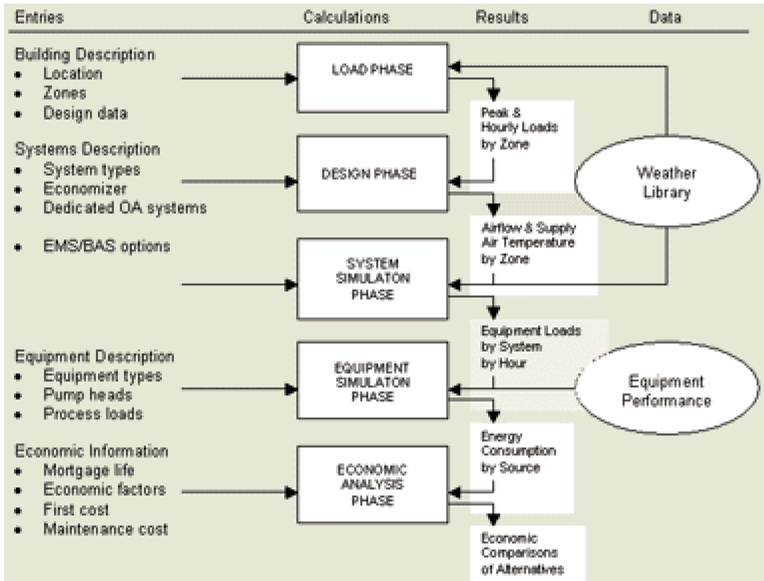
Introduction to TRACE

To fully appreciate the capabilities of the Trane Air Conditioning Economics program and to obtain maximum value from its use, the following is a thorough explanation of the program.



Program Organization

The TRACE program incorporates five major phases, each with specific tasks or functions that must be performed to provide a complete energy and economic analysis. The names of these