input control signal (Input 5). The capacity refers to the heat input to the fluid and not the gross capacity of the device. In this model, the user provides a file of boiler and combustion efficiency at various combinations of the inlet steam temperature and the boiler part-load ratio. The boiler efficiency is then divided into the required steam input energy to calculate the required fuel input to the model. The combustion efficiency is used to calculate the boiler thermal losses. Overall efficiency is lower than the combustion efficiency due to boiler thermal losses and any cycling effects. This model accepts, condensate, saturated or superheated steam. The boiler is assumed to be off if the inlet steam flow rate is zero, the input control signal is zero, or if the inlet steam enthalpy is greater than or equal to the desired outlet steam enthalpy. If the desired outlet steam conditions cannot be met due to capacity limitations, the machine will run at its available capacity and the outlet steam state calculated.

This model is based on ASHRAE's definition of boiler efficiencies as published in 2000 ASHRAE Systems and Equipment Handbook

Type 640: Feedwater Storage Tank

This component models a feedwater storage tank with two steam inlets and two steam outlets. The tank is assumed to be kept at a constant pressure and any steam inlets that are below this tank pressure are diverted around the storage tank (outlet state = inlet state). Steam inlets at pressures higher than the tank pressure are assumed to instantaneously and adiabatically expand to the tank pressure before mixing with the tank fluid. The tank is modeled as a fully-mixed, constant-volume storage tank with losses to the surroundings. This device is meant to store sub-cooled liquid steam and will vent any steam that occurs from a boiling condition within the tank. The inlet steam flows are completely mixed with the storage fluid and the resultant storage tank condition is then outlet. For example, if 100 kg/h of steam enters at inlet 1 then 100 kg/h of storage fluid exit the tank at outlet one. The tank can be of any geometry (cylindrical, spherical, etc.) as the user enters the storage volume and the surface area. The model accounts for the capacitance of the storage fluid and uses a 1^{st}-order differential equation to solve for the tank temperatures given the inlet steam conditions and the tank losses.

Type 659: Exhaust Gas Supplemental Firing or Proportional Hot Water Boiler

An auxiliary heater is modeled to elevate the temperature of a flow stream using either internal control, external control or a combination of both types of control. The heater is designed to add heat to the flow stream at a user-designated rate (Q_{max}*γ) whenever the heater outlet temperature is less than a user-specified maximum (T_{set}).
By specifying a value of one for the control function input and specifying a sufficiently large value of Q_{max}, this routine will perform like an auxiliary heater with internal control to maintain an outlet temperature of T_{set}.
By providing a control function between zero and one from a thermostat or controller, this routine will perform like a furnace adding heat at a rate of Q_{max}*γ but not exceeding an outlet temperature of T_{set}. In this application, a constant outlet temperature is not sought and T_{set} may be thought of as an arbitrary safety limit.

Type 682: Heating and Cooling Loads Imposed on a Flow Stream

Often in simulating an HVAC or CHP system the heating and cooling loads on the building have already been determined either by measurement or through the use of another simulation program but the simulation task at hand is to simulate the effect of these loads upon a plant that is under design or that cannot be modeled in the same software package. Type682 simply imposes a user-specified load (cooling = positive load, heating = negative load) on a flow stream of liquid and calculates the resultant outlet fluid conditions. Boiling and freezing effects are ignored so the user must be careful when using this component. This simple model can represent any number of devices such as chillers, water-loop building loads, radiators, heat pumps etc. where the physics of the device are not important and the removal of the correct amount of energy from a flow stream IS important.

Type 717: Double-Effect Steam-Fired Absorption Chiller (Three-File Format)

Type717 uses a normalized catalog data lookup approach to model a double-effect steam-fired absorption chiller. “Steam-Fired” indicates that the energy supplied to the machine’s generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided in the .\Tess Models\SampleCatalogData\AbsorptionChiller\Double-Effect\Steam-Fired\Combined_S2_S3_Approach\ directory. If the manufacturer’s performance data that you have been provided does not conform well to the structure of the three files required by Type717, consider the use of either Type615 (in the TESS CHP Library) or Type676 (in the TESS HVAC Library). These alternate models use the same methodology as Type717 but require a different data file format (one that is commonly used by certain manufacturers).

Type 718: Single-Effect Steam-Fired Absorption Chiller (Trane Data Format)

Type718 uses a normalized catalog data lookup approach to model a single-effect steam-fired absorption chiller. “Steam-Fired” indicates that the energy supplied to the machine’s generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided in the .\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Steam-Fired\Trane Model\ directory. The format of the data files matches the type of performance data that is typically reported by Trane (an absorption chiller manufacturer). If the manufacturer’s performance data that you have been provided does not conform well to the structure of the files required by Type718, consider the use of either Type616 or Type719 (both in the TESS CHP Library) or Type679 (in the TESS HVAC Library). These alternate models use the same methodology as Type718 but require different data file formats.

Type 719: Single-Effect Steam-Fired Absorption Chiller (York Data Format)

Type719 uses a normalized catalog data lookup approach to model a single-effect steam-fired absorption chiller. "Steam-Fired" indicates that the energy supplied to the machine's generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided in the .\Tess Models\SampleCatalogData\AbsorptionChiller\Single-Effect\Steam-Fired\York Model\ directory. The format of the data files matches the type of performance data that is typically reported by York (an absorption chiller manufacturer). If the manufacturer's performance data that you have been provided does not conform well to the structure of the files required by Type719, consider the use of either Type616 or Type718 (both in the TESS CHP Library) or Type679 (in the TESS HVAC Library). These alternate models use the same methodology as Type719 but require a different data file format (one that is commonly used by other manufacturers).

Type 722: Steam Turbine - Load Following with Max Steam Flow

This model simulates a steam turbine that meets a user-specified electrical load by varying the mass flow rate of steam entering the turbine. As the model calculates the required steam flow at turbine inlet, the input steam flow rate to the model is not used except as a mass balance check upon convergence at each time step. This model relies on an isentropic efficiency approach to calculate the performance of the steam turbine given the steam inlet conditions and the turbine back-pressure. The delivered output power from the turbine is limited by the capacity of the turbine. Specifying a required power greater than the capacity of the machine will cause the machine to operate at its rated capacity and to report the load not met. The power may also be limited by the maximum steam flow rate that the turbine is able to use at the current time step (as set by a user-defined input).

Type 907: Internal Combustion Engine / Generator Set

This component models an engine generator; a device used to generate electricity by burning fuel in an internal combustion engine. The model relies on an external data file which contains efficiency, air flow rate (fraction of rated flow rate) and heat transfer data (fraction of total energy output) as a function of the intake temperature and the part load ratio (power over rated power). A sample catalog data file is shown in this document as a syntax reference. The engine can be run to meet a known electrical load or can be run to provide a desired outlet coolant temperature.

Type 981: Steam Accumulator (new in v18)

This component models a steam accumulator; a device used to store steam energy during times of high steam production and low load and use it later when steam production is less than the load. The device is typically a storage vessel partially filled with water with an inlet for charging steam flow and an outlet for discharging the steam.

Controls Library

Type 658: Humidistat

This ON/OFF differential device is most often used to control the operation of a humidifier based on the temperatures and relative humidities of the zone and inlet air ventilation stream. The humidistat generates a control function which can have a value of 1 or 0. The value of the control signal is set as a function of the difference between a set point relative humidity and the relative humidity of the zone air, compared with two dead band relative humidity differences. The new value of the control function also depends upon the value of the input control function at the previous time step. The controller is normally used with the input control signal connected to the output control signal, providing a hysteresis effect. However, control signals from different components may be used as the input control signal for this component if a more detailed form of hysteresis is desired.

Type 661: Delayed Output Device

This component models a "sticky" controller where the outputs are set to the input values from a user-defined previous time step. For example, the user could decide to have the outputs to another component be based on the zone temperatures from the previous hour or even from the previous day.

Type 698: Five Stage Room Thermostat for n Temperatures

This ON/OFF differential device models a five stage room thermostat which outputs five control signals that can be used to control an HVAC system having a three stage heating source and a two stage cooling source. This version of the model is designed to allow the user to specify multiple temperatures (up to 25) to watch with the same set of set points. The controller contains hysteresis effects and is equipped with a parameter that allows the user to set the number of controller oscillations permitted within a single time step before the output values "stick."

Type 910: Parallel Staged-Device Controller (new in v18)

In many central plants a load is served not by a single device but by a "stack" of devices. When the load is small, one device may suffice to meet it. As the load increases beyond the capacity of that one device, another is brought online and both devices operate in parallel to meet the load. When the load decreases to the point that the devices in the stack reach their minimum turndown ratio (or some other point) then one of the devices drops offline and the load is met by one fewer devices in the stack.

Type 911: Differential Controller with Lockouts

This controller is almost identical in nature to Type 2. It generates a control function γ_o that can have values of 0 or 1. The value of γ_o is chosen as a function of the difference between upper and lower temperatures, T_H and T_L, compared with two dead band temperature differences, ΔT_H and ΔT_L. The new value of γ_o is dependent on whether $\gamma_i = 0$ or 1. This controller differs from Type 2 in that it contains lockouts; once the controller turns ON, it must stay ON until a user specified amount of time has passed. Likewise, once the controller turns OFF, it stays OFF until a user specified amount of time has passed. The controller is normally used with γ_o connected to γ_i giving a hysteresis effect. For safety considerations, a high limit cut-out is included. Regardless of the dead band conditions or the lockout time, the control function will be set to zero if the high limit condition is exceeded. Note that this controller is not restricted to sensing temperatures, even though temperature notation is used throughout the documentation. This component also differs from Type2 in that it does not implement the Powell's Method solver.

Type 953: Tempering Valve Controller

Type953 models a tempering valve controller that can operate in either heating or cooling mode. The Type takes the source temperature, the tempering temperature and a set point temperature. It determines the fraction of fluid that should go through the source and the fraction of fluid that should bypass the source and be used to temper the source outflow.

Type 970: N-Stage Differential Heating Controller with Multiple Setpoints, Multiple Deadbands and Time Delay

Type970 is an n-stage heating thermostat which outputs *n* on/off control functions that can be used to control a system having *n* levels of heating alternatives. Although temperature notation is used, this controller can be based on any consistent set of input variable types. This model is a replacement for Type 671 and allows the user to have different deadbands for each setpoint, and this component also has on and off time delays.

Type 971: N-Stage Differential Cooling Controller with Multiple Setpoints, Multiple Deadbands and Time Delay

Typ971 is an n-stage cooling thermostat which outputs *n* on/off control functions that can be used to control a system having *n* levels of cooling alternatives. Although temperature notation is used, this controller can be based on any consistent set of input variable types. This model is a replacement for Type 672 and allows the user to have different deadbands for each setpoint, and this component also has on and off time delays.

Type 973: N-Stage Differential Controller with 1 Setpoint, 1 Deadband and Time Delay

Type973 models an n-stage differential controller with the parameter option to be in either heating mode or cooling mode. There is one setpoint with one deadband for this controller. This controller has time delay for the subsequent stages to turn on and to turn off.

Type 974: N-Stage Differential Controller with 1 Setpoint, 2 Deadbands, Minimum Run Time, and Time Delay

Type974 models an n-stage differential controller with the parameter option to be in either heating mode or cooling mode. There is one setpoint with a “turn on” deadband and a “turn off” deadband for this controller; this is how this controller differs from the Type973 controller. This controller has time delay for the subsequent stages to turn on and to turn off.

Type 975: Switched Value Holder (new in v18)

This component holds an input value for a time step or longer and is used to promote convergence in advanced controllers. The user provides a second input that is a control signal that indicates to the component to either keep the currently held value or update it to the current input value.

Type 980: On/Off Time Calculator

This component watches a control signal and calculates the current "on" and "off" times of the signal.

Type 1233: Thermostatic Control with Specified Run-Time

This component models a "run-time" controller that will turn "ON" when a temperatures falls below a user-specified setpoint temperature and will stay on until the specified run-time period has elapsed or until the monitored temperature rises above the safety-limit temperature. The device can then come back ON only when the monitored temperature falls below the setpoint temperature *and* enough time has passed to clear the minimum "off-time" condition.

Type 1250: Outside Air Reset Controller

This component generates two outputs; a temperature dependent setpoint and an on/off signal. The user provides the mode (heating or cooling) and two pairs of ambient/setpoint combinations.

Type 1325: Lead/Lag Source Selector (new in v18)

Larger HVAC systems often include “stacks” of staged devices that allow them to better modulate to meet a varying load. As a load increases, device 1 is brought online until it reaches full capacity at which point device 2 is brought online as well. If the same physical device is always the first one to start then it receives more wear and tear than do the other devices in the stack and will need to be replaced earlier. In order to prevent the problem the staging order is changed periodically. Such control is called “lead/lag;” the lead device changes every so often to normalize wear on the system. Type1325 models such a device.

Type 1328: Triggered Input Delay (new in v18)

This component models a "sticky" controller where the outputs are set to the input values from a user-defined previous time step. This component is similar to TESS Type661 but allows the user to indicate whether the value should be updated or not.

Type 1329: Ideal Combination Selector (new in v18)

This component checks each combination of n-supplied values and finds the combination that is closest to the ideal value. For example, this component can check different pumps and find the combination of pumps that gives a flow rate closest to the target flow rate. Options exist for constraining the solution to be above or below the target value.

Type 1502: N-Stage Heating Aquastat or Simple Thermostat

An n-stage heating aquastat/simple thermostat is modeled to output n ON/OFF control functions that can be used to control a fluid cooling system having up to an n stage heating source(s). The component was Type502 in previous TESS Libraries versions, but it has been updated and allocated a new Type number.

Type 1503: N-Stage Cooling Aquastat or Simple Thermostat

An n-stage cooling aquastat/simple thermostat is modeled to output n ON/OFF control functions that can be used to control a fluid cooling system having up to an n-stage heating source. The component was Type503 in previous TESS Libraries versions, but it has been updated and allocated a new Type number.

Type 1504: Trip Timer (new in v18)

This routine models a trip timer; a device that will run for a user-specified period of time once a temperature threshold has been passed.

Type 1505: Event Counter (new in v18)

This component is used to count the number of times a device was "off" and then turns "on".

Type 1506: Multi-Monitoring Temperature Controller (new in v18)

This controller watches two temperatures/inputs and makes a control decision to turn the controller based upon one of the temperatures/inputs and make the control decision to turn the controller off based upon a separate temperature/input. In heating mode, this controller will turn on when the value of the "On" monitored variable falls to/below the "On" setpoint and stay on until the "Off" monitored variable rises to/above the "Off" setpoint. In cooling mode, this controller will turn on when the value of the "On" monitored variable rises to/ above the "On" setpoint and stay on until the "Off" monitored variable falls to/below the "Off" setpoint. There is no hysteresis or deadbands in this model. The decisions are made at the end of each TRNSYS timestep so small timesteps should be utilized when using this model. Once the controller turns on it will stay on for a user-specified minimum time period. Once it turns off it will stay off for a user-specified amount of time before being allowed to turn back on.his component watches a control signal and calculates the current "on" and "off" times of the signal.

Type 1669: Proportional Controller

This component returns a control signal between 0 and 1 that is related to the current value of an input as compared to a user defined minimum and maximum value. The component was built from Type 669 of an earlier release of the TESS Controller's Library version and was improved to have a maximum rate of increase and a maximum rate of decrease for the control signal.

Electrical Library

Type 549: Lithium-ion Battery (new in v18)

This component models a lithium-ion battery using the voltage model proposed by Tremblay [1] and as implemented in the National Renewable Energy Laboratory's Solar Advisor Module software [2] as described in the software's documentation [3]. In addition to the voltage model, the component includes a simple energy balance to estimate energy exchange between the battery bank and its surroundings. The component does not include capacity degradation as a function of battery life or number of charge/discharge cycles. It also does not model thermal runaway that can occur if a lithium-ion battery is charged or discharged at too great a rate. It does, however, include the effects of ambient temperature on the battery's present state of charge.

Type 551: Photovoltaic Array Shading

It is known that even partial shading of photovoltaics (PV) can have a dramatic effect upon array performance. However, the relationship between the shaded area of a photovoltaic array and the drop in electrical performance due to that shaded area is not only highly non-linear but depends upon the placement of the array with regards to surrounding objects and upon the array's inter and intra modular electrical connections. In order to accurately perform a shading analysis of a photovoltaic array, information about the specific order in which modules are connected in series in parallel, as well as some method for determining time dependent shadow patterns on the array are needed. Only in very rare circumstances would a user have access to such information. As an alternative, component Type551 has been developed as a simplified method for bracketing the effect of shading. Users are asked to select between two general array configurations: generally horizontal rows or generally vertical rows. The first configuration would be appropriate for a series of ballasted roof pan photovoltaics on a flat or sloped roof. The second would be appropriate in a high rise building in which PV is used as a window shading device.
The Type assumes that the array is divided into a user specified number of equal length rows and that all rows in the array are identically sloped. Based on configuration parameters and current input values, the component outputs two different estimates of radiation incident on the array rows. In the more conservative of the two estimates, a row that is partially shaded from beam radiation is assumed to "see" only diffuse radiation. In the less conservative estimate, the fraction of the array exposed to beam radiation is computed and the entire array is assumed to be exposed evenly to that reduced amount.

Type 554: Flywheel Energy Storage System (new in v18)

This component models a flywheel energy storage system (FESS). Flywheels are mechanical devices that utilize a rotating wheel, disc, or drum to store energy. Flywheels store energy as kinetic rotational energy; the flywheel spins faster when it is charged, and its spin decelerates when it is discharged. Common applications are for short-term, rapid-response energy storage systems, especially for storing and smoothing the power supply from intermittent power sources such as wind turbines or solar cells. They can also be used for accumulating energy from a low-power source for rapid discharge later, at a rate that couldn't be achieved by the original source.
The number of (identical) flywheels in the system and the moment of inertia, maximum rotational speed, and minimum rotational speed of the flywheels must be provided as parameters to the model. The model assumes the charge/discharge load is distributed evenly across all flywheels in the system. Round-trip efficiency is also supplied as a model parameter. Power stored in (+) or withdrawn from (-) the flywheel system is provided as an input to the model. For decay periods (when the flywheels are neither charging nor discharging to load), a linear relationship between torque loss and rotational speed is assumed; slope and intercept of the torque loss equation are provided as parameters to the model. These decay losses may include any rotational speed-dependent losses, such as drag, bearing friction, eddy currents, and hysteresis.

The model calculates the rotational speed of the flywheels, the torque on the flywheels, the power losses from the flywheel system, and the overall state of charge of the flywheel system. If the power supplied to (or drawn from) the flywheel system would send the rotation of the flywheels above (or below) their specified limits, the model assumes the flywheel system can dump power to (or draw power from) some sink, or source as needed to maintain the flywheels within their speed limitations. A warning is tallied in the .lst file at the end of the simulation for each occurrence in which the flywheel's speed limitations would have been exceeded. The excess power dumped from (or supplied to) the flywheel in these instances is also an output of the model.
This model is compatible with the Type 48 regulator/inverter for coupling the flywheel to a variable power source and/or a variable imposed load.

Type 560: Unglazed Combined PV/T Solar Collector
This component is intended to model an un-glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to a fluid stream passing through tubes bonded to an absorber plate located beneath the PV cells. The waste heat rejected to the fluid stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications.
This model relies on linear factors relating the efficiency of the PV cells to the cell temperature and the incident solar radiation. The cells are assumed to be operating at their maximum power point condition.
The thermal model of this collector relies on algorithms presented in Chapter 6 of "Solar Engineering of Thermal Processes" textbook by Duffie and Beckman (2nd Edition).

Type 562: Simple Glazed or Unglazed PV Panel
Type562 models either a glazed or unglazed photovoltaic array, basing its performance calculation on a user provided overall array efficiency. Efficiency may be constant, variable, provided as a function of cell temperature and incident radiation in an external file or provided for reference conditions along with coefficients that describe the effect of cell temperature and incident radiation changes. This model is appropriate for PV arrays that are connected to a load through a maximum power point tracking device since the efficiency of the Type562 PV is not dependent upon load voltage.

Type 563: Unglazed Combined PV/T Solar Collector (Interacts w/ Type 56)
This component is intended to model an un-glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to a fluid stream passing through tubes bonded to an absorber plate located beneath the PV cells. The waste heat rejected to the fluid stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications.
This model relies on linear factors relating the efficiency of the PV cells to the cell temperature and also the incident solar radiation. The cells are assumed to be operating at their maximum power point condition.
The thermal model of this collector relies on algorithms presented in "Solar Engineering of Thermal Processes" (Beckman, 1991) [1].
This version of the PV/T collector may be connected to the multi-zone building model in TRNSYS so that the impact of the collector on the building heating and cooling loads can be evaluated.

Type 566: Glazed Building-Integrated PV System (Interacts w/ Zone Air Temperature)
This component is intended to model a glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. The waste heat rejected to the air stream is useful for two reasons; 1) it cools the PV cells allowing higher power

conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications including heating of room air. This model is intended to operate with simple building models that can provide the temperature of the zone air on the back-side of the collector and possibly provide an estimate of the radiant temperature for back-side radiation calculations (the room air temperature may be used as a suitable estimate of the radiant temperature if surface temperatures are not available).

The model allows for the user to choose between two methods of handling the off-normal solar radiation effects. The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition; implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied by the classic "Solar Engineering of Thermal Processes" textbook (Beckman, 1991) [1].

Type 567: Glazed Building-Integrated PV System (Interacts w/ Type 56)

This component is intended to model a glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. The waste heat rejected to the air stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications including heating of room air. This model is intended to operate with detailed building models that can provide the temperature of the back surface of the collector (zone air/collector back interface) given the mean surface temperature of the lower flow channel. The Type 56 multi-zone building model in TRNSYS in one of these detailed zone models. Instructions for connecting this model to a Type 56 building can be found later in this document.

The model allows for the user to choose between two methods of handling the off-normal solar radiation effects. The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition; implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied by the classic "Solar Engineering of Thermal Processes" textbook (Beckman, 1991) [1].

Type 568: Un-Glazed Building-Integrated PV System (Interfaces w/ Type 56)

This component is intended to model an un-glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. The waste heat rejected to the air stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications including heating of room air. This model is intended to operate with detailed building models that can provide the temperature of the back surface of the collector (zone air/collector back interface) given the mean surface temperature of the lower flow channel. The Type 56 multi-zone building model in TRNSYS in one of these detailed zone models. Instructions for connecting this model to a Type 56 building can be found later in this document.

The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition; implying that the voltage and current are not calculated by the model.

The thermal model of this collector relies on algorithms supplied by the classic "Solar Engineering of Thermal Processes" textbook (Beckman, 1991) [1].

Type 569: Un-Glazed Building-Integrated PV System (Interfaces w/ Zone Air Temperature)

This component is intended to model an un-glazed solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to an air stream passing beneath the absorbing PV surface. The waste heat rejected to the air stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications including heating of room air. This model is intended to operate with simple building models that can provide the temperature of the zone air on the back-side of the collector and possibly provide an estimate of the radiant temperature for back-side radiation calculations (the room air temperature may be used as a suitable estimate of the radiant temperature if surface temperatures are not available).
The model allows the user three options on specifying how the cell temperature, and the incident solar radiation affect the PV efficiency. The cells are assumed to be operating at their maximum power point condition; implying that the voltage and current are not calculated by the model.
The thermal model of this collector relies on algorithms supplied by "Solar Engineering of Thermal Processes" textbook (Beckman, 1991) [1]

Type 590: Simple PV Panel with PCM Layer and Embedded Heat Exchanger (new in v18)

Type590 models either a glazed or unglazed photovoltaic array that includes a layer of phase change material (PCM). The PCM may have a heat exchanger embedded in it. The model bases its electrical performance calculation on a user provided overall array efficiency. Efficiency may be constant, variable, provided as a function of cell temperature and incident radiation in an external file or provided for reference conditions along with coefficients that describe the effect of cell temperature and incident radiation changes. This model is most appropriate for PV arrays that are connected to a load through a maximum power point tracking device since the efficiency of the Type590 PV is not dependent upon load voltage unless the user employs provides efficiency as an input and calculates that efficiency based on load voltage.

Type 723: Inverter (new in v18)

This component models an inverter that reads its efficiency from an external data file as a function of part load ratio and input voltage. The algorithms are very similar to those contained in standard TRNSYS Type190. They are here in an external Type so that other PV module models can be combined with an inverter.

Type 724: Power Optimizer / Voltage Converter (new in v18)

Type724 models a device that converts an electrical power input at one voltage to an electrical power output at another (user specified) voltage. The device is assumed to have a range of input power and voltages over which it can operate. If the input electrical power falls outside of the range, the device will not function. The device's efficiency is assumed to be a function of the input voltage and part load ratio.

Type 726: Proportional Lighting Controller

This component returns a control signal between a user-defined minimum value and 1 that is related to the value of an input signal at the current time step and compared to user defined minimum and maximum values. The component can be used to simulate an ON/OFF controller by setting the minimum and maximum set point values equal to one another. The controller differs from other proportional controllers in that it generates its maximum signal at the lower set point and its minimum signal at its upper set point. In this regard, the output is inverted from that of a typical controller.

Type 727: Continually Stepped Light Fixtures

This component is intended to model one of many control strategies for reduced energy usage lighting. It takes two control signals and is only ON if both control signals are ON. One of the two control signals is digital, the other an analog value between 0 and 1. The light supplied by the fixture (and its corresponding heat gain) are stepped linearly with the value of the analog control signal. In a typical application, the digital control signals might be connected to the occupancy of a room, while the analog signal is connected to a daylight level sensor. The model also features an automatic delayed shut off as would be appropriate to model lighting connected to a motion sensor. When the digital control signal drops to zero, the lights stay on (and continue to draw power and create a heat gain in the space) for a user settable amount of time.

Type 728: Multiple Power Level Lights

This component is intended to model one of many control strategies for reduced energy usage lighting. It takes two control signals and is only ON if both control signals are ON. In a typical application, one of the control signals might be connected to the occupancy of a room, while the other is connected to a daylight level sensor. The model also features an automatic delayed shut off as would be appropriate to model lighting connected to a motion sensor. When one of the two control signals drops to zero, the lights stay on (and continue to draw power and create a heat gain in the space) for a user settable amount of time. Finally, users may specify the number of power levels at which the lighting may be operated. Both power draw and heat gain are correspondingly stepped back.

Type 1236: Planned and Random Down Times

This component models a piece of equipment (utility grid, air conditioner, etc.) that becomes unavailable at planned and/or random intervals throughout a simulation. As parameters, it takes the number of random outages in a given year, the minimum and the maximum allowable outage length, a random number seed, the number of planned outages, and the start time and duration of each planned outage.

Type 1340: Carnot Heat Engine (new in v18)

The Carnot cycle is an idealized sequence of gas expansions and compressions that can occur between a hot and cold temperature. Its efficiency provides a maximum theoretical efficiency against which actual engine efficiencies can be compared.

This component models a simple heat engine whose efficiency is based on multiplying the calculated Carnot efficiency by a user-defined factor.

Type 1343: Combined PV/T Solar Collector

This component is intended to model a solar collector which has the dual purpose of creating power from embedded photovoltaic (PV) cells and providing heat to a fluid stream passing through channels bonded to an absorber plate located beneath the PV cells. The waste heat rejected to the fluid stream is useful for two reasons; 1) it cools the PV cells allowing higher power conversion efficiencies and 2) it provides a source of heat for many possible low-grade temperature applications.

This model relies on linear factors relating the efficiency of the PV cells to the cell temperature and also the incident solar radiation. The cells are assumed to be operating at their maximum power point condition.

The thermal model of this collector relies on a two-dimensional heat transfer approach; vertically through the various material layers, and then along the length of the flow channels. Heat transfer across the channels (across the width of the collector) is ignored. The flow channels are assumed to occupy a large fraction of the absorber surface such that heat transfer in the vertical fin located between adjacent flow channels is considered negligible. The long wave radiation is calculated from algorithms for small, “gray”, convex surfaces within a large enclosure.

Ground Coupling Library

Type 653: Simple Floor Heating System

This component models a simple radiant slab (floor heating or cooling) system that operates under the assumption that the slab can be treated as a single lump of isothermal mass and that the fluid to slab energy transfer can be modeled using a heat exchanger effectiveness approach.

Type 714: ASHRAE Slab Heat Transfer

In 2001 ASHRAE Fundamentals Chapter 31, the American Society of Heating and Refrigeration Engineers proposes a simplified method for calculating the energy transfer through a rectangular slab on grade with various insulation schemes (back insulation, side insulation, no insulation, etc.). The same chapter extends the simplified method to calculating energy transfer through basements. This Type should be used for slabs while Type715 is available for calculating energy transfer through basements.

Type 715: ASHRAE Basement Heat Transfer

In 2001 ASHRAE Fundamentals Chapter 31 [1], the American Society of Heating and Refrigeration Engineers proposes a simplified method for calculating the energy transfer through a rectangular aspect ratio basement with various insulation schemes (back insulation, side insulation, no insulation, etc.). The same chapter also presents the simplified method as it applies to calculating energy transfer through slabs. This Type should be used for basements while Type714 is available for calculating energy transfer through slabs. Because of the methodology used, this model is not appropriate for use with Type56 but can be used with simplified building models such as standard TRNSYS Type88, or the TESS simplified multizone building model (Type660).

Type 957: Soil Wrapper for Buried Rectangular Storage Tank

This routine models the energy transfer from a liquid-filled, rectangular storage tank to the soil surrounding it. The energy transfer between the tank and surrounding ground is assumed to be conductive only and moisture effects within the soil are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple, but effective, iterative method. Options for far-field soil heat transfer and soil-surface conditions are provided to the user. This model is intended to interface with the Type 531 storage tank model found in the TESS Storage Tank library but may be applied to any storage tank model with fixed isothermal tank nodes and a rectangular cylinder shape.

Type 993: Detailed Radiant Floor

This routine models a series of fluid-filled, parallel, horizontal pipes buried in a radiant floor slab. The energy transfer from the floor and pipes to the slab and within the slab is assumed to be conductive only and moisture effects are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the slab and pipes and solves the resulting inter-dependent differential equations using a simple iterative analytical method. This model assumes that the slab surface is flat and has homogenous thermal properties

This model calculates the average surface temperature of the slab directly underneath the floor of the building zone. The average surface temperature is then passed to a building model as input for the floor. The building model calculates the rate of energy that passes from the floor into the slab based on the boundary floor temperatures provided by this model, the current air temperatures, sensible and latent gains, radiation exchange, etc. The temperatures of each of the “nodes” of the 3-dimensional slab field can be calculated by this model from the slab heat transfer provided by the building model, the thermal history of the slab, the properties of the slab, the entering fluid temperature, and thermal history of the pipes. Based on the calculated slab temperature and the zonal heat flow, the average zonal surface temperature can be calculated and passed back to the building model. This iterative methodology is then solved with the standard TRNSYS convergence algorithms.

Type 1244: User-Mapped Slabs and Basement Model

This component models a basement and/or slabs using a 3-D finite difference approach. The intent of the model is to interact with a building model using the TRNSYS Multizone Building Model (Type56). To create the 3-D mesh used to model the ground, the user creates a map of the soil nodes beneath the ground.
There is a tutorial available for creating the soil noding data file and connecting Type1244 to Type56 in a project. The tutorial is in the Tess Models\Examples\Ground Coupling Library\Type56 Basement Example Tutorial folder. A second example project is available in the Tess Models\Examples\Ground Coupling Library\Type56 Basement Example folder. An example data file with explanation of variables is in the Tess Models\SampleCatalogData\Type1244 folder.

Type 1255: Monolithic Slabs for Non-Type56 Buildings

This subroutine models a slab that communicates thermally with the ground. The slab can be on or in the ground and contain one or more zones. Type1255 is not intended for use with the Type 56 multi-zone building model, but rather with building models that provide the air temperature, radiation-exchange temperature, and the incident surface radiation. The ground temperatures are solved using a 3-D finite difference solution method and the user must supply a data file that contains the mesh sizing and a map of the zones.

Type 1256: Slabs, Basements, and Crawlspaces for Non-Type56 Buildings

This subroutine models multi-zone slab/basement/crawlspace conditions that communicate thermally with the ground. This subroutine is not intended for use with the Type 56 multi-zone building model in TRNSYS. This model is intended to work with building/zone models that can provide the energy balance terms for each surface (air temperature, long-wave radiation exchange temperature, incident radiation (lights, solar etc.)). The material temperatures are solved using a 3-D finite difference solution method and the user must have created an external data file which maps the three-dimensional air, soil, floor, wall, insulation, and footer materials.

Type 1301: Soil Wrapper for Buried Inverted Truncated Conical Storage Tank (new in v18)

This routine models the energy exchange between a storage tank with a truncated conical shape and the surrounding soil. The model is intended to be coupled with the TESS truncated conical storage tank model (Type1535).

Type 1302: Soil Wrapper for Buried Vertically Cylindrical Storage Tank (new in v18)

This routine models the energy exchange between a storage tank with a vertically cylindrical shape and the surrounding soil. The model is intended to be coupled with the TESS truncated conical storage tank model (Type1534).

Geothermal Heat Pump Library

Type 548: Vertical Ground Heat Exchanger (multi-instance compatible) (new in v18)

This subroutine models a vertical heat exchanger that interacts thermally with the ground. It is a more flexible and multi-instance-compatible version of the original TRNSYS vertical ground heat exchanger model, Type 557, which is still available in the Xtras folder of the TESS GHP library of components. This ground heat exchanger model is most commonly used in ground source heat pump applications. This subroutine models either a U-tube ground heat exchanger or a concentric tube ground heat exchanger. A heat carrier fluid is circulated through the ground heat exchanger and either rejects heat to or absorbs heat from the ground, depending on the temperatures of the heat carrier fluid and the ground.

In typical U-tube ground heat exchanger applications, a vertical borehole is drilled into the ground. A U-tube heat exchanger is then pushed into the borehole. The top of the heat exchanger is typically several feet below the surface of the ground. The borehole is filled with a fill material (either virgin soil or a grout of some type).

In typical concentric tube heat exchanger application the borehole is just slightly larger than the outer pipe of the ground heat exchanger, but the same process applies. The borehole is drilled into the ground, and the heat exchanger is pushed into the borehole.

The program assumes that the boreholes are placed uniformly within a cylindrical storage volume of ground. There is convective heat transfer within the pipes and conductive heat transfer between the pipes and the storage volume. The temperature in the ground is calculated from three parts; a global temperature, a local solution, and a steady-flux solution. The global and local problems are solved with the use of an explicit finite difference method. The steady flux solution is obtained analytically. The temperature is then calculated using superposition methods.

Type 557: Vertical Ground Heat Exchanger

Type557 is the original TRNSYS implementation of the vertical ground heat exchanger, based on algorithms developed at the Department of Mathematical Physics at the University of Lund, Sweden (Hellstrom, Goran, "Duct Ground Heat Storage Model, Manual for Computer Code"). With the release of TESSLibs18, Type557 was replaced with Type548. Type548 uses the same underlying algorithms as Type557 for the heat transfer solution, but includes new features such as multi-instance compatibility (more than one instance of Type548 may be used in a simulation) and the ability to specify multiple fluid inlets/outlets and designate flowpaths through the borefield. Please see documentation of Type548 for thorough discussion of these features. Type557 is still available with TESSLibs18 for legacy compatibility; the proforma for the Type may be found in the Xtras folder of the TESS GHP library of components in the Simulation Studio.

Type 951: Buried Noded Twin Pipe

Type 951 models a buried twin pipe – two identical pipes symmetrically embedded in a common casing (insulation or other fill material) which is buried horizontally in the ground. The model is built on, and largely fundamentally identical to, Type 952, the buried noded single pipe model.

Flow in the twin pipes may be either parallel or counterflow. The working fluid is assumed to be the same in both pipes. Thermal resistances are calculated between the pipes and between each pipe and the outer surface/soil boundary. The resulting resistance network is based on the work of Wallenten[1]. The model accounts for the thermal mass (capacitance) of the fluid and the pipe walls, but not for the thermal mass of the embedding casing, nor for the thermal mass of any gap and its material (air, insulation, or other) between the outermost surface of the pipe walls and the embedding casing. Conduction along the axial direction for the fluid and pipe wall are also taken into account. The casing material is surrounded by a three-dimensional finite difference soil conduction network to calculate heat accumulation and dissipation in the soil.

Type 952: Buried Noded Pipe

This routine models the energy transfer from a liquid-filled cylindrical pipe to the soil surrounding it. The energy transfer between the pipe and surrounding ground is assumed to be conductive only; moisture effects within the soil are not accounted for in the model. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple, but effective, iterative method. The pipe may be insulated or un-insulated. Ground-surface effects are not modeled by this component; the pipe is instead assumed to be buried at a sufficient depth that the ground temperature far from the pipe in all directions is governed by depth and time of year.

Type 997: Horizontal Ground Heat Exchanger

This subroutine models a buried heat exchanger consisting of one or more layers of horizontal pipes that interact thermally with the ground. A heat exchange fluid circulates through the pipes and rejects or absorbs heat from the surrounding soil depending on the latter's local temperature. In addition to supporting multiple layers of pipes, the subroutine can also model multiple distinct soil layers, an insulating layer and conditioned zone's surface above and buried to the sides of the heat exchanger, and a groundwater wash layer permeating the soil around the pipes. Each tube may be externally connected or linked to another tube. A flexible method for defining the flow path in the network of parallel pipes allows the user to plumb the field in any desired configuration (including but not limited to n tubes in parallel, a single serpentine tube, m serpentine pipes, etc.)
If the horizontal ground heat exchanger is installed beneath a building, the model may be used with any building model from the detailed multi-zone Type56 approach to the simplified building models such as Type12, Type88, or TESS Type660.
These exchangers are generally arranged with pipes spaced at least 5 ft apart, and at least 4-6 ft deep. This minimizes thermal interference among the pipes, but still subjects the pipes to effects of solar radiation, which affects soil temperatures down to about 30 ft. These radiation affects cause cyclic change in soil temperature that lag behind surface temperatures, are increased by the presence of groundwater, and decrease with depth. Placing the heat exchanger deeper reduces these effects, but increases costs of installation and operation.
The routine assumes that each layer of the heat exchanger consists of the same number of evenly spaced pipes of identical length, though the layers need not be evenly distributed vertically. Heat transfer occurs by convection within the pipes, and then by conduction through the pipe walls and the soil; heat transfer from the soil surface to the surrounding (either directly to the environment or through insulation to a conditioned zone) occurs by radiation and convection. The soil that thermally interacts with the heat exchanger pipes is divided into a 3-D mesh solved using a fully-implicit finite-difference approach; different possible boundary conditions can then be applied to simultaneously solve for the soil temperature gradient along with heat transfer rates, energy storage rates, and fluid outlet temperatures. The soil temperature data is exported to an external file.

Type 999: Horizontal Ground Heat Exchanger (multi-instance compatible) (new in v18)

With the release of TESSLibs18, Type 999 is now the multi-instance-compatible version of the Type 997 horizontal ground heat exchanger model. The TESSLibs18 version of Type 997 will simulate much faster than its v17 predecessor, but as of v18 only one instance of Type 997 is allowed per project. Projects with multiple instances of Type 997 created prior to TESSLibsv18 will need to replace instances of Type 997 with Type 999. The proforma for Type 999 is available in the extras folder of the TESS GHP library. See documentation of Type 997 for complete mathematical description and hints and tips for this Type.

Type 1330: District Loop Buried Pipe (new in v18)

Type 1330 models a buried pipe with a heating (or cooling) load applied along its length. It is designed for applications in which a lumped heating or cooling load may be satisfied by withdrawing energy from (or rejecting energy to) a fluid stream within a pipe deeply buried in the soil, such as for district loop heating and cooling systems.

Type 1330 is built on, and largely fundamentally identical to, Type 952, the buried noded single pipe model. In addition to the features and assumptions of Type 952, Type 1330 also allows the user to specify a heating (or cooling) load along the length of the pipe, as well as minimum and maximum temperature limits for imposing loads on the fluid within the pipe. The buried pipe will satisfy the loads applied, provided they do not cause the fluid to exceed its specified maximum temperature (for cooling loads) or minimum temperature (for heating loads).

High Temperature Solar Library

Type 1257: Parabolic Trough Solar Collector

Type1257 models a concentrating parabolic trough solar collector. This subroutine is unlike other parabolic trough models in that the mass of the working fluid in the absorber tube and the change in fluid properties with temperature is accounted for in the model. The subroutine also allows the user to model a row of identical solar collectors connected in series.

Type 1258: Flow Diverter

Type1258 models a diverting valve that splits a liquid inlet volumetric flow into fractional outlet volumetric flows. One inlet flow may be split into as many as 1000 individual streams. The limit of 1000 inlet flows can be modified in the FORTRAN source code.

Type 1259: Field Pipes

Type1259 models a fluid-filled pipe using the concept of isothermal "nodes". This subroutine is unlike other pipe models in that the change in fluid properties with temperature is accounted for in the model.

Type 1260: Mixing Valve

Type1260 models a multiple-port fluid mixing valve (tee piece) where the enthalpy of the fluid is considered to be a quadratic function of temperature.

Type 1261: Expansion Tank

Type1261 models a variable-volume, fluid-filled storage tank. The fluid in the storage tank is assumed to be fully mixed (no stratification). This subroutine accounts for the change in fluid properties with temperature. This subroutine is often used in closed loop piping projects to model the impact of changing fluid volume with temperature.

Type 1262: Array Shading

This component determines incident radiation upon an array of collectors that shade one another. This model is for single axis tracking parabolic trough collectors that utilize beam radiation only. The tracking axis is assumed to be horizontal (parallel to the ground), on a north-south axis such that the collectors track east to west over the day.

Type 1263: Variable Speed Pump

Type1263 models a variable speed pump in a manner similar to most other pump models. It differs in that the user is able to specify either a linear or a quadratic relationship between fluid temperature and enthalpy and between fluid temperature and fluid density over the pump's working temperature range. This feature is intended to allow users to deal with the working fluids that are typical in high temperature solar applications.

HVAC Library

Type 506: Direct Evaporative Cooler (Swamp Cooler)

Type506 models an evaporative cooling device for which the user supplies the inlet air conditions and the saturation efficiency and the model calculates the outlet air conditions. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature. The device is not equipped with controls that monitor the conditions of the outlet air. When the device is ON (based on a user supplied control signal value), Type506 cools the air as much as it can given the entering conditions and the device efficiency. If a controlled evaporative cooling device is more appropriate to the user's circumstances, Type507 may be used. Type507 models a similar direct evaporative cooling device but takes a target air outlet relative humidity.

Type 507: Controlled Direct Evaporative Cooling Device (Fogging Device)

General DescriptionType507 models an evaporative cooling device for which the user supplies the inlet air conditions and a target air outlet relative humidity. The outlet air dry bulb temperature is modulated given to achieve the desired outlet relative humidity. The cooling process is assumed to be a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature.

Type 508: Cooling Coil with Various Control Modes

Type508 models a cooling coil using one of four control modes. The cooling coil is modeled using a bypass approach in which the user specifies a fraction of the air stream that bypasses the coil. The remainder of the air stream is assumed to exit the coil at the average temperature of the fluid in the coil and at saturated conditions. The two air streams are remixed after the coil. In its unrestrained (uncontrolled) mode of operation, the coil cools and dehumidifies the air stream as much as possible given the inlet conditions of both the air and the fluid streams. The model is alternatively able to internally bypass fluid around the coil so as to maintain the outlet air dry bulb temperature above a user specified minimum, to maintain the air outlet absolute humidity ratio above a user specified minimum or to maintain the fluid outlet temperature below some user specified maximum.

Type 510: Closed Circuit Cooling Tower

Type510 models a closed circuit cooling tower; a device used to cool a liquid stream by evaporating water from the outside of coils containing the working fluid. The working fluid is completely isolated from the air and water in this type of system. Closed circuit cooling towers are often referred to as indirect cooling towers or indirect evaporators.

Type 511: Dry Fluid Cooler

A dry fluid cooler is an HVAC device in which air is blown across coils that contain a hot liquid. The liquid in the coils does not come into direct contact with the air. The component assumes that the device can be modeled as a single-pass, cross-flow heat exchanger but allows the user the option of specifying whether both air and liquid are mixed, whether the air is mixed and the liquid is unmixed, or whether the air is unmixed and the liquid is not. Mixed air refers to a situation where the air is not in channels as it flows across the tubes. It does not mean that the air and water are mixed with each other. In an "unmixed" cross flow heat exchanger, air flows perpendicular to the tube bank but does so in channels. A schematic representation of a dry fluid cooler is pictured below for reference.

Type 525: Variable Speed Compressor Air (Source) -to-Water Heat Pump (Performance Map; Humidity Effects Neglected) (new in v18)

This component models an air source heat pump that has a liquid stream on the load side. The compressor in the device can modulate its speed in order to maintain a user-specified liquid outlet temperature. The heat pump conditions the liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) an air cooled condenser.

This model is based on user-supplied data files containing catalog data for the and compressor power as a function of temperature of air entering the heat pump, the desired water outlet temperature, and the part load ratio at which the heat pump must operate. The required data can be obtained from the catalog performance data files that are typically provided by manufacturers in tabular form.

The model accounts for compressor power as well as both the fan and pump power associated with the device. The pump is assumed to be a single speed on/off device whereas the fan is assumed to be variable speed.

Type525 offers two liquid side control modes. In one, the pump flow rate is assumed to be constant when on and the pump is assumed to be on when there is a call for active heating or cooling. In the other, Type509 takes an additional input for the pump control signal and the pump flow rate is taken to be the value of the pump control signal multiplied by the rated pump flow rate. The pump power is computed from the pump affinity law.

Type 526: Heat Emitter / Simple Radiator (new in v18)

Type526 provides a simplified model of a high temperature/low mass heat emitter like fin-tube convectors. The model does not include any capacitance for the heat emitter, so heat output is only calculated when there is fluid flow through the emitter.

Type 527: Auxiliary Boiler with Thermal Capacitance (new in v18)

Type527 provides a model of a boiler with capacitance. The boiler model takes as input a control signal, an on temperature, and an off temperature. If the control signal is on and the boiler temperature is below the on temperature the burner power will be added to the boiler, if the boiler temperature is above the off temperature then the burner power will not be added even if the control signal is on.

Type 600: Two-Pipe Fan Coil (Mass Flow Parameters)

Type600 models an air handling device that mixed two streams of air, passes the mixed stream across a fan and then across a coil that contains either hot or cold water. The model relies on the bypass factor approach to modeling the energy exchange between the air stream and the water coil. Type600 models a free floating coil in that the model contains no internal controls on either the water or the air outlet temperature. The outlet conditions of both sides are a result only of the inlet conditions and the user-specified coil bypass fraction. Type600 differs from Type928 only in that it takes its flow rate inputs as mass flow rates (whereas Type928 takes them as volumetric flow rates). Type996 models a two-pipe fan coil using a performance map approach.

Type 641: Simple Adiabatic Humidifier

This model represents a simple adiabatic humidifier whose outlet air state is determined by an energy balance. Thermal losses from the humidifier are neglected. The model allows for the humidifier not to respond immediately to the control signal but to reach its steady state moisture gain rate exponentially. Furthermore, the model allows the user to determine whether condensate leaves the humidifier at the temperature at which it enters, at the temperature of the air exiting the humidifier or at any point in between.

Type 651: Residential Cooling Coil (Air Conditioner) – Performance Map Method, Separate File Format

Type651 models a residential cooling coil, more commonly known as a residential air conditioner. It relies on catalog data provided as external text files to determine coil performance. Example data files and information on data file format are provided. A version of this component (Type921) that uses a single-file format instead of two separate files and whose performance data is normalized is also available. A two-speed version is available in Type923 and a model that makes use of coefficients in place of the performance map is available in Type964.

Type 655: Air Cooled Chiller

Type655 models a vapor compression air cooled chiller. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided.

Type 659: Auxiliary Fluid Heater with Proportional Control (Proportional Boiler)

Type659 models an external, proportionally controlled fluid heater. External proportional control (an input signal between 0 and 1) is in effect as long as a fluid set point temperature is not exceeded. If the set point is exceeded, the proportional control is internally modified to limit the fluid outlet temperature to the set point as with Type6.

Type 663: Electric Unit Heater with Variable Speed Fan and Proportional Control

Type663 models an electric unit heater whose fan speed and heating power are proportionally and externally controlled. Proportional control indicates that both fan speed and heating power can vary between 0 and their rated values. External control indicates that the fraction of rated capacity or speed is specified as a time dependent value by the user and is provided to the model as an input. The heater is designed not to exceed a user specified set point temperature. If at any point in the simulation the heater capacity and control signal would result in an outlet temperature higher than the set point, the external control signal value will be overridden. Fan power is specified as a polynomial relating normalized mass flow rate to normalized fan power. The user may control the extent to which the fan power results in a temperature rise in the air stream.

Type 664: Electric Unit Heater with Variable Speed Fan, Proportional Control, and Damper Control

Type664 models an electric unit heater whose fan speed, heating power, and fraction of outdoor air are proportionally and externally controlled. Proportional control indicates that these three variables can have any value between 0 and their rated values. External control indicates that the fraction of rated capacity, speed, or outdoor air is specified as a time dependent value by the user and is provided to the model as an input. The heater is designed not to exceed a user specified set point temperature. If at any point in the simulation the heater capacity and control signal would result in an outlet temperature higher than the set point, the external control signal value will be overridden. Fan power is specified as a polynomial relating normalized mass flow rate to normalized fan power. The user may also control the extent to which the fan power results in a temperature rise in the air stream.

Type 666: Water Cooled Chiller

Type666 models a vapor compression style water cooled chiller. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided.

Type 667: Air To Air Heat Recovery Device

Type667 uses a "constant effectiveness – minimum capacitance" approach to model an air to air heat recovery device in which two air streams are passed near each other so that both energy and possibly moisture may be transferred between the streams. Because of the "constant effectiveness – minimum capacitance" methodology, the model may be used to model a device with any configuration of air streams (parallel flow, cross flow, counter flow, etc.) and may be used to model the sensible and latent aspects of an air to air heat exchanger, an enthalpy wheel, a hygroscopic heat exchanger or a permeable walled flat plate recuperator, among other devices.

Type 670: Air Heating Coil (Keeps the Outlet Air Temperature below a User-Specified Setpoint)

Type670 simulates an air heating coil with an internally controlled bypass damper that acts to maintain the outlet air temperature above the inlet air temperature and below a user-specified set point temperature.

Type 673: Two Pipe Console Unit in Energy Rate Control

Type673 models a piece of HVAC equipment commonly known as a two pipe console unit. Such devices pass air across a tube bank that contains either hot or cold fluid. Depending upon the temperature of the air and the fluid, the air will exit either hotter or colder than it entered. Type673 models a two pipe console unit in energy rate control mode, meaning that sensible and latent loads are inputs to the model. Type673 includes a "number of identical units" parameter that allows for easy scaling of the system to meet the building load.

Type 676: Double-Effect Steam-Fired Absorption Chiller

Type676 uses a normalized catalog data lookup approach to model a double-effect steam-fired absorption chiller. "Steam-Fired" indicates that the energy supplied to the machine's generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided. If the manufacturer's performance data that you have been provided does not conform well to the structure of the four files required by Type676, consider the use of either Type615 or Type717 (both in the TESS CHP Library) as they use the same methodology as Type676 but require a different data file format (one that is commonly used by certain manufacturers).

Type 677: Double-Effect Hot Water-Fired Absorption Chiller

Type677 uses a normalized catalog data lookup approach to model a double-effect hot-water fired absorption chiller. "Hot Water-Fired" indicates that the energy supplied to the machine's generator comes from a hot water stream. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

Type 678: Double-Effect Direct-Fired Absorption Chiller

Type678 uses a normalized catalog data lookup approach to model a double-effect direct fired absorption chiller. "Direct Fired" indicates that the energy that must be supplied to the machine's generator comes from a burner (natural gas or other combustible fuel) built into the machine. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

Type 679: Single-Effect Steam-Fired Absorption Chiller

Type679 uses a normalized catalog data lookup approach to model a single-effect steam-fired absorption chiller. "Steam-Fired" indicates that the energy supplied to the machine's generator comes from a steam source. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

Type 681: Single-Effect Direct-Fired Absorption Chiller

Type681 uses a normalized catalog data lookup approach to model a single-effect direct fired absorption chiller. "Direct Fired" indicates that the energy that must be supplied to the machine's generator comes from a series of burners built into the device. Because the data files are normalized, the user may model any size chiller using a given set of data files. Example files are provided.

Type 684: Air Side Economizer

Type684 models an air side economizer that internally determines an appropriate mixture of outside and return air that will result in air delivered to the zone at the same temperature, enthalpy, or humidity ratio as air that would be delivered by a cooling coil.

Type 688: Dehumidifier

Type688 models a stand-alone "all in one" dehumidifier in which the air stream is in contact with the evaporator section (cools and dehumidifies the air), and with the condenser section (reheats the air) of the refrigerant loop. The user can control the amount of heat that is added to the flow stream by setting an input value; a value of zero signifies that no air reheating is done and that all the compressor and evaporator energy is rejected to the surroundings. A value of one signifies that all the compressor and evaporator energy is added back into the air stream flowing across the coils. The model relies on a data file containing performance data at various entering air conditions. The power reported in this data file should contain only the compressor power as the fan power is handled separately.

Type 689: Heat Pipe

Type689 models a passive device called a heat pipe, which transfers energy from one fluid stream to another - often times the same fluid stream but with a heating or cooling device inserted between the two heat exchangers of the heat pipe. Heat pipes are commonly used in dehumidification applications where warm humid air is cooled to near its dew point using the heat pipe, then is further cooled and dehumidified in a dehumidifier, then is passed back across the other end of the heat pipe where it is reheated using the heat removed from the first cooling in the heat pipe.

Type 692: Performance Map Fluid Cooler

Type692 models a simple fluid cooling device. The model relies on an external, user-supplied data file that contains device capacity and COP as a function of the inlet fluid temperature and a sink temperature.

Type 696: Air Stream Conditioning Device

Type696 models a simple air conditioning device that adds or removes sensible and latent energy from an air stream to meet user-specified set point conditions of temperature and / or humidity. In this device the sensible condition controls the latent decisions. In other words the device cannot heat and dehumidify or cool and humidify the air stream. It can, however, heat and humidify or cool and dehumidify. To use the component effectively as a dehumidifying coil, set the set point temperature in cooling to the inlet air temperature and the humidity set point to desired level, then set the IREHEAT parameter value to 1 so that the air is returned (through reheat after dehumidification) to its inlet condition or set IREHEAT to 0 allow for a free-floating outlet temperature. To operate this component as a temperature controlled device only, choose the RH input mode and set the maximum outlet RH to 100% (for cooling /dehumidification mode) and the minimum outlet RH to 0% (for heating / humidification mode).

Type 697: Performance Map Cooling Coil

Type697 models a simple air cooling device that removes energy from an air stream according to performance data found in a combination of three external data files and based upon the flow rates and inlet conditions of the air stream and a liquid stream. Normally a water stream is used but if the external data is available for other liquids, that data can be used equally well. A version of this component that uses a single external file is also available in Type995

Type 700: Simple Boiler with Efficiency Inputs

Type700 models a simple steam boiler. According to ASHRAE, a boiler is defined by its overall efficiency (output/input) and by its combustion efficiency ((input energy-stack energy)/input energy). In this model, the boiler efficiency and the combustion efficiency are supplied as inputs to the model. A version of this component also exists (Type751) in which boiler and combustion efficiency are read as a function of entering liquid temperature and device part load ratio from an external data file. This component (Type700) assumes that device efficiency is not a function of inlet conditions.

Type 716: Rotary Desiccant Dehumidifier

This component models a rotary desiccant dehumidifier containing nominal silica gel whose performance is based on equations for F1-F2 potentials developed by Jurinak [3]. The model computes the values of F1 and F2 for a given set of design conditions then computes the outlet conditions of both the process and regeneration streams. There are no controls built into the model. Type1716 takes F1 and F2 as parameters but allows controls on the process air outlet. Type1225 offers a performance map version of a rotary desiccant dehumidifier. A schematic of the rotary wheel desiccant dehumidifier modeled by this Type is shown in **Error! Reference source not found.** below.

Type 751: Simple Boiler with Efficiency from Data File

Type751 models a simple steam boiler. According to ASHRAE, a boiler is defined by its overall efficiency (output/input) and by its combustion efficiency ((input energy-stack energy)/input energy). In this model, the boiler efficiency and the combustion efficiency are read from an external data file in which they are provided as a function of entering liquid temperature and device part load ratio. A version of this component exists (Type700) in which the combustion and boiler efficiency values are specified as inputs to the model instead of in an external data file.

Type 752: Simple Cooling Coil with Various Control Modes

Type752 models a cooling coil using a bypass fraction approach. A user-defined fraction of the inlet air stream is assumed to reach the average temperature of the liquid filled coils of the device while the remaining fraction is assumed to completely bypass the effects of the coil. The two air streams then mix back together and the outlet conditions are calculated. The Type752 cooling coil differs from other cooling coil models in that it does not treat the liquid side of the system at all. It is assumed that the coil is not constrained by the liquid side or in other words, that the liquid side can absorb as much energy from the air side as needed. Type752 can be used in three different control modes; in one control mode, the outlet dry bulb temperature of the air stream is maintained at a desired level. In another control mode the air outlet humidity is maintained at a desired level. In the third control strategy both temperature and humidity are maintained at desired levels. This cooling coil model is not designed to be used in a free float mode because nothing is known about the conditions of liquid entering the device. The model reports the amount of energy removed from the air stream and (if both temperature and humidity are controlled) the amount of reheat energy required to bring the temperature back up to the desired level after meeting the humidity requirement.

Type 753: Heating Coil with Various Control Modes

Type753 models a heating coil using one of three control modes. The heating coil is modeled using a bypass approach in which the user specifies a fraction of the air stream that bypasses the coil. The remainder of the air stream is assumed to exit the coil at the average temperature of the fluid in the coil. The air stream passing through the coil is then remixed with the air stream that bypassed the coil. In its unrestrained (uncontrolled) mode of operation, the coil heats the air stream as much as possible given the inlet conditions of both the air and the fluid streams. The model is alternatively able to internally bypass air around the coil so as to maintain the outlet air dry bulb temperature above a user specified minimum, or to maintain the fluid outlet temperature above a user specified minimum.

Type 754: Heater/Humidifier

Type754 models a device that can heat and / or humidify an air stream. Depending upon the device control mode, the outlet air stream dry bulb temperature, dry bulb temperature and relative humidity, dry bulb temperature and humidity ratio, or humidity ratio only will be maintained by the device. Type754 is not capacity limited but reports the sensible and latent energy required to meet the requested outlet condition based on the air inlet conditions.

Type 757: Indirect Evaporative Cooler

Type757 models an evaporative cooling device for which the user supplies the inlet air conditions of a primary and secondary air stream and the device effectiveness as a function of primary stream inlet air dry bulb temperature and secondary stream inlet air wet bulb temperature. The model calculates outlet air conditions and assumes that the secondary air stream process is a constant wet bulb temperature process meaning that air enters and exits at the same wet bulb temperature. The device is not equipped with controls that monitor the conditions of the outlet air. When the device is ON (based on a user supplied control signal value), Type757 cools the primary air stream as much as it can given the entering conditions and the device effectiveness.

Type 760: Air To Air Sensible Heat Exchanger

Type760 uses an effectiveness – minimum capacitance approach to model an air to air heat exchanger that transfers only sensible energy. If moisture transfer as well as sensible energy transfer between the exhaust and fresh air streams is important, Type667 (an air to air heat recovery device) uses similar principals to this model but also accounts for moisture transfer between the air streams. Type760 includes five different control modes. In the first of these control modes, the outlet temperatures of the two air streams are completely uncontrolled. In the other four operation modes, the temperature of either the fresh or exhaust air streams is maintained either above or below a user defined set point.

Type 762: Steam Humidifier (Various Control Modes) (new in v18)

Type762 is very similar to Type641 in that it includes the same control modes as well as a time constant such that the steady state moisture addition rate is not reached immediately. It differs from Type641 in that water entering the humidifier is heated to a desired steam state before being added to the air stream.

Type 779: Active Chilled Beam (new in v18)

In an active chilled beam, a primary air stream (usually conditioned) passes through a duct along the spine of the beam and out into the body of the beam through a series of nozzles. As the primary air passes through the nozzles, it induces a secondary flow of air from the local vicinity of the beam, over a set of water coils and into the body of the beam. Primary and secondary air streams mix and are returned to the space.

Type 781: Simple Air-Cooled Chiller Stack (new in v18)

Type781 models a stack of identical vapor compression air-cooled chillers. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided. Each chiller in the stack is modeled in the same manner as Type655.

Type 786: Variable Speed Compressor Air (source) to Air Heat Pump – One Indoor Unit per Outdoor Unit (new in v18)

Type786 uses a manufacturer's catalog data approach to model an air (source) to air heat pump (air flows on both the condenser and evaporator sides of the device). Such devices are sometimes referred to as air source heat pumps or as split system heat pumps. The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). Type786 is a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type786 is mathematically very similar to Type954. However, it asks the user to specify heating mode and cooling mode supply air temperature and adjusts its capacity internally to supply air at the desired condition. An external data file allows the user to specify how much power the heat pump consumes when its compressor is operating at reduced speed.

Type 787: Simple Water-Cooled Chiller Stack (new in v18)

Type787 models a stack of identical vapor compression water-cooled chillers. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided. Each chiller in the stack is modeled in the same manner as Type666.

Type 788: Simple Boiler Stack (new in v18)

Type788 models a stack of identical boilers. It relies on catalog data provided as external text files to determine boiler performance. Example data files and information on data file format are provided. Each boiler in the stack is modeled in the same manner as Type751.

Type790: Multi-Rejection (Natatorium) Dehumidifier (new in v18)

Like Type918, this component models a dehumidifier that can reject its waste heat back into the dehumidified air stream, into a liquid stream, or to the ambient. The model relies on a data file containing performance data at various entering air conditions. The power reported in the data file should include both the compressor power and the fan power.

Type790's data file is normalized in that it takes device rated capacity, sensible capacity, power draw, and heat of rejection as parameters and expects the values given in the catalog data to be given as multipliers on those rated values. Type790 differs from Type918 in that Type918 does not include an economizer, auxiliary heat, or internal controls.

Type 791: Simple Electric Baseboard Heater (new in v18)

This simple model takes the total capacity of a heater and splits it between convective and radiative energy gains.

Type 792: Hot Water Radiator (Correction Factor Method) (new in v18)

Type792 proposes to model a radiator whose energy output is proportional to the difference between the average radiator temperature and the surroundings. The proportionality is defined as a function of the temperature difference in an external data file.

Type 793: Variable Speed Compressor Water (Source) to Air Heat Pump (new in v18)
Type793 uses a manufacturer's catalog data approach to model a water (source) to air heat pump. Such devices are sometimes referred to as geothermal heat pumps or simply as water source heat pumps. The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). Type793 is a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type793 is mathematically very similar to Type919. However, it asks the user to specify heating mode and cooling mode supply air temperature and adjusts its capacity internally to supply air at the desired condition. An external data file allows the user to specify how much power the heat pump consumes when its compressor is operating at reduced speed.

Type 909: Adsorption Chiller (Performance Map)
Adsorption is the process by which particles (molecules of water in this case) adhere to a surface. Adsorption chillers cool a liquid stream by evaporating water onto the surface of a solid desiccant matrix. The desiccant can adsorb more moisture than can a normal surface. The desiccant matrix is then regenerated (dried back out) by means of a low temperature water stream. Energy is rejected to a third liquid stream typically called the cooling water.

Type909 relies on a text data file containing a performance map that specifies the chiller's capacity and COP as a function of inlet hot water temperature, cooling water temperature

Type 917: Air to Water Heat Pump (Air Humidity Effects Estimated)
This component models a single-stage air source heat pump that has a liquid stream on the load side. The liquid side is also equipped with an optional desuperheater that can be used to heat a secondary liquid stream (such as a service hot water circuit). The heat pump conditions the primary liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) an air cooled condenser.

The optional desuperheater can be used to either heat or cool a secondary liquid stream.

This model is based on user-supplied data files containing catalog data for the capacity (total capacity in heating mode and both total and sensible capacities in cooling mode) and power. As a function of entering water temperature to the heat pump, the entering water flow rate and the air flow rate. Other user-generated performance maps are used to modify the capacities and power based on off-design indoor air temperatures. The required data can be obtained from the catalog performance data files that are typically provided by manufacturers in tabular form.

Type 918: Multi-Mode Dehumidifier
This component models a dehumidifier that can reject its waste heat back into the dehumidified air stream, into a liquid stream, or to the ambient. The model relies on a data file containing performance data at various entering air conditions. The power reported in the data file should include both the compressor power and the fan power. Type918's data file is normalized in that it takes device rated capacity, sensible capacity, power draw, and heat of rejection as parameters and expects the values given in the catalog data to be given as multipliers on those rated values. It differs from Type790 in that Type790 includes internal controls, auxiliary heat, and an air side economizer in order to model the kind of air handlers that are often installed in natatoriums.

Type 919: Water Source Heat Pump
This component models a single-stage liquid source heat pump with an optional desuperheater for hot water heating. The heat pump conditions a moist air stream by rejecting energy to (cooling mode) or absorbing energy

from (heating mode) a liquid stream. This heat pump model was intended for a residential ground source heat pump application, but may be used in any liquid source application.
The heat pump has a desuperheater attached to a secondary liquid stream. In cooling mode, the desuperheater relieves the primary liquid stream of some of the burden of rejecting energy. However, in heating mode, use of the desuperheater causes the heat pump to absorb the energy required for both space and domestic water heating from the primary liquid loop.
This model is based on user-supplied data files containing catalog data for the capacity (both total and sensible in cooling mode) and power, normalized by their rated values, and based on the entering water temperature to the heat pump, the entering water flow rate and the air flow rate. Other curve fits are used to modify the capacities and power based on off-design indoor air temperatures. The required data can be obtained from the catalog performance data files that are typically provided by manufacturers in tabular form. Type 919 takes airflow and water flow, again normalized to rated values, as its input.

Type 921: Residential Cooling Coil (Air Conditioner) – Unified File Format

Type921 models a residential cooling coil, more commonly known as a residential air conditioner. It relies on catalog data provided as an external text file to determine coil performance. Example data files and information on data file format are provided. A functionally identical version of this component (Type651) that uses a multiple file format instead of a single file and whose performance data is not normalized is also available. A two-speed version is available in Type923 and a model that makes use of coefficients in place of the performance map is available in Type964.

Type 922 Two Speed Air-to-Air Heat Pump (Performance Map)

Type922 is a two-speed version of the Type954 air-to-air heat pump model. Type922 uses a manufacturer's catalog data approach to model an air to air heat pump (air flows on both the condenser and evaporator sides of the device). Such devices are sometimes referred to as air source heat pumps or as split system heat pumps. The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). In heating mode, the device is equipped with one of three auxiliary heater types: no auxiliary heat available, two element electric auxiliary heat, or gas fired auxiliary heat. Like Type954, Type922 is a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type 923: Two-Speed Residential Cooling Coil (Air Conditioner)

Type923 models a two speed residential cooling coil, more commonly known as a residential air conditioner. It is functionally identical to Type921, relying on catalog data provided in a pair of external text files to determine coil performance. Example data files and information on data file format are provided. Where Type921 models a single speed residential air conditioner, Type923 models a device that has a low cooling/low fan speed setting and a high cooling/high fan speed setting.

Type 927: Normalized Water-to-Water Heat Pump (Performance Map)

This component models a single-stage heat pump. The heat pump conditions a one liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second. This model is a performance map meaning that its results are based on information contained in a user-supplied data files containing catalog data for the capacity and power draw as a function of entering load and source temperatures. Type927 operates in temperature level control much like an actual heat pump would; when the user defined control signal indicates that the unit should be ON in either heating or cooling mode, it operates at its capacity level until the control signal values changes. A two-stage version of this component is available in Type1221

Type 928: Two-Pipe Fan Coil (Volumetric Flow Parameters)

Type928 models an air handling device that mixed two streams of air, passes the mixed stream across a fan and then across a coil that contains either hot or cold water. The model relies on the bypass factor approach to modeling the energy exchange between the air stream and the water coil. Type928 models a free floating coil in that the model contains no internal controls on either the water or the air outlet temperature. The outlet conditions of both sides are a result only of the inlet conditions and the user-specified coil bypass fraction. Type928 differs from Type600 only in that it takes its flow rate inputs as volumetric flow rates (whereas Type600 takes them as mass flow rates). Type996 models a two-pipe fan coil using a performance map approach.

Type 929: Simple Gas Fired Heating Coil

Much like Type6 does for liquids, Type929 represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The gas fired heating coil is bound by a heating capacity and an efficiency. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

Type 930: Simple Electric Heating Coil

Much like Type6 does for liquids, Type930 represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The electric heating coil is bound by a heating capacity and assumes an efficiency of 100%. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account.

Type 941: Air-to-Water Heat Pump (Performance Map; Humidity Effects Neglected)

This component models a single-stage air source heat pump that has a liquid stream on the load side. The liquid side is also equipped with an optional desuperheater that can be used to heat a secondary liquid stream (such as a service hot water circuit). The heat pump conditions the primary liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) an air cooled condenser.

The optional desuperheater can be used to either heat or cool a secondary liquid stream.

This model is based on user-supplied data files containing catalog data for the capacity (total capacity in heating mode and both total and sensible capacities in cooling mode) and power. As a function of entering water temperature to the heat pump, the entering water flow rate and the air flow rate. Other user-generated performance maps are used to modify the capacities and power based on off-design indoor air temperatures. The required data can be obtained from the catalog performance data files that are typically provided by manufacturers in tabular form.

Type 954: Air-to-Air (Air Source or Split System) Performance Map Heat Pump

Type954 uses a manufacturer’s catalog data approach to model an air to air heat pump (air flows on both the condenser and evaporator sides of the device). Such devices are sometimes referred to as air source heat pumps or as split system heat pumps. The model includes mixing algorithms and damper settings so that the indoor air may be the result of two streams from different sources (recirculation and makeup air for example). In heating mode, the device is equipped with one of three auxiliary heater types: no auxiliary heat available, two element electric auxiliary heat, or gas fired auxiliary heat. The model is also equipped with a capacity multiplier parameter so that the heat pump may be quickly resized without having to resort to finding new data files. Type954 is also a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type 987: 4-Pipe Fan Coil (Performance Map)

Type987 models a fan box that contains an outside air damper, a hot water heating coil and a chilled water cooling coil. As with many TRNSYS components, the user is not obligated to use water in the coils but may specify any liquid whose specific heat is constant over the temperature range in the simulation. The model relies on a pair of external data files that relate the fan coil's capacity to its entering air and liquid conditions. A third file relates fan power to fan relative speed.

Type 995: Performance Map Cooling Coil - Unified File Format

Type995 models a simple air cooling device that removes energy from an air stream according to performance data found in an external data files and based upon the flow rates and inlet conditions of the air stream and a liquid stream. Normally a water stream is used but if the external data is available for other liquids, that data can be used equally well. A version of this component in which the performance data is broken up into multiple external files is available in Type697.

Type 996: 2-Pipe Fan Coil (Performance Map)

Type987 models a fan box that contains an outside air damper, a hot water heating coil and a chilled water cooling coil. As with many TRNSYS components, the user is not obligated to use water in the coils but may specify any liquid whose specific heat is constant over the temperature range in the simulation. The model relies on a pair of external data files that relate the fan coil's capacity to its entering air and liquid conditions. A third file relates fan power to fan relative speed.

Type 1221: Two-Stage Water-to-Water Heat Pump (Performance Map)

This component models a two-stage heat pump. The heat pump conditions a one liquid stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a second. This model is a performance map meaning that its results are based on information contained in a user-supplied data files containing catalog data for the capacity and power draw as a function of entering load and source temperatures. Type1221 operates in temperature level control much like an actual heat pump would; when the user defined control signal indicates that the unit should be ON in either heating or cooling mode, it operates at its capacity level until the control signal values changes. A one-stage version of this component is available in Type927

Type 1225: Rotary Desiccant Dehumidifier (Performance Map)

Type1225 offers an alternative to the Type716 rotary desiccant dehumidifier model. Where Type716 characterizes the performance of the dehumidifier using isopotential curves for a particular desiccant, Type1225 simply reads outlet conditions from an external data file as a function of inlet conditions. The advantage of Type716 is that the model is applicable for all possible inlet states of process and regeneration air. Its disadvantage is that the coefficients required to describe the desiccant can be difficult to find. Type1225 can be simpler to set up and use but the validity of the model is only as good as the data contained in the external file.

Type 1231: Hydronic Heat-Distributing Unit (Radiator)

Type1231 models low-temperature hydronic heat-distributing units such as radiators, convectors, and baseboard and finned-tube units. These types of unit supply heat through a combination of radiation and convection without fans. For a full description of these units and their usage please see ASHRAE Handbook – HVAC Systems and Equipment [ASHRAE 2004].

Type 1246: Auxiliary Cooler

Type1246 models a liquid cooling device that can modulate its cooling output to achieve a desired outlet temperature.

Type 1247: Water Source Heat Pump Section of an Air Handler

Like most of the TESS Library heat pump models, Type1247 uses a manufacturer's catalog data approach to model a water (source) to air (load) heat pump section that might appear in an air handler. At heart, Type1247 is very similar to the Type919 water-to-air heat pump. It differs in that it does not include algorithms to mix return and fresh air, it does not include any auxiliary heating, and it does not include the ability to define a domestic/service water heating desuperheater. Like Type919, Type1247 is a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type 1248: Air to Air Heat Pump Section of an Air Handler

Like most of the TESS Library heat pump models, Type1248 uses a manufacturer's catalog data approach to model an air to air heat pump section that might appear in an air handler. At heart, Type1248 is very similar to the Type954 air-to-air heat pump. It differs in that it does not include algorithms to mix return and fresh air, it does not include any auxiliary heating, and it does not include the ability to define a domestic/service water heating desuperheater. Like Type954, Type1248 is a normalized model in that it takes device rated capacity and power draw as parameters and expects the values given in the catalog data to be given as multipliers on those rated values.

Type 1305: Heat Recovery Chiller (new in v18)

Type1305 models a vapor compression style water-cooled chiller. It relies on catalog data provided as external text files to determine chiller performance. Example data files and information on data file format are provided. The user has the option of setting a desired chilled water leaving temperature or a leaving cooling water temperature (heat recovery chiller mode)

Type 1320: Water Cooled Chiller Stack (Variable Condenser Flow) (new in v18)

Type1320 models a stack of identical chillers in much the same way as Types666 and 787. There are two important differences. First, Type1320's performance is based on the average chilled water temperature rather than on the leaving chilled water temperature. Second Type1320 asks the user to provide a desired temperature difference between the entering and leaving condenser water temperature and computes the flow rate required in order to achieve that temperature difference.

Type 1323: Variable Speed Compressor Water (Source) to Water Heat Pump (new in v18)

This component models a water (source) to water heat pump based on data files of normalized manufacturer's catalog data that is similar to the data required by other heat pump models. In this Type the heat pump attempts to meet a user-specified outlet water temperature given the maximum capacity of the unit at the current conditions. The Type can model multiple heat pumps operating in parallel.

Type 1324: Heating-Only Variable Speed Compressor Water (Source) to Water Heat Pump with Flow Modulation (new in v18)

This component models a *heating-only* water-to-water heat pump whose load side flow rate and compressor speed can adjust to maintain a desired outlet temperature on the load side. The heat pump heats a liquid stream by absorbing energy from a second liquid stream. This model is based on user-supplied data files containing catalog data for the normalized capacity and power draw, based on the entering load and source temperatures and the normalized source flow rate. This model will attempt to heat the load stream to the user-specified outlet temperature but capacity and flow restrictions may keep it from reaching that goal. It is very important to note that this model sets the load flow rate.

Type 1327: Heat Pump based on the Lorenz Cycle (new in v18)

Type1327 takes a somewhat different approach to modeling a heat pump. In most cases an on/off and heat/cool input is set to the heat pump model, which in turn calculates heat pump performance and the amount of power that the heat pump consumes. In some cases, however, a heat pump is to be run as best it can be whenever some amount of power is available. Type1327 asks the user to provide the amount of available power as well as some values that describe a Lorenz cycle. The Lorenz cycle is a more practical representation of a refrigerant cycle than the Carnot cycle in that unlike the Carnot cycle it *does not* assume that the thermal reservoirs stay at constant temperature and it allows there to be some thermal resistance between the refrigerant and the working fluids in the thermal reservoirs.

Type 1332: Counter Flow HX that takes Design Conditions and Works out UA; Multiple Control Modes (new in v18)

A zero capacitance sensible heat exchanger is modeled in a counter or parallel flow arrangement. Given the hot and cold side inlet temperatures and flow rates, the effectiveness is calculated based on design conditions as outlined in [1]

This model differs from other heat exchangers in that it allows various control modes that can limit the outlet temperature on either the hot side or the cold side (among others). It takes control mode as an input so that the mode can change throughout the simulation. It replaces six heat exchanger models that were available in an earlier TESS Libraries release and each of which modeled a single control mode.

Type 1333: Temperature Limiting Device / Pressure Relief Valve (new in v18)

This routine models a simple temperature limiting device for a liquid flow stream. It compares an inlet temperature to a user-defined maximum allowable temperature and, if the inlet temperature is higher than the maximum allowable temperature, it dumps as much energy as needed to bring the inlet temperature down to the maximum allowable temperature.

Type 1337: Sensible Only Heat Exchanger; Effectiveness Input, Multiple Control Modes (new in v18)

This routine simulates a sensible heat exchanger, giving outlet temperatures and flowrates of hot and cold streams based on the effectiveness approach as described in multiple sources including Incropera and Dewitt: Introduction to Heat Transfer [1]. This model differs from other heat exchangers in that it allows various control modes that can limit the outlet temperature on either the hot side or the cold side (among others). It takes control mode as an input so that the mode can change throughout the simulation. It replaces six heat exchanger models that were available in an earlier TESS Libraries release and each of which modeled a single control mode.

Type 1338: Heat Recovery Chiller Stack (Identical Chillers) (new in v18)

This component models a water-cooled chiller using a look-up table approach into two external performance data files. The first file contains the chiller capacity and COP as a function of the cooling water inlet temperature and chilled water set-point temperature. The second file contains the fraction of full load power data as a function of the chiller part load ratio. In this update, the chiller sets the flow rate for the cooling loop based upon the user-provided condenser loop temperature rise.

Type 1339: Detailed Heat Recovery Chiller Stack (Non Identical Chillers) (new in v18)

This component models a water-cooled heat recovery chiller bank using a look-up table approach into two external performance data files. The first file contains the chiller capacity and COP as a function of the cooling water inlet temperature and chilled water set-point temperature. The second file contains the fraction of full load power data as a function of the chiller part load ratio. This model will meet any simultaneous loads using the best combination of available chillers and then attempt to meet the balance of the heating or cooling load using the best remaining combination of chillers. In this non-simultaneous operation mode, the source stream will be used as the heat sink (cooling mode) or heat source (heating mode). Capacity for each chiller will be checked on both a power basis (enough heating/cooling capacity to meet the load) as well as a flow basis. Each chiller is assumed to have the same normalized performance. The source flow will be set based on a user-specified delta T for the source stream and the flow bounds checked.

Type 1344: Electric Thermal Storage (Ceramic Brick) – Air Version (new in v18)

Type 1344 models a thermal/electric storage device that is commonly used to store cheap off-peak electricity as heat in a storage medium and then discharge air through the device to provide space heat. This particular component models a ceramic brick heat storage device where the bricks are heated by electrical heating elements and then discharged by blowing air through channels within the bricks. This model assumes an integral fan and that the air flows uniformly down the channels on one side of the storage and then doubles back and flows uniformly down the other side before being discharged. An integral bypass damper modulates the air flow through the storage in order to provide a user-defined outlet air temperature.

The user provides the physical details of the storage device (length, width, depth, material properties, the number, size and location of the air channels), details on the insulation (thermal properties and thickness on each of the 6 faces), the rated heater power, and details of the fan (rated power, rated flow rate, and an exponent to account for off-rated flow conditions) as parameters to the model. The inlet air conditions to the model, the environment conditions (for thermal losses), the control signals for the fan and heater, and the setpoint for the outlet air are then provided to the model as inputs (time varying). The model then solves for the outlet air conditions, the power consumption of the heater and the fan, losses to the environment, and the rate of change of energy stored in the materials of the device.

Type 1369: Electric Thermal Storage (Ceramic Brick) – Liquid Version (new in v18)

Type 1369 models a thermal/electric storage device that is commonly used to store less expensive off-peak electricity as heat in a storage medium, then heating a process liquid stream when heat is needed. This particular component models a ceramic brick heat storage device where the bricks are heated by electrical heating elements and then discharged by blowing air through channels within the bricks. The air then passes across an air-to-liquid heat exchanger and heats an incoming liquid stream. This model assumes an integral fan and that the air flows uniformly down the channels on one side of the storage and then doubles back and flows uniformly down the other side before being discharged into the heat exchanger. An integral bypass damper modulates the air flow through the storage in order to provide a user-defined outlet liquid temperature.

The user provides the physical details of the storage device (length, width, depth, material properties, the number, size and location of the air channels), details on the insulation (thermal properties and thickness on each of the 6 faces), the rated heater power, and details of the fan (rated power, rated flow rate, and an exponent to account for off-rated flow conditions) as parameters to the model. The inlet liquid conditions to the model, the environment conditions (for thermal losses), the control signals for the fan and heater, and the setpoint for the outlet liquid stream are then provided to the model as inputs (time varying). The model then solves for the outlet air and liquid conditions, the power consumption of the heater and the fan, losses to the environment, and the rate of change of energy stored in the materials of the device.

Type 1716: Rotary Desiccant Dehumidifier with Process Air Humidity Control

This component models a rotary desiccant dehumidifier containing nominal silica gel whose performance is based on equations for F1-F2 potentials developed by Jurinak [3]. Unlike Type716, this version of the model takes the values of F1 and F2 as parameters (instead of computing them) but allows controls on the process air outlet. Type1225 offers a performance map version of a rotary desiccant dehumidifier.

Hydronics Library

Type 604: Bi-Directional Noded Pipe

Type604 models a liquid filled pipe that can accommodate flow in either direction. Unlike the standard Type 31 pipe model in TRNSYS, Type 604 can also consider the effects of the pipe and insulation mass. The model calculates the heat loss coefficient based on the fluid properties, the pipe properties, the insulation properties, and convection (forced and natural) and radiation from the outer surface to the environment. The model assumes that the pipe can be characterized by a series of thermally connected, fully-mixed fluid nodes. This mimics a plug-flow model when the number of nodes is high. The model does not allow for flow in both directions at the same time step

Type 607: Air Duct (Thermal Model)

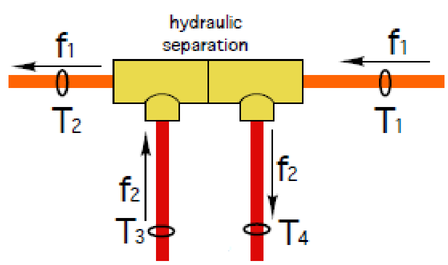
Type 607 models heat loss (or gain) between a duct and its surroundings. The duct's cross section may be either circular or non-circular. The duct is modeled as a series of connected, fully-mixed air nodes in steady-state operation. Calculations are based in part on algorithms from "Duct Thermal Performance Models for Large Commercial Buildings" (Craig Wray, LBNL, 2003), as well as on classic first principles of heat transfer. Pressure drop effects are not calculated. The duct may be insulated, if desired. Both forced and free convection (natural convection) effects are considered on the outer surface.

Type 642: Single Speed Fan

Type 642 models a single speed (constant speed) fan that maintains a constant fluid outlet mass flow rate. As with most pumps and fans in TRNSYS, Type 642 sets the downstream flow rate; it only uses the mass flow rate input to perform a mass balance check over the fan. Type 642 sets the downstream flow rate based on its rated flow rate parameter and a binary interpretation of its control signal input (either ON or OFF). Fan starting and stopping characteristics are not modeled.

Type 643: Closely Spaced Tees (new in v18)

Type 643 models the closely spaced tees commonly used in primary-secondary piping arrangements. A diagram of two closely spaced tees is shown in the figure below:



As shown in the figure fluid stream 1 (f_1) passes straight through the top straight section of the tees, while fluid stream 2 (f_2) passes up into the left-hand tee, makes a U-turn, and comes down and out of the right-hand tee. While the two fluid streams are hydraulically separate (no mixing), they are thermally coupled through the tees, and fluid stream 1 will change temperature from T_1 through T_2 and fluid stream 2 from T_3 to T_4 in passing through the tees. The closely spaced tees are modeled as an ideal counterflow heat exchanger in this Type.

Type 644: Two Speed Fan/Blower

Type 644 models a two speed (high speed or low speed) fan that maintains a constant fluid outlet mass flow rate and power consumption consistent with either its high-speed or low-speed control signal. As with most pump and fan Types in TRNSYS, Type 644 sets the downstream mass flow rate; the inlet mass flow rate is only used to perform a mass balance check over the fan. Type 644 sets the downstream flow rate based on its rated flow rate for high-speed or low-speed operation and its corresponding low-speed or high-speed control signal input.

Type 646: Air Supply Plenum With Up To 100 Ports

Type 646 models a supply air plenum with one inlet port and up to 100 outlet ports. The mass flow rate from each port is the inlet mass flow rate multiplied by the user-specified fraction of the inlet flow rate to assign to that port. The limit of 100 outlet flows may be modified in the FORTRAN source code.

Type 647: Flow Diverter With Up To 100 Ports

Type 647 models a liquid diverting valve that splits an inlet mass flow into up to 100 outlet mass flows. The mass flow rate out of each port is the product of the inlet mass flow rate and a user-specified fraction of the flow rate to assign to that port. The limit of 100 outlet flows may be modified in the FORTRAN source code.

Type 648: Air Return Plenum With Up To 100 Ports

Type 648 models a return air plenum in which up to 100 individual air flows are mixed to set the properties of the one air flow exiting the plenum. The limit of 100 inlets can be modified in the FORTRAN source code.

Type 649: Flow Mixer With Up To 100 Ports

Type 649 models a mixing valve that combines up to 100 individual liquid streams into a single outlet fluid stream. The outlet flow rate is the sum of the inlet flow rates, and the outlet temperature is the weighted (by mass flow) average temperature of the inlet flow rates. The model assumes all inlet flows are of a liquid with the same specific heat. The limit of 100 inlet flows can be modified in the FORTRAN source code.

Type 662: Variable Speed Fan/Blower

Type 662 models a variable speed fan that sets the outlet flow rate as the product of the rated mass flow rate and an input control signal. The power drawn by the fan at a given control signal (or fraction of rated mass flow rate) can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type 662 sets the downstream flow; the mass flow rate input is only used by the Type to perform a mass balance check over the fan. Fan starting and stopping characteristics are not modeled.

Type 695: Variable Speed Pump, Control Signal, Power from Head and Desired Flow Rate

The Type 695 variable-speed pump model sets its outlet mass flow rate as the product of its rated (or maximum) mass flow rate and an input control signal. The control signal may vary continuously between 0 and 1. Type 695 can also be used to model a constant speed pump, provided the user diligently sets the control signal to either 0 (off) or 1 (on at rated flow), and never sets a control signal value other than 0 or 1. As with most pumps and fans in TRNSYS, Type 695 takes mass flow rate as an input, but ignores the value except in order to perform mass balance checks. The pump's efficiency is calculated as a function of flow rate from a polynomial with user-specified coefficients; this efficiency is used in turn with the ideal work of the pump to calculate the actual pump power. Pump starting and stopping characteristics are not modeled.

Type 709: Pipe (U Value Calculated From Physical Characteristics)

Type 709 models the thermal behavior of fluid flow in a pipe or duct using segments of fluid of variable size. At each time step, a new segment of fluid enters the pipe at its inlet temperature; the mass of the new segment is equal to the mass flow rate multiplied by the simulation time step. This entering fluid shifts the position of existing segments down the pipe, and the outlet temperature and mass flow of the pipe is that of the collection of one or

more segments that are "pushed" out by the inlet flow. This is also known as a "plug-flow" approach to fluid flow modeling. This model does not account for any conduction or mixing between adjacent fluid segments. A maximum of 25 segments are allowed in the pipe. When the maximum is reached, the two adjacent segments with the closest temperatures are combined to make a single segment. Type 709 differs from Type 31 in its approach to modeling the overall heat loss coefficient (UA) from the pipe; instead of requiring the user to provide an overall UA value for the pipe and its insulation, Type 709 calculates the overall loss coefficient from the physical characteristics of the pipe material, fluid, and insulation material.
The documentation for Type 709 that follows is taken largely from the documentation of Type 31.

Type 740: Constant Speed Pump, Control Signal, Power Calculated From Pressure Rise and Pump Efficiency

Type 740 models a single speed (constant speed) pump that sets its outlet mass flow rate as the product of its rated (or maximum) mass flow rate and a binary interpretation of an input control signal (off if <=0.5, on at rated flow if >0.5). The pump's power draw is calculated from pressure rise, overall pump efficiency, motor efficiency, and fluid properties. As with most pumps and fans in TRNSYS, Type 740 takes mass flow rate as an input, but ignores the value except in order to perform mass balance checks. Pump starting and stopping characteristics are not modeled.

Type 741: Variable Speed Pump, Control Signal, Power Calculated From Pressure Rise and Pump Efficiency

Type 741 models a variable speed pump that sets the downstream flow rate as the product of its rated flow rate (a parameter) and its control signal input. The pump's power draw is calculated from pressure rise, overall pump efficiency, motor efficiency, and fluid properties. As with most pumps and fans in TRNSYS, Type 741 takes mass flow rate as an input but ignores the value except to perform mass balance checks. Pump starting and stopping characteristics are not modeled.

Type 742: Pump with Mass Flow Input, Power from Pressure Rise and Pump Efficiency

Type 742 models a pump that sets its outlet mass flow rate equal to a user specified inlet mass flow rate. *Unlike* most pumps and fans in TRNSYS, Type 742 passes the inlet mass flow rate of fluid through to its output; it does NOT use the inlet mass flow rate to perform a mass balance check over the pump. Since mass flow rate is an input, Type 742 is equally well suited to model a constant speed pump, two-speed pump, or variable speed pump. The pump's power draw is calculated from pressure rise, overall pump efficiency, motor efficiency, fluid flow rate, and fluid properties. Pump starting and stopping characteristics are not modeled.

Type 743: Pump with Mass Flow Input, Power from Power Curve Polynomial

Type 743 models a pump that sets its outlet mass flow rate to a user-specified inlet mass flow rate. *Unlike* most pumps and fans in TRNSYS, Type 743 passes the inlet mass flow rate of fluid through to its output; it does NOT use the inlet mass flow rate to perform a mass balance check over the pump. Since mass flow rate is an input, Type 743 is equally well suited to model a constant speed pump, two-speed pump, or variable speed pump. The pump's power draw is calculated from its flow rate (as a fraction of its rated flow rate) from a user-specified polynomial. Pump starting and stopping characteristics are not modeled.

Type 744: Variable Speed Fan, Mass Flow Input, Power from Power Curve Polynomial

Type 744 models a fan that sets its outlet mass flow rate to a user-specified inlet mass flow rate. *Unlike* most pumps and fans in TRNSYS, Type 744 passes the inlet mass flow rate of fluid directly through to its output; it does NOT use the inlet mass flow rate to perform a mass balance check over the fan. Since mass flow rate is an input, Type 744 is equally suited to model a constant speed fan or variable speed fan. The fan's power draw is calculated from its flow rate (as a fraction of its rated flow rate) based on a polynomial with user-specified coefficients. Fan starting and stopping characteristics are not modeled.

Type 745: Pump with Mass Flow from Available Power, Power from Pressure Rise and Pump Efficiency

Type 745 models a pump that sets its outlet mass flow rate based on user specified available power. Flow rate is calculated from available pump power based on the pressure change over the pump and the pump's efficiency; if the flow rate calculated exceeds the rated (maximum) flow rate of the pump, flow rate is set equal to rated flow rate, and pump power consumed is re-calculated accordingly. Like most pumps and fans in TRNSYS, Type 745 sets the downstream flow; the inlet mass flow rate is only used to check the mass balance over the pump. This pump model is particularly useful for direct drive applications in which a pump is directly connected to an intermittent power source.

Type 746: Pump with Mass Flow from Available Power, Power Calculated from Power Curve

Type 746 models a pump that sets its outlet mass flow rate based on user specified available power. It then calculates the power drawn by the pump from a polynomial relationship between fraction of rated power and fraction of rated flow rate. Like most pumps and fans in TRNSYS, Type 746 sets the downstream flow; the inlet mass flow rate is only used to check the mass balance over the pump. This pump model is useful for direct drive applications in which a pump is directly connected to an intermittent power source.

Type 747: Constant Speed Pump, Mass Flow Rate from System Curve and Head Curve

Type 747 models a pump that sets the mass flow rate based on a binary interpretation of a control signal (either ON or OFF) and the intersection point between the system head curve and the pump head curve. The system head curve is specified by a polynomial equation with user-supplied coefficients, and the pump head curve is supplied by the user through an external data file. Like most pumps and fans in TRNSYS, Type 747 sets the downstream flow; the inlet mass flow rate is only used to check the mass balance over the pump. Pump starting and stopping characteristics are not modeled.

Type 748: Variable Speed Pump, Desired Mass Flow as Input, Power from System Curve and Head Curve

Type 748 models a pump that sets the mass flow rate based on the desired mass flow rate and the intersection point between the system head curve and a series of pump head curves at various pump speeds. The system head curve is specified by a polynomial equation with user-supplied coefficients, and the pump head curves at various pump speeds are supplied by the user through an external data file. Like most pumps and fans in TRNSYS, Type 748 sets the downstream flow; the inlet mass flow rate (which is separate from the desired mass flow rate) is only used to check the mass balance over the pump. Pump starting and stopping characteristics are not modeled.

Type 749: Variable Speed Pump, Power Input, Match System Curve and Head Curve

Type 749 models a pump that sets the mass flow rate based on the power available and the intersection point between the system head curve and a series of pump head curves at various pump speeds. The system head curve is specified by a polynomial equation with user-supplied coefficients, and the pump head curves at various pump speeds are supplied by the user through an external data file. Like most pumps and fans in TRNSYS, Type 749 sets the downstream flow; the inlet mass flow rate is only used to check the mass balance over the pump. Pump starting and stopping characteristics are not modeled.

Type 750: Variable Speed Pump, Fraction of Rated Speed Input, Power from System Curve and Head Curve

Type 750 models a variable speed pump that sets the mass flow rate based on the fraction of rated speed at which the pump is running (its control signal input) and the intersection point between the system head curve and a series of pump head curves at the specified fraction of full pump speed. The system head curve is specified by a polynomial equation with user-supplied coefficients, and the pump head curves at various pump speeds are supplied by the user through an external data file. Like most pumps and fans in TRNSYS, Type 750 sets the downstream mass flow rate; the inlet mass flow rate is only used to check the mass balance over the pump. Pump starting and stopping characteristics are not modeled.

Type 784: Pipe with Heating Cable (new in v18)

Type 784 models a liquid filled pipe that can accommodate flow in either direction and includes a heating cable along its length. The heating cable supplies thermal power to each pipe node as the product of the cable's rated power per unit length (Parameter 24), the pipe node length, and the cable control signal (Input 5). The Type is built from the TESS Type 604 bi-directional pipe model and shares most of its underlying algorithms with those of Type 604. The only differences between Type 784 and its predecessor, Type 604, are the inclusion of a heating cable and the omission of an optional solar radiation input at the outermost surface of the pipe/insulation. Please see the documentation of Type 604 for any mathematical reference for this Type that does not directly pertain to the heating cable feature.

Type 924: Two-Speed Fan/Blower (Volumetric Flow Parameters)

Type 924 models a two speed fan that sets the downstream flow rate based on its rated flow rate for high-speed or low-speed operation and its corresponding low-speed or high-speed control signal input. The Type is nearly identical to Type 644, save the fact that Type 644 sets the rated *mass* flow rate as a parameter, whereas Type 924 sets the rated *volumetric* flow rate as a parameter, using the outlet air state and an internal psychrometrics routine to convert the rated volumetric flow rate to mass flow rate at the outlet. As with most pump and fan Types in TRNSYS, Type 924 sets the downstream mass flow rate; the inlet mass flow rate is only used to perform a mass balance check over the fan.

Type 926: Variable-Speed Fan/Blower (Volumetric Flow Parameters)

Type 926 models a variable speed fan that sets the downstream flowrate based on its rated flowrate and the control signal input, which may vary continuously between 0 (off) and 1 (on at rated flowrate). The rated flowrate is specified as a maximum volumetric flow rate. This volumetric flowrate is converted to a mass flow rate by multiplying by the density of the inlet air, which is determined by the TRNSYS psychrometrics routine from the inlet air temperature, pressure, and moisture content. The power drawn by the fan at a given flow rate can be any polynomial expression of the control signal (Mode 1), or it may be a function of a power law with user-specified coefficients (Mode 2), or it may be retrieved as a function of control signal from an external data file (Mode 3). As with most pumps and fans in TRNSYS, Type 926 sets the downstream flowrate; the flow rate input to the model is only used to check the mass balance over the fan. Fan starting and stopping characteristics are not modeled.

Type 976: Two-Speed Pump (Mass Flow)

Type 976 models a two speed (high speed or low speed) pump that sets the downstream flow rate and power consumption based on its rated flow rate and power consumption for low-speed or high-speed operation and its corresponding low-speed or high-speed control signal input. Type 976 sets the downstream mass flow rate; the inlet mass flow rate is only used to perform a mass balance check over the pump. Pump starting and stopping characteristics are not modeled, nor are pressure drop effects.

Type 977: Variable Speed Pump, Volumetric Flow, Power Curve Polynomial

The Type 977 variable-speed pump model sets the outlet mass flow rate as the user-specified rated flow rate (converted to mass flow by a user-supplied fluid density) multiplied by a control signal input. As with many pumps and fans in TRNSYS, Type 977 sets the downstream flow rate; the mass flow input is only used to perform a mass balance check over the pump. The pump's power draw is calculated as a function of flow rate by one of the following three methods: from a user-specified polynomial with user-specified coefficients, by a power law with user-specified coefficients, or from a user-supplied lookup table. Pump starting and stopping characteristics are not modeled.

Type 978: Variable Speed Pump-Diverter Combo

Type 978 models a variable speed pump governed by a modulating control function between 0 and 1. This pump model sets the downstream flow rate as the product of its rated flow rate and its control signal. Pump power draw (as a fraction of its rated power) is calculated from its flow rate (as a fraction of its rated flow rate) from a user-specified polynomial. Type 978 also features an integrated diverter valve upstream of the pump; if the inlet mass flow rate is greater than the flow rate set by the pump, the difference between the inlet mass flow rate and the flow rate set by the pump is diverted as a separate outlet fluid stream. Pump starting and stopping characteristics are not modeled, nor are pressure drop effects.

Type 983: Variable Speed Pump Bank (new in v18)

Type 983 models a variable speed pump bank of up to 25 identical pumps. Each pump in the pump bank has its own control signal and sets its outlet mass flow rate as the product of the rated mass flow per pump and its control signal. All of the governing equations for pump power and heat transfer to the working fluid and to the ambient surroundings are based on those of the standard TRNSYS Type 110 variable-speed pump. In effect, Type 983 represents a bank of up to 25 identical Type 110 pump models in parallel, modeled with a single inlet to the pump bank supply manifold and a single return from the pump bank return manifold. Pump starting and stopping are not modeled, nor are pressure drop effects.

Type 1336: Hydronic Hub (new in v18)

Type 1336 is a hydronic hub which may have up to 100 inlets and up to 100 outlets. In many ways, it is similar to a combination of the flow mixer with up to 100 inlets (Type 649) and the flow diverter with up to 100 outlets (Type 647). The inlet fluids are fully thermally mixed within the hydronic hub, then diverted to the outlet ports based on the desired flow specified for each port. Unlike Types 647 or 649, Type 1336 also has the option to account for the thermal mass (or thermal capacitance) of the fluid within the hub, as well as thermal losses from the hub to the surrounding environment. Type 1336 assumes the hub is a constant-volume device and that all fluids through the hub have the same (constant) specific heat and density.

Loads and Structures Library

Type 660: Lumped Capacitance Multizone Building

This Type models the temperature and humidity level of a simple building zone subject to infiltration effects, ventilation effects, skin losses, internal heat and mass gains, and conductive and convective exchanges with adjacent zones. The model uses two differential equations to solve for the heat and mass balances at each time step.

This model is unique in that the user may operate the building in one of two control modes. In the first mode, the user controls the temperature and humidity of the zone externally through the control of the ventilation flow stream. This method of control is termed "temperature level control" and requires that the user typically set the available heating, cooling, humidifying and dehumidifying capacities to zero.

In the second mode, the temperature and humidity are ideally controlled inside the model to maintain user specified set points. The model then outputs the energies that were required to maintain these set points. This method of control is often termed "energy rate control."

Multiple instances of Type660 can be used to simulate a multizone building. The user is asked to specify the conductance between adjacent zones as well as the amount of air coming from that zone.

Type 682: Heating and Cooling Loads Imposed on a Flow Stream

Often in simulating an HVAC system, the heating and cooling loads on the building have already been determined, either by measurement or through the use of another simulation program and yet the simulation task at hand is to simulate the effect of these loads upon the system. This component allows for there to be an interaction between such pre-calculated loads and the HVAC system by imposing the load upon a liquid flowing through a device. This model simply imposes a user-specified load (cooling = positive load, heating = negative load) on a flow stream and calculates the resultant outlet fluid conditions. Boiling and freezing effects are ignored so be careful when using this component. This simple model can represent any number of devices such as chillers, water-loop building loads, radiators, heat pumps etc. where the physics of the device are not important and the removal of the correct amount of energy from a flow stream IS important.

Type 686: Synthetic Building Loads Generator

This component will generate hourly heating and cooling loads for a synthetic building based on user-defined peak heating and cooling loads and modifying sine-wave functions used to account for seasonal variations, time-of-day variations and weekday/weekend differences. The user may also have the model generate some random noise on both an hourly basis and a daily basis to more realistically model real building loads. This component is an excellent first choice for simulations requiring heating and cooling loads for commercial, industrial, and residential buildings. The model represents a quick method of providing realistic loads without the time-intensive modeling required of a real building.

Type 687: NFRC Window

The Type687 model calculates the amount of solar energy and illumination transmitted through a window given only the basic information available on the National Fenestration Rating Council label of any window commercially available in the United States. It takes, as input data the window's solar heat gain coefficient, overall u value and visible light transmittance.

Type 690: Energy Rate Control Loads Conversion

This component takes sensible and latent loads (likely calculated from another simulation program or algorithm) and converts them to temperatures and humidities for TRNSYS simulations by imposing the loads on a simple building model. The user provides the loads as well as an estimate of the thermal and moisture capacitance of the building and the model calculates the resultant temperature and humidity based on two differential equations. The model also allows the user to introduce ventilation air to the model, which may be externally controlled and conditioned, to offset the imposed loads.

Type 693: Loads Imposed on an Air Stream

Often in simulating an HVAC system, the heating and cooling loads on the building have already been determined, either by measurement or through the use of another simulation program. This component allows for there to be an interaction between such precalculated loads and the HVAC system by imposing them upon air flowing through a duct.

Type 759: Lumped Capacitance Multizone Building with no Controls.

This Type models the temperature and humidity level of a simple building zone subject to infiltration effects, ventilation effects, skin losses, internal heat and mass gains, and conductive and convective exchanges with adjacent zones. The model uses two differential equations to solve for the heat and mass balances at each time step. The zone temperature and humidity are controlled externally through the conditioning of a ventilation flow stream.

Type 780: Evapotranspiration (Penman-Monteith Algorithm) (new in v18)

This component uses the Penman-Monteith algorithm [1] to compute the rate at which readily available soil water is vaporized from a vegetated surface. It accounts for both evaporation (water vaporizing from the soil surface and wet vegetation) and transpiration (water vaporizing within the plant and passing out through the leaves).

Type 782: Adaptive Comfort Calculator (new in v18)

This component is an implementation of the ASHRAE predicted mean vote (PMV) / predicted percent of people dissatisfied (PPD) calculation that is presented in ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy [1]. The model incorporates the algorithms that are used to compute the standard effective temperature (SET) that results from elevated airspeeds in a room [2]. It is also able to back calculate the occupant clothing level that would be required in order for the room to achieve a PMV that falls between a user set minimum and maximum value.

Type 912: Open Window Controller

The building energy simulation software package DOE2 takes a simplified approach to modeling the amount of infiltration associated with opening windows in a zone. In fact it does not actually calculate the amount of air flowing through an open window but asks the user to pre-specify the air change rate and then implements a series of checks to determine the probability that the window is open at any given point in the simulation. Type912 is an implementation of that DOE2 open window controller; it imposes a number of restrictions on when the window can be open (ambient conditions, mechanical ventilation lockouts, reset times, etc.) then takes a random number from a normal distribution and compares it to the user defined probability that the window is open at the current time step.

Type 936: Refrigerator

This component models as refrigerator. The component utilizes an external data file with the performance of the device with the dependent variables of capacity fraction and COP fraction. The independent variables in the external data file are zone (source) temperature and load temperatures. The heat transfer to and from the refrigerator device is governed by a differential equation that is solved analytically.

Type 963: Lumped Capacitance

This subroutine models any piece of equipment or building mass which can be effectively modeled as a single lumped capacitance. A simple first order differential equation describes the response of the "lump" to changes in its environment temperature or heat flows into or out of the "lump". This component models a lump of mass which can be characterized by a single differential equation relating the temperature of the mass to time, heat transfer to the environment through the skin of the mass. Capacitance effects are included.

Type 1227: Stack Flow

This component calculates the air flow through an opening due to stack effect (inside/outside temperature difference.) It is based on ASHRAE Fundamentals 2005 Ch.27 eq.30

Type 1367: Core/Shell Lumped Capacitance Model with Liquid Heat Exchange Core/Shell Lumped Capacitance Model with Liquid Heat Exchange (new in v18)

Type 1367 models a simple lumped capacitance material that interacts with a liquid flow stream that passes through the material. This model improves on many of the pure lumped capacitance models in that it retains a pure isothermal core, but this core is surrounded by an external conductive shell which interacts with the environment. This model has many uses and is often used to study ceramic brick thermal storage devices.

The user provides the physical details of the storage device (volume, material properties, and fraction of the volume that is assumed to be "core") as parameters to the model. The inlet fluid conditions to the model, the environment conditions (for thermal losses), the overall heat loss coefficient, and the maximum outlet liquid temperature are then provided to the model as inputs (time varying). The model then solves for the outlet fluid conditions, losses to the environment, and the rate of change of energy stored in the device.

Type 1368: Core/Shell Lumped Capacitance Model with Liquid Heat Exchange Core/Shell Lumped Capacitance Model with Air Heat Exchange (new in v18)

Type 1368 models a simple lumped capacitance material that interacts with an air flow stream that passes through the material. This model improves on many of the pure lumped capacitance models in that it retains a pure isothermal core, but this core is surrounded by an external conductive shell which interacts with the environment. This model has many uses and is often used to study ceramic brick thermal storage devices.

The user provides the physical details of the storage device (volume, material properties, and fraction of the volume that is assumed to be "core") as parameters to the model. The inlet air conditions to the model, the environment conditions (for thermal losses), the overall heat loss coefficient, and the maximum outlet air temperature are then provided to the model as inputs (time varying). The model then solves for the outlet air conditions, losses to the environment, and the rate of change of energy stored in the device.

Type 2280: Latent Load Calculator

This subroutine calculates the latent cooling and associated moisture removal rate for a particular sensible cooling rate given the zone and ambient conditions and assuming that cooling is being done by rejecting energy to ambient using something like a cooling coil and condenser. The correlations for latent cooling come from DOE2.1 curves.

Optimization Library

Type 758: TRNOpt Printer

Type758 is a ghost component in that it has no proforma. When a user launches a TRNOpt optimization, TRNOpt makes a copy of the TRNSYS input file that GenOpt will work with. In copying the input file it makes two main changes. First, it replaces the optimization variable names (see section **Error! Reference source not found.**) with codes that GenOpt will recognize and reset as it sees fit. Second, TRNOpt adds the Type758 printer component, which produces the outputs that GenOpt will read and interpret in order to choose new sets of variable values and to determine when an optimum has been reached.

Type 778: Error Function Calculator (new in v18)

Often when running a simulation to match measured results the error function (i.e. the difference between the two sets of results) we use is the root mean squared error. There are times, however, when there is more than one difference that we want to include in the overall error (for example the difference between measured and simulated temperature at both the source and load side of a heat exchanger). There are also times when squaring the error can over (or under) emphasize the impact of one erroneous data point. This component can be used to compute simple or complex error functions.

Type 783: RMSE Calculator / Calibration Analyzer (new in v18)

This component serves two purposes. As the simulation progresses, it computes the root mean squared error and absolute error between two sets of input data. One or the other of these error values can be used as the “cost function” that GenOpt is working to minimize. The second purpose is that at the end of the simulation, the Type generates a report that compares the two sets of input data computing (among other things) the coefficient of determination, more commonly known as the r-squared value.

Solar Library

With TESSLibs v18, the Solar Library has been completely re-structured; several enhancements for flexibility, accuracy, and ease of selection/comparison between models have been made, and few component models from the v17 library are completely unchanged from that version. Rather than retain the v17 component numbering, the entire collection of solar collector components in the v18 library has been re-numbered. The table below lists the v17 Type number of all prior solar collector components, the v18 Type number of the updated (or nearest comparable) Type in the v18 library, and a comprehensive list of revisions in the source code and/or proformas between the models (see following table for revision note descriptions). In addition to the revisions below, some parameters, inputs, and/or outputs may in a different order as compared to the v17 model.

Type 543: Single Cover Top Loss Model

Type 543 performs a combined radiation and convection energy balance on a plate of known temperature that is separated from an ambient temperature (for convection calculations) and an effective sky temperature (for radiation calculations) by a single sheet of transparent cover material. The model iterates to balance energy and to converge upon a cover temperature. Wind effects on the outer cover surface are modeled. This model can be used to calculate a time dependent top loss coefficient for solar collector models that take top loss coefficients as an input. The energy balance methodology of this component was developed at the National Renewable Energy Laboratory [1].

Type 544: Double Cover Top Loss Model

Type 544 performs a combined radiation and convection energy balance on a plate of known temperature that is separated from an ambient temperature (for convection calculations) and an effective sky temperature (for radiation calculations) by two sheets of transparent cover material. The model iterates to balance energy and to converge upon a temperature for each of the two covers. Wind effects on the outer cover surface are modeled. This model can be used to calculate a time dependent top loss coefficient for solar collector models that take top loss coefficients as an input. The energy balance methodology of this component was developed at the National Renewable Energy Laboratory [1]. This model assumes that the mass of the cover materials is negligible such that there is no storage of energy in the covers and that the covers only communicate to the sky for radiation calculations (not also to the surrounding ground).

Type 546: Radiation Splitter

Type 546 determines the beam and diffuse radiation split on a tilted surface, given the total radiation on the surface, the surface orientation, and the extraterrestrial horizontal radiation. The routine solves one of three available diffuse fraction correlations for the clearness index, then solves for the total horizontal, horizontal diffuse, and horizontal beam radiation values using one of two available sky diffuse radiation models.

Type 1252: Surface Shading for Beam Radiation

Type 1252 models the shading of surfaces from beam radiation due to obstructions between the surface and the sun.

Type 1262: Concentrating Collector Shading

Type 1262 models the shading of parabolic trough collectors that are arranged in consecutive rows. The work is based on the work of Stuetzle (2002) and assumes that the collectors are oriented with a North-South axis (collectors track east to west during the day) and are on flat ground.

Type 1286: Solar Collector, ISO Standard 9806:2017 (9-Parameter Eqn.), 1-D IAMs (new in v18)

Type 1286 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the ISO9806:2017 collector standard. In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of the angle of incidence of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of glazed and un-glazed flat plate collectors.

Type 1287: Solar Collector, ISO Standard 9806:2017 (9-Parameter Eqn.), 2-D IAMs (new in v18)

Type 1287 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the ISO9806:2017 collector standard. In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of both the transverse and longitudinal incidence angles of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of optically non-symmetrical collectors such as evacuated tube collectors and concentrating collectors.

Type 1345: Solar Collector, ISO Standard 9806:2013 (3-Parameter Eqn.) with 2-D IAMs (new in v18)

Type 1345 (formerly Type 538) models an evacuated tube solar collector, or it may be used to model any collector for which the efficiency can be modeled with a linear or quadratic efficiency curve and the off-normal radiation effects can be treated with bi-axial incidence angle modifiers (IAMs). This standard is often referred to as the 3-parameter model and is commonly utilized in SRCC's OG-100 collector standard.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The capacitance (mass) of the collector may be accounted for in this model as well. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from a standard efficiency test versus a ratio of fluid temperature minus ambient temperature to radiation ($\Delta T/I_T$). The model assumes that the efficiency vs. $\Delta T/I_T$ curve can be modeled as either a linear equation or a quadratic equation. The model will calculate the collector fin efficiency (*F'*), the collector loss coefficient, and the transmittance-absorptance product at normal incidence, based on the user-provided efficiency equation coefficients. Off-normal solar radiation is accounted for by utilizing bi-axial IAMs; the user must provide an external data file containing bi-axial IAM data. The bi-axial IAM data are useful for considering non-optically symmetric collectors, such as evacuated tubes. Some of the manual sections for this component are taken directly from section 4.11.3 (Type 71: Evacuated tube solar collector) of the TRNSYS v18 mathematical description manual.

Type 1346: Solar Collector, ISO Standard 9806:2013 (3 Parameter Eqn.) with 1-D IAMs (new in v18)

Type 1346 (formerly Type 539) models a glazed flat-plate solar collector, or it may be used to model any collector for which the efficiency can be modeled with a linear or quadratic efficiency curve and the off-normal radiation effects can be treated with incidence angle modifiers (IAMs) that are strictly a function of the incidence angle. This standard is often referred to as the 3-parameter model and is commonly utilized in SRCC's OG-100 collector standard.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user provides the results from a standard collector efficiency test; the model will calculate the collector fin efficiency (*F'*) to calculate the collector loss coefficient and the transmittance-absorptance product at normal incidence. Off-normal solar radiation is accounted for by utilizing single-axis, quadratic multipliers, as described in the next section. Some of the manual sections for this component are taken directly from section 4.11.1 (Type 1: Flat plate collector, quadratic efficiency) of the TRNSYS v18 mathematical description manual.

Type 1347: Un-Glazed Solar Collector, 1-D IAMs, Linear/Quadratic Efficiency Equation (new in v18)

This subroutine models an unglazed or wind/infrared sensitive solar collector where the collector efficiency and off-normal performance are modeled with quadratic curve-fits found from collector tests. This routine is based on the original Type 539 and Type 553 source code, but the efficiency equation is based on the net solar radiation (short wave minus net long wave), and the efficiency coefficients are moved to inputs as they often depend on the wind velocity or other factors. This model can be used to calculate the performance of un-glazed solar collectors that were tested to the ISO 9806:2013 standard or the EN12975 un-glazed, steady-state performance standard.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user provides the results from a standard collector efficiency test; the model will calculate the collector fin efficiency (*F'*) in order to calculate the collector loss coefficient and the transmittance-absorptance product at normal incidence. Off-normal solar radiation is accounted for by utilizing single-axis multipliers, as described in the next section.

Type 1348: Un-Glazed Solar Collector with 1-D IAMs (new in v18)

This subroutine models an unglazed or wind/infrared sensitive solar collector where the collector efficiency and off-normal performance are modeled with quadratic curve-fits found from collector tests. This routine is based on the original Type 553 source code where the efficiency equation is based on the net solar radiation (short wave minus net long wave), and the efficiency coefficients include wind dependent terms. This model can be used to calculate the performance of un-glazed solar collectors that were tested to the ISO 9806:2013 standard or the EN12975 un-glazed, steady-state performance standard.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user provides the results from a standard collector efficiency test; the model will calculate the collector fin efficiency (*F'*) in order to calculate the collector loss coefficient and the transmittance-absorptance product at normal incidence. Off-normal solar radiation is accounted for by utilizing single-axis multipliers, as described in the next section.

Type 1349: Solar Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D IAMs (new in v18)

Type 1349 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 solar collector standard (a predecessor to the ISO9806-2017 standard). In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of both the transverse and longitudinal incidence angles of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of optically non-symmetrical collectors such as evacuated tube collectors and concentrating collectors.

Type 1350: Solar Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D IAMs (new in v18)

Type 1350 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 quasi-dynamic collector standard. In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of the angle of incidence of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of glazed and un-glazed flat plate collectors.

Type 1351: Concentrating Collector, 3-Parameter Eqn., Direct Normal Radiation, 2-D IAMs (new in v18)

Type 1351 models a concentrating solar collector for which the efficiency can be modeled with a linear or quadratic efficiency curve based on the direct normal solar radiation and the off-normal radiation effects can be treated with bi-axial incidence angle modifiers (IAMs). This methodology is often referred to as the Rabl approach for modeling concentrating solar collectors.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The capacitance (mass) of the collector may be accounted for in this model as well. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from a standard efficiency test versus a ratio of fluid temperature minus ambient temperature to radiation ($\Delta T/I_T$). The model assumes that the efficiency vs. $\Delta T/I_T$ curve can be modeled as either a linear equation or a quadratic equation. The model will calculate the collector fin efficiency (*F'*), the collector loss coefficient, and the transmittance-absorptance product at normal incidence, based on the user-provided efficiency equation coefficients. Off-normal solar radiation is accounted for by utilizing bi-axial IAMs; the user must provide an external data file containing bi-axial IAM data. The bi-axial IAM data are useful for considering non-optically symmetric collectors. Some of the manual sections for this component are taken directly from section 4.11.3 (Type 71: Evacuated tube solar collector) of the TRNSYS v18 mathematical description manual.

The derivation of this model is fundamentally equivalent to that of Type 1345 and it is left to the user to review that manual section for the solution details. The differences between this model and Type 1345 are highlighted below.

Type 1352: Concentrating Collector, 3-Parameter Eqn., Direct Normal Radiation, 1-D IAMs (new in v18)

Type 1352 models a concentrating solar collector for which the efficiency can be modeled with a linear or quadratic efficiency curve based on the direct normal solar radiation and the off-normal radiation effects can be treated with single-axis incidence angle modifiers (IAMs). This methodology is often referred to as the Rabl approach for modeling concentrating solar collectors.

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The capacitance (mass) of the collector may be accounted for in this model as well. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from a standard efficiency test versus a ratio of fluid temperature minus ambient temperature to radiation

($\Delta T/I_T$). The model assumes that the efficiency vs. $\Delta T/I_T$ curve can be modeled as either a linear equation or a quadratic equation. The model will calculate the collector fin efficiency (*F'*), the collector loss coefficient, and the transmittance-absorptance product at normal incidence, based on the user-provided efficiency equation coefficients. Off-normal solar radiation is accounted for by utilizing single-axis IAMs; the user must provide an external data file containing the IAM data. The single-axis IAM data are useful for considering collectors that are optically symmetric. Some of the manual sections for this component are taken directly from section 4.11.3 (Type 71: Evacuated tube solar collector) of the TRNSYS v18 mathematical description manual.

The derivation of this model is fundamentally equivalent to that of Type 1346 and it is left to the user to review that manual section for the solution details. The differences between this model and Type 1346 are highlighted below.

Type 1353: Concentrating Collector, 3-Parameter Eqn., 2-D IAMs (new in v18)

Type 1353 models a concentrating solar collector for which the efficiency can be modeled with a linear or quadratic efficiency curve based on the incident beam solar radiation and the off-normal radiation effects can be treated with bi-axial incidence angle modifiers (IAMs).

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The capacitance (mass) of the collector may be accounted for in this model as well. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from a standard efficiency test versus a ratio of fluid temperature minus ambient temperature to radiation ($\Delta T/I_T$). The model assumes that the efficiency vs. $\Delta T/I_T$ curve can be modeled as either a linear equation or a quadratic equation. The model will calculate the collector fin efficiency (*F'*), the collector loss coefficient, and the transmittance-absorptance product at normal incidence, based on the user-provided efficiency equation coefficients. Off-normal solar radiation is accounted for by utilizing bi-axial IAMs; the user must provide an external data file containing bi-axial IAM data. The bi-axial IAM data are useful for considering non-optically symmetric collectors. Some of the manual sections for this component are taken directly from section 4.11.3 (Type 71: Evacuated tube solar collector) of the TRNSYS v18 mathematical description manual.

The derivation of this model is fundamentally equivalent to that of Type 1345 and it is left to the user to review that manual section for the solution details. The differences between this model and Type 1345 are highlighted below.

Type 1354: Concentrating Collector, 3-Parameter Eqn., 1-D IAMs (new in v18)

Type 1354 models a concentrating solar collector for which the efficiency can be modeled with a linear or quadratic efficiency curve based on the incident beam solar radiation and the off-normal radiation effects can be treated with single-axis incidence angle modifiers (IAMs).

The user has the option of controlling the flow rate through the collector to maintain a desired outlet temperature. The capacitance (mass) of the collector may be accounted for in this model as well. The total collector array may consist of collectors connected in series and in parallel. The thermal performance of the total collector array is determined by the number of modules in series and the characteristics of each module. The user must provide results from a standard efficiency test versus a ratio of fluid temperature minus ambient temperature to radiation ($\Delta T/I_T$). The model assumes that the efficiency vs. $\Delta T/I_T$ curve can be modeled as either a linear equation or a quadratic equation. The model will calculate the collector fin efficiency (*F'*), the collector loss coefficient, and the transmittance-absorptance product at normal incidence, based on the user-provided efficiency equation coefficients. Off-normal solar radiation is accounted for by utilizing single-axis IAMs; the user must provide an external data file containing the IAM data. The single-axis IAM data are useful for considering collectors that are optically symmetric. Some of the manual sections for this component are taken directly from section 4.11.3 (Type 71: Evacuated tube solar collector) of the TRNSYS v18 mathematical description manual.

The derivation of this model is fundamentally equivalent to that of Type 1346 and it is left to the user to review that manual section for the solution details. The differences between this model and Type 1346 are highlighted below.

Type 1355: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D IAMs (new in v18)

Type 1355 models the transient performance of a concentrating liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 solar collector standard (a predecessor to the ISO9806-2017 standard). In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of both the transverse and longitudinal incidence angles of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of optically non-symmetrical collectors such as evacuated tube collectors and many concentrating collectors.

Type 1356: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D IAMs (new in v18)

Type 1356 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 quasi-dynamic collector standard. In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of the angle of incidence of beam radiation on the absorbing surface of the collector.

Type 1357: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 2-D Direct IAMs, Constant Diffuse IAMs (new in v18)

Type 1357 models the transient performance of a concentrating liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 solar collector standard (a predecessor to the ISO9806-2017 standard). In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of both the transverse and longitudinal incidence angles of beam radiation on the absorbing surface of the collector. This IAM behavior is typical of optically non-symmetrical collectors such as evacuated tube collectors and many concentrating collectors. Type 1357 varies from Type 1355 in that in this model, the diffuse incidence angle modifier (IAM_D) is a parameter to the model and remains constant throughout the simulation. Conversely, in Type 1355, the diffuse incidence angle modifier is calculated each time the slope or azimuth of the collector changes.

Type 1358: Concentrating Collector, Standard EN12975-2 (7-Parameter Eqn.), 1-D Direct IAMs, Constant Diffuse IAMs (new in v18)

Type 1358 models the transient performance of a liquid solar thermal collector (or collector array) where the collector has been tested to the EN12975-2 quasi-dynamic collector standard. In this version, the incidence angle modifiers (IAMs) for beam radiation are read from an external data file which contains the incidence angle modifier data as a function of the angle of incidence of beam radiation on the absorbing surface of the collector. Type 1358 varies from Type1356 in that in this model, the diffuse incidence angle modifier (IAM_D) is a parameter to the model and remains constant throughout the simulation. Conversely, in Type 1356, the diffuse incidence angle modifier is calculated each time the slope or azimuth of the collector changes.

Type 1359: Tubular Integral Collector Storage (ICS) System with 2-D IAMs (new in v18)

This component is intended to model an integral collector storage system, a solar collector design in which the collector and storage sections of a typical solar domestic hot water system are combined into one unit. The model is intended to be applied to ICS systems that store fluid in several tubes that are connected in series and placed within a collector enclosure.

The storage section of the ICS collector is divided into N isothermal temperature nodes. N is typically chosen to represent the number of tubes in the ICS collector; however, the user has the option of dividing the individual tubes into sections (nodes) as well. The nodes are defined from the inlet of the collector to the outlet of the collector along the flow direction. The nodes interact thermally with each other through conduction in the water along adjacent nodes in the same pipe, conduction in the pipes between adjacent nodes in separate pipes, and convection/radiation to corresponding nodes in adjacent tubes. The nodes also interact with the environment through solar gains and thermal losses through the cover, edges, and bottom surface. This model assumes that the storage enclosure is rectangular; other geometries are possible by manipulating the length, width, and depth parameters to achieve the correct top, bottom, and edge areas for loss calculations. The length, width, and depth parameters are used only to calculate the areas; there is no other distinction intended.

Type 1360: Tubular Integral Collector Storage (ICS) System with 1-D IAMs (new in v18)

This component is intended to model an integral collector storage system, a solar collector design in which the collector and storage sections of a typical solar domestic hot water system are combined into one unit. The model is intended for ICS systems that store fluid in several tubes connected in series and placed within a collector enclosure.

The storage section of the ICS collector is divided into N isothermal temperature nodes. N is typically chosen to represent the number of tubes in the ICS collector; however, the user has the option of dividing the individual tubes into sections (nodes) as well. The nodes are defined from the inlet of the collector to the outlet of the collector along the flow direction. The nodes interact thermally with each other through conduction in the water along adjacent nodes in the same pipe, conduction in the pipes between adjacent nodes in separate pipes, and convection/radiation to corresponding nodes in adjacent tubes. The nodes also interact with the environment through solar gains and thermal losses through the cover, edges, and bottom surface. This model assumes that the storage enclosure is rectangular; other geometries are possible by manipulating the length, width, and depth parameters to achieve the correct top, bottom, and edge areas for loss calculations. The length, width, and depth parameters are used only to calculate the areas; there is no other distinction intended.

Type 1361: Glazed Flat Plate Collector, Theoretical, Serpentine Riser Tubes (new in v18)

Type 1361 simulates a flat plate solar collector with serpentine tubes and with one or more glazings (transparent covers), operating in steady (no thermal mass or thermal capacitance effects are modeled). Efficiency and performance are based on the theoretical efficiency modelling method outlined in *Solar Engineering of Thermal Processes*, by JA Duffy and WA Beckman. This method is purely analytical in operation; it does not employ any numerical methods or the experimentally derived efficiency and incidence angle modifiers used by the other flat plate collector Types. A field of multiple collectors may be modeled by multiplying the collector length by the total number connected in series, and the width by the ratio of total number collectors over the total number in series The user must fully describe the collector geometry by providing the collector length and width, the absorber plate thickness, the number of glazings, the dimensions of the collector fluid flow tube, and the number of serpentine bends in the tube. The refraction index and extinction coefficient must be specified for the glazings, as well as the emissivity and absorptance of the absorber plate. The model assumes constant specific heat for the collector fluid, which is provided by the user as a parameter to the model. From these values, the input weather data, and user-provided collector edge and bottom heat loss coefficients, Type 1361 calculates the collector's heat removal factor (F_R) and efficiency factor (F') and determines fluid outlet temperatures, useful energy gain, and various losses. There are two modes available for determining the collector's top-loss coefficient: it can either be set manually by the user, or analytically derived from the other inputs.

Type 1362: Glazed Flat Plate Collector, Theoretical, Simplified Top Losses (new in v18)

Type 1362 simulates a flat plate solar collector with standard riser tubes and with one or more glazings (transparent covers), operating in steady state (no thermal mass or thermal capacitance effects are modeled). Efficiency and performance are based on the theoretical efficiency modelling method outlined in *Solar Engineering of Thermal Processes*, by JA Duffy and WA Beckman. This method is purely analytical in operation; it does not employ any numerical methods or the experimentally derived efficiency and incidence angle modifiers employed by the other flat plate collector types. A field of multiple collectors may be modeled by multiplying the collector length by the total number connected in series, and the width by the ratio of total number collectors over the total number in series The user must fully describe the collector geometry by providing the collector length and width, the absorber plate thickness, the number of glazings, the dimensions of the collector fluid flow tube, and the number of riser tubes. The refraction index and extinction coefficient must be specified for the glazings, as well as the emissivity and absorptance of the absorber plate. The model assumes constant specific heat for the collector fluid, which is provided by the user as a parameter to the model. From these values, the input weather data, and user-provided collector edge and bottom heat loss coefficients, Type 1362 calculates the collector's heat removal factor (F_R) and efficiency factor (F') and determines fluid outlet temperatures, useful energy gain, and various losses. There are two modes available for determining the collector's top-loss coefficient: it can either be set manually by the user, or analytically derived from the other inputs. For a more detailed analytical model that employs a numerical routine and calculates thermal resistances and heat transfer coefficients from material properties, use Type 1364 (one cover) or Type 1363 (two covers).

Type 1363: Glazed Flat Plate Collector, Theoretical, Standard Risers, Two Covers (new in v18)

Type 1363 simulates a flat plate solar collector with standard riser tubes and two glazings (transparent covers) that may differ from each other, operating in steady state (no thermal mass or thermal capacitance effects are modeled). Efficiency and performance are based on the method outlined in *Solar Engineering of Thermal Processes*, by JA Duffy and WA Beckman. The method of computation by Type 1363 is numerical finite difference; increasing the number of finite difference nodes increases accuracy at the expense of computation time. The Type does not require any experimentally derived efficiency or incidence angle modifiers. The user must fully describe the collector geometry by providing the collector length, width, and depth, as well dimensions and thermal and optical properties of the absorber plate, covers, tubes, and insulation. The model assumes constant properties for the collector fluid, which are provided by the user as parameters to the model. From these values and the input weather data, Type 1363 calculates the collector's heat removal factor (F_R) and efficiency factor (F') and determines fluid outlet temperature, useful energy gain, and various losses. See Type 1364 for a comparable model with just a single collector glazing (cover); if more covers are required, Type 1362 may be used, though this model assumes identical covers and requires user-provided heat loss coefficients for the collector back and edges.

Type 1364: Glazed Flat Plate Collector, Theoretical, Standard Risers, One Cover (new in v18)

Type 1364 simulates a flat plate solar collector with standard riser tubes and a single glazing (transparent cover) operating in steady state (no thermal mass or thermal capacitance effects are modeled). Efficiency and performance are based on the method outlined in *Solar Engineering of Thermal Processes*, by JA Duffy and WA Beckman. The method of computation by Type 1364 is numerical finite difference; increasing the number of finite difference nodes increases accuracy at the expense of computation time. The Type does not require any experimentally derived efficiency or incidence angle modifiers. The user must fully describe the collector geometry by providing the collector length, width, and depth, as well dimensions and thermal and optical properties of the absorber plate, cover, tubes, and insulation. The model assumes constant properties for the collector fluid, which are provided by the user as parameters to the model. From these values and the input weather data, Type 1364 calculates the collector's heat removal factor (F_R) and efficiency factor (F') and determines fluid outlet temperature, useful energy gain, and various losses. See Type 1363 for a comparable model with two collector glazings (covers) that may have separate properties; if more covers are required, Type 1362 may be used, though this model assumes identical covers and requires user-provided heat loss coefficients for the collector back and edges.

Type 1365: Unglazed Air Heating Collector (new in v18)

Type 1365 models an un-glazed solar collector that passes air behind the absorbing plate. Moist air calculations are not included in the model. The thermal model of this collector relies on algorithms given in "Solar Engineering of Thermal Processes" by J.A. Duffie and W.A. Beckman.

Type 1366: Unglazed Flat Plate Collector, Theoretical (new in v18)

Type 1366 models an un-glazed (or wind- and infrared-sensitive) flat plate solar collector for which collector performance is modeled from the collector fin efficiency factor (F'), the collector overall loss coefficient for the back and edges (U_L), and convection and radiation losses from the top surface, which are derived from supplied absorptance and emissivity values and theoretical first principles. Effects of off-normal solar radiation are accounted for with single-axis incidence angle multipliers (IAMs), supplied by the user through an external data file. This collector model is a steady-state model; capacitance (or thermal mass) effects are not accounted for by this model.

Type 1366 is largely based on, and hereafter replaces, Type 559 from TESS Libraries Versions 17 and earlier. See the 'Hints and Tips' section of this documentation for a comprehensive list of updates and comparisons between Type 1366 and its predecessor, Type 559.

Thermal Storage Library

Type 529: Tank-in-Tank with Immersed Heat Exchangers (new in v18)

Type 529 models a vertical, cylindrical storage tank with an immersed cylindrical storage tank and optional immersed heat exchangers. This routine solves the coupled differential equations imposed by considering the mass of the fluid in the main storage tank, the mass of the fluid in the smaller immersed storage tank, and the mass of the fluid in the heat exchanger(s).

Type 529 was built from the starting point of Type 1534, the vertical tank with immersed heat exchanger(s); many algorithms and features are common between the Types. Refer to the documentation of Type 1534 for description of internal UA calculations for the immersed heat exchanger(s), the tank noding scheme, fluid mixing between tank nodes, tank losses to the ambient, and other operations common to both models. The following documentation addresses features unique to Type 529 as compared to Type 1534.

Type 938: Heat Pump Water Heater (Liquid Flow)

This component models a single-stage air-source heat pump that is designed to heat a liquid stream while cooling and dehumidifying an air stream. The model is based on user-supplied data files containing manufacturer's catalog information for the total and sensible air stream cooling capacity, the compressor power, and the rejection capacity, based on the entering water temperature, entering air temperature, and entering air relative humidity. Technically, the same heat pump could be used to cool a liquid stream while heating an air stream. However, such applications are rare and such pieces of equipment are hard to find; since this component relies on manufacturer's data, it is limited to modeling liquid heating / air cooling applications.

Type 940: Tankless Water Heater

Type940 models a tankless water heater; a device used to heat a liquid stream by the addition of heat from either an electric heating element or a gas combustion heating source. In simple terms it is an auxiliary heater with internal controls to modulate the heat input to the fluid.

Type 959: Heat Pump Water Heater (Storage Tank) (new in v18)

This component models a simple heat pump cycle used to extract heat from an air stream and transfer that heat to a storage tank, the heat pump section of a heat pump water heater. The model relies on an external data file that provides the performance (COP) and capacity of the device as a function of the temperature of the water and wet bulb temperature of the incoming air.

Type 1229: Gas Heating Device for Liquid Storage Tanks (new in v18)

Type1229 models an auxiliary heating device that adds energy to a tank model such as the thermal storage tank models discussed in this manual that do not have heater models built into them.

Type 1237: Cylindrical Storage Tank with Wrap-Around Heat Exchanger and Dip Tube

This component models a fluid-filled, constant volume storage tank with a wrap-around heat exchanger. The component has an optional dip tube or user-defined inlet/outlet ports. This component models a cylindrical tank with a vertical configuration and a single-tube wrap-around heat exchanger bonded to the outer wall of the tank. The fluid in the storage tank interacts with the fluid in the heat exchanger (through heat transfer through the tank edges covered by the heat exchanger), with the environment (through thermal losses from the top, bottom, and edges not covered by the heat exchanger), and with flow streams that pass into and out of the storage tank. To model the stratification observed in storage tanks, the tank is divided into isothermal temperature nodes; the user controls the degree of stratification through the specification of the number of nodes. Each constant-volume node interacts thermally with the nodes above and below through fluid conduction between nodes and through fluid movement (which may be either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). Auxiliary heat may be provided to each isothermal node individually, using inputs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

Type 1239: Single Element Electric Heating Device for Liquid Storage Tanks (new in v18)

This subroutine models an electric heating device for a liquid-filled thermal storage tank.

Type 1240: Dual-Element Electric Heating Device for Liquid Storage Tanks (new in v18)

This Type models an energy input device typically used in water heating applications. When in operation mode 1, the dual element system operates as a master-slave where the lower element (slave) can be activated only when the upper element (master) is OFF. In operation mode 0 there is no master-slave operation and both elements function independently according to their respective control signal inputs.

Type 1334: Simple Ice Storage Tank with Immersed Constant Effectiveness Heat Exchanger(s) (new in v18)

This subroutine models a simple fluid-filled thermal storage tank whose contents are allowed to change between the liquid and solid phases. The tank is assumed to be isothermal and is equipped with a simple heat exchanger. Most often, this component is used to model a simple ice storage tank although because the model asks for the user to specify both solid and liquid phase properties of the fluid it can be used to model a wider variety of phase change materials. One important assumption made by the model, however, is that the fluid is assumed not to change temperatures as it goes through phase transition.

Type 1531: Flat Bottom Storage Tank with Immersed Heat Exchanger

This subroutine models a uniform cross section, fluid-filled, constant volume storage tank with immersed heat exchangers. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the top, bottom, and edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of “nodes”. Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms; fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user has the ability to specify one of four different immersed heat exchanger types (or no HX if desired); horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant. In this configuration, all nodes have the same height and the same volume as the cross-sectional area is constant with height. The tank is assumed to have a flat top and a flat bottom, but the sides may be of any shape. The model takes the perimeter length, top and bottom surface area, and the fluid volume to calculate the surface areas.

Type 1532: Spherical Storage Tank with Immersed Heat Exchanger

This subroutine models a spherical, fluid-filled, constant volume storage tank with immersed heat exchangers. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes." Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms; fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user can specify one of four different immersed heat exchanger types (or no HX if desired), horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

Type 1533: Horizontal Cylindrical Storage Tank with Immersed Heat Exchanger

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a cylindrical tank with a horizontal configuration. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the left end, right end, and edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes". Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms; fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user can specify one of four different immersed heat exchanger types (or no HX if desired), horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

Type 1534: Vertical Cylindrical Storage Tank with Immersed Heat Exchanger

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models a cylindrical tank with a vertical configuration. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the top, bottom, and edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes". Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms: fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user can specify one of four different immersed heat exchanger types (or no HX if desired), horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

This component can be combined with Type1302 in the Ground Coupling library to model situations in which the storage tank is buried in soil.

Type 1535: Inverted Conical Storage Tank with Immersed Heat Exchanger (new in v18)

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models an inverted, truncated, conical storage tank with a vertical configuration. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the top, bottom, and edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes." Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms: fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user can specify one of four different immersed heat exchanger types (or no HX if desired), horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

This component can be combined with Type1301 in the Ground Coupling library to model situations in which the storage tank is buried in soil.

Type 1536: Inverted Truncated Rectangular Pyramid Storage Tank with Immersed Heat Exchanger (new in v18)

This subroutine models a fluid-filled, constant volume storage tank with immersed heat exchangers. This component models an inverted, truncated, rectangular pyramid storage tank with a vertical configuration. The fluid in the storage tank interacts with the fluid in the heat exchangers (through heat transfer with the immersed heat exchangers), with the environment (through thermal losses from the top, bottom, and edges) and with flow streams that pass into and out of the storage tank. The tank is divided into isothermal temperature nodes (to model stratification observed in storage tanks) where the user controls the degree of stratification through the specification of the number of "nodes." Each constant-volume node is assumed to be isothermal and interacts thermally with the nodes above and below through several mechanisms; fluid conduction between nodes, and through fluid movement (either forced movement from inlet flow streams or natural destratification mixing due to temperature inversions in the tank). The user can specify one of four different immersed heat exchanger types (or no HX if desired), horizontal tube bank, vertical tube bank, serpentine tube, or coiled tube. Auxiliary heat may be provided to each isothermal node individually, using INPUTs to the model. This model does *not* consider temperature-dependent fluid properties; all fluid properties must be entered by the user and are assumed constant.

Type 1537: Horizontal Cylinder with Loss Coefficients as Inputs (new in v18)

This component is identical to Type1533 except that in this Type, the loss coefficients are taken as inputs rather than as parameters, allowing them to change with time throughout the course of the simulation if desired.

Utility Library

Type 535: Triggered Printer

The Type 535 triggered event printer component is used to output (or print) selected system variables not at specified intervals of time, but rather whenever an 'event' is triggered, or whenever the value of the first input is >0.

The maximum number of variables per Type 535 has been set to 500 in the Fortran source code. There is no specific limit on the number of Type 535 units that can be used in a simulation. Note that the number of variables per printer is limited by the maximum line length (or file width) in TRNSYS; see the 'Programmer's Guide' manual in the Documentation folder of the main TRNSYS directory for further reference on TRNSYS global constants.

Type 546: Total Radiation Splitter (new in v18)

Type 546 splits the total radiation on a surface into its beam, sky diffuse, and ground-reflected diffuse radiation components on the surface. Several TRNSYS Types require radiation on a given surface entered as separate inputs for beam (direct) radiation, diffuse radiation from the sky, and diffuse radiation reflected from the ground; these components of the total radiation have different angles of incidence to the surface and thus different modifiers to transmittance/absorptance based on the incidence angle. If only the total radiation on the surface is available, Type 546 may be used to approximately calculate the split between beam, sky diffuse, and ground-reflected diffuse radiation.

Type 571: Infiltration into a Conditioned Zone (K1, K2, K3 Method)

Type 571 models infiltration into a conditioned zone based on wind speed and temperature difference between the conditioned zone and the ambient surroundings. ASHRAE has long recommended the use of a semi-empirical model for the calculation of infiltration to a conditioned zone. This so-called K1, K2, K3 method is considered less rigorous than infiltration calculation based on dynamic wind pressure, buoyancy forces, and envelope characteristics. However, as more rigorous modeling requires parameters difficult to measure without a blower door test, the K1, K2, K3 model remains acceptable as a more accessible calculation method for infiltration.

Type 572: Equipment Fouling

Type 572 may be used to degrade and reset the performance of other components over the course of a simulation. For example, as a solar thermal collector sits on a roof, dust and pollen accumulate on its glass cover, degrading its performance until it rains or until it is washed. The component calculates a "fouling factor" for equipment as a function of time. Cleanings may be scheduled, at which time the fouling factor is reset to zero. The model also allows for the equipment to self-clean at a user-specified rate with a control signal input.

Type 573: Output Device for Average Day of Each Month

Type 573 creates an hourly profile for up to ten inputs (alternatives) for the average day of each simulated month. The hourly profiles for each month are printed to an output file, which may be viewed in Microsoft Excel or any spreadsheet /charting program.

Type 574: ASHRAE Occupancy Loads

The ASHRAE Handbook of Fundamentals lists typical latent and sensible loads for occupancy based on the activity level of the occupants. This component takes, as parameters, the number of different people types and their associated activity level, and as inputs the number of people at each of these activity levels. The outputs from this component are the latent and sensible loads for the building (totals and per activity).

Type 575: Sky Temperature

Type 575 calculates an effective sky temperature based on the dew point temperature, the station pressure, the fraction of opaque cloud cover, and the emissivity of the clouds. Effective sky temperature is most commonly used to calculate longwave radiation losses from solar collectors and other structures.

Type 575 is similar toType 69, the effective sky temperature model available in the Physical Phenomena folder of the standard TRNSYS component library. Both models calculate clear sky emissivity, the emissivity of the sky in the presence of clouds, and the effective sky temperature based on equations developed in "Characteristics of Infrared Sky Radiation in the U.S.A." (Berdahl, 1984) and in the TARP Reference Manual (Walton, 1983). Type 575 and Type 69 differ in their input/derivation of the fraction of cloud cover, the emissivity of clouds, and the atmospheric pressure. Overall, Type 575 offers more flexibility over each of these inputs than Type 69.

Type 576: Two Dimensional Bin Sorter

This component calculates the number of hours during the simulation in which the inputs fall within a two-dimensional grid of user-specified bins. It is useful for cross-referencing the frequency that one input lies in a given range (e.g. dry bulb temperature) versus the range of another input (e.g. wet bulb temperature, sky temperature, windspeed, equipment part-load, and so forth). The user must provide the number of bins for each of the inputs and the minimum and maximum values for the bins. The model will then sort the inputs into these bins, producing a 2-D grid upon completion. The outputs from this model are written to a user-specified file.

Type 577: Random Number Generator (Uniform Distribution)

This model generates a random number drawn from a uniformly distributed set based on a user-supplied minimum value, a user-supplied maximum value, and a user-supplied initial seed. See Type 578 for a random number generator drawn from a normally distributed (bell curve) set.

Type 578: Random Number Generator (Normal Distribution)

This model generates a random number drawn from a normally (or bell curve) distributed set based on a user-supplied mean, a user-supplied standard deviation, and a user-supplied initial seed. See Type 577 for a random number generator drawn from a uniformly distributed set.

Type 579: Nested Forcing Function

Type 579 is a nested forcing function model that allows the user to "tier" up to five forcing functions, with the schedule of the tertiary function dependent on the values of the prior forcing functions. This eliminates stacking multiple Type 14 forcing functions and equations to set a schedule for an input that changes based on, for example, time of day (occupied vs unoccupied), day of week (weekday vs weekend), and month of year (school semester vs summer recess).

Type 581: Multidimensional Data Interpolation

Type 581 is a generalized adaptation of Type 42, the Interpolator model available with the standard TRNSYS library. Type 581 builds on Type 42 by allowing unlimited values of the independent variable(s) in the data file and allowing interpolation in up to six dimensions. This component can be used to interpolate a 'map' (such as an equipment performance map) of up to six independent variables (such as entering air or water temperature(s), pressure(s), part load, and so forth), returning up to ten dependent variables (such as thermal energy generated or absorbed, power consumed, coefficient of performance, and so forth). See the description below for example data file configurations. An interpolation code for each independent variable allows the user to either fully interpolate the data table or choose the nearest value from the table for that input.

Type 582: Life Cycle Cost Analysis

Type 582 calculates life cycle cost of a system and up to 10 alternatives by the P1 P2 method. One of the most common measures of engineering economics is the life cycle cost of a system. The P1 P2 method determines the life cycle cost of a purchase option or alternative based on two economic indicators. The first indicator, P1, is the ratio of the life cycle fuel cost to the first year fuel cost. A low value of P1 indicates that immediate fuel costs are high; consequently, potential immediate fuel savings are important. The second indicator, P2, is the ratio of life cycle expenditures (incurred as a result of the investment) to the investment amount. A high value of P2 indicates that the investment has a low first cost but higher costs over the life of the equipment. Type 582 can either calculate P1 and P2 based on a set of simple economic indicators, or it can accept values of P1 and P2 directly. In both modes, the component calculates the life cycle cost for up to ten system alternatives. More alternatives may be added by modifying a single parameter in the Fortran code and recompiling. The model then compares each alternative to a user-designated comparison system.

Type 584: Out of Setpoint /Zone Temperature Watcher

Type 584 watches an input temperature/value at each timestep and compares that value to its setpoint and deadband for that timestep. If the watched temperature/value exceeds the relevant setpoint by more than the deadband allows, the Type records and (if desired) prints information on the time, duration, and extent to which the setpoint was exceeded. This Type is used most often to watch the zone temperatures of building models operating in temperature level control; with temperature level control, it is fairly common for the temperature of a zone to exceed the cooling set point temperature or fall below the heating set point temperature for a short period. The component may also be used more generically to monitor mass flow rate, relative humidity, power, or any watched variable which is to be maintained within a given range but may at times exceed that range.

Type 586: Pressure Drop Calculator

Type 586 models the pressure drop through a piping network of up to 100 sections using the Darcy-Weisbach equation. The user may define the density and viscosity of the working fluid, or the user may select pure water, diluted propylene glycol, or diluted ethylene glycol as the working fluid, allowing the TRNSYS Fluid Properties routine to return fluid density and viscosity. Total pressure drop over the network is output from the Type, as well as the pressure drop over each pipe section.

Type 932: Sherman Grimsrud Infiltration

Type 932 calculates infiltration by the Sherman-Grimsrud infiltration model as described in the ASHRAE Handbook of Fundamentals [1]. Parameters of the Sherman-Grimsrud infiltration model are the effective leakage area of the zone, indoor/outdoor temperature difference, and wind speed, as well as the semi-empirical stack coefficient C_s and wind coefficient C_w. See the ASHRAE Handbook for recommended formulations of C_s and C_w as a function of shelter class and building height.

Type 932 is similar to Type 75, the Sherman-Grimsrud infiltration model available in the Loads and Structures folder of the standard TRNSYS library of components. Both models calculate volumetric flowrate of infiltration air and infiltration energy based on the Sherman-Grimsrud function of the semi-empirical stack coefficient C_s and wind coefficient C_w. Type 75 uses internal tables from the 1997 ASHRAE Handbook of Fundamentals to look up C_s and C_w, based on the number of floors in the building (for C_s) and on both the number of floors in the building and a shielding class that describes the shelter of the surrounding terrain (for C_w). Type 932 allows the user to set C_s and C_w directly as parameters, which allows the user greater flexibility to interpolate or extrapolate the ASHRAE tables, update the values based on updated tables, or use these values as tuning handles to optimize a fit to data. Type 932 also allows the user to model up to 10 zones with the same instance of the Type.

Type 932 is also similar to Type 960, which is also an infiltration model based on stack and wind coefficients. In Type 932, the coefficients C_s and C_w are input directly by the user; see Type 960 for an infiltration model that calculates comparable coefficients internally as a function of building height, zone temperature, and relative leakage of floors, ceilings, and windows/walls/doors as fractions of total leakage.

Type 939: Running Average Calculator

Type 939 keeps a running total and running average of a number of inputs over a user-defined time period.

Type 960: Lawrence Berkeley National Labs Infiltration Model

Type 960 calculates infiltration by the Lawrence Berkeley National Labs (LBL) infiltration model, which is similar to the Sherman Grimsrud model recommended by ASHRAE (see Type 932). The LBL method adds to the Sherman Grimsrud model by calculating values of stack and wind pressure coefficient instead of requiring the user to enter them from tabulated data. Like the Sherman Grimsrud model, the LBL model is based on knowledge of the building's overall leakage area as might be obtained by a blower door test.

Type 980: On/Off Time Calculator

Type 980 watches a control signal and records the running "on" and "off" times of that signal. After convergence, if the input control signal is greater than 0.5, the "on time" output increases by one timestep, and the "off time" output is set to zero. If the input control signal is zero, the "on time" output is set to zero and the "off time" output increases by one timestep. The "on time" and "off time" hours reported may be monitored and recorded as a simulation output, or the hours may be used as part of a multi-level control strategy to ensure that equipment doesn't cycle too frequently or infrequently.

Type 1232: Flat-Plate Convection Calculator

Type 1232 calculates the heat transfer convection coefficient off of a flat plate exposed to air at any inclination angle between 0° (horizontal) and 90° (vertical). Five different correlation modes are available for the user to choose from; some modes calculate the convection coefficient only a function of windspeed, while others integrate both forced and natural convection correlations into calculating the overall convection coefficient. The flat-plate convection calculator is useful with some flat-plate solar collector, PV, and other models that calculate heat loss from a flat surface as a function of a user-input convection coefficient.

Type 1236: Planned and Random Equipment Outages

This component models a piece of equipment (utility grid, air conditioner, etc.) that becomes unavailable at planned and/or random intervals throughout a simulation. As parameters, it takes the number of random outages in a given year, the minimum and the maximum allowable outage length, a random number seed, the number of planned outages, and the start time and duration of each planned outage.

Type 1238: Simulation Event Alert

The Type 1238 audio event alert plays a .wav file of the user's choice when the value of an input varies from its previous value by more than the assigned tolerance. When simulations run unmonitored over several minutes or hours, the event alert can provide audio notification of significant simulation changes, such as a control signal change, a change in an error or warning flag output, or other notable deviations. Each input may have its own associated .wav file, but all inputs for a given instance of the Type must use the same tolerance. Note that the event alert does not directly detect whether an input has exceeded a setpoint or other threshold, only whether the input has changed from its previous value; it may, however, be used in conjunction with a thermostat, equation block, or other logic to achieve this effect.

Type 1243: Water Draw Profile (as Parameters)

Type 1243 takes an hourly average water draw profile and calculates the water draw profile for time steps less than an hour. The hourly average water draw profile is defined by a total daily usage (in gallons), a fraction of the daily total consumed for each hour of a 24-hour period, and a maximum usage rate not to be exceeded for each hour of a 24-hour period. Proformas are available with default fractions of the daily total suited for the ASHRAE 90.2 standard, the Building America standard, the Solar Rating and Certification Corporation (SRCC) standard, a sample morning-weighted profile, and a sample user-defined profile. Type 1243 sets the hourly fractions and maximum hourly usage rates through the parameters of the proforma; see Type 1251 for a comparable Type that sets these parameters through an external data file, with the (optional) aid of a normalization 'wizard.'

Type 1251: Water Draw Profile (from Data File)

Type 1251 takes an hourly average water draw profile and calculates the water draw profile for time steps less than an hour. The hourly average water draw profile is defined by a total daily usage (in gallons), a fraction of the daily total consumed for each hour of a 24-hour period, and a maximum usage rate not to be exceeded for each hour of a 24-hour period. Proformas are available with default fractions of the daily total suited for the ASHRAE 90.2 standard, the Building America standard, the Solar Rating and Certification Corporation (SRCC) standard, a sample morning-weighted profile, and a sample user-defined profile. Type 1251 sets the hourly fractions and maximum hourly usage rates through an external data file, with the (optional) aid of a normalization 'wizard;' see Type 1243 for a comparable Type that sets these parameters through the parameters of the proforma.

Type 1252: Beam Shading Calculator

Type 1252 calculates whether or not the beam radiation on a surface is obstructed by one or more objects. Up to 25 objects may be defined for consideration. If the beam radiation on the surface is obstructed by one or more of the objects, the calculator returns 0 for the beam radiation on the surface, else it returns the input beam radiation for the surface. Fractional shading of a surface is not accounted for by this model.

Type 1299: Sums Inputs and Produces One Output

Type 1299 sums up to 500 inputs and outputs the sum of these inputs as a single output. It is useful for summarizing power consumption, thermal losses, flow rates, and so forth that occur over a number of similar components in a simulation. Type 1299 accomplishes this task without either writing a (potentially large) equation block to do the summation or summing the outputs in post processing through a spreadsheet or other tool. The Type is similar to Type 1317; Types 1299 and 1317 differ in that Type 1299 assumes only one category, while Type 1317 allows the user to specify a different category for each input and outputs the sums by category.

Type 1316: Component Output Summary (new in v18)

Type 1316 calculates the sum and average of up to 100 specified outputs of specified Types within a project. In large projects with multiple instances of the same Type (such as a multi-zone building with multiple pumps, heat pumps, fans, and so forth), Type 1316 can greatly simplify summarizing and assessing the outputs of these multiple instances in aggregate, without the cumbersome connections and equations required to complete the same task within an equation block.

Type 1317: Category Aggregator

Type 1317 allows up to 500 inputs (total) and outputs the sum of these inputs by category for up to 20 categories. It is useful for summarizing power consumption, thermal losses, flow rates, and so forth that occur over a number of similar components across different categories in a simulation. Type 1317 accomplishes this task without either writing a (potentially large) equation block to do the summation or summing the outputs in post processing through a spreadsheet or other tool. The Type is similar to Type 1299; Types 1299 and 1317 differ in that Type 1299 assumes only one category, while Type 1317 allows the user to specify a different category for each input and outputs the sums by category.

Type 1331: Plume Predictor (new in v18)

Type 1331 calculates whether moist air released from a device outlet (such as a cooling tower) into the ambient air may create a plume. It is based on the algorithms of Cizek and Nozicka ('Cooling tower plume', AIP Conference Proceedings, 2016). The output of the Type is 1 if a plume is likely, 0 otherwise. The Type does not model the height, volume, droplet diameter, or other characteristics of the plume.

Type 1370: Min/Max Calculator with Control Signal (new in v18)

Type 1370 calculates the minimum and maximum values for an input over a specified time range. An on/off control signal for each input determines whether the value should be assessed at the current time step. Type 1370 may be used to assess, for example, the minimum and maximum temperatures of a zone over a week during occupied hours only, or the minimum and maximum temperatures of a tank over the simulation, but only during hours when ancillary equipment for that tank is ON.

Type 1576: Two Dimensional Bin Sorter – Integrating

Type 1576 is an integrating version of the Type 576 two-dimensional bin sorter. While Type 576 simply tallies the total hours of the simulation in which the inputs fall within user-specified bins, Type 1576 produces an integrated total for each user-specified bin, based on a rate input (in units of X per hour) at each time step (Input 3). For example, if Input 3 is power (kJ/h), the total energy (kJ) accumulated in each bin will be shown in the bin outputs. Type 1576 is useful for summarizing total energy available from a source or consumed or lost by a device for each user-specified bin during a simulation. To obtain an average rate for each bin, the user may divide the output of each bin in Type 1576 by the output of each bin in Type 576 with the same parameters.

Type 2260: Wind Speed Converter

Type 2260 takes the wind speed measurement from a weather station at a given measurement height and shear exponent (or wind velocity profile exponent, or site terrain roughness) and converts it to wind speed at a different shear exponent and up to 10 different building heights.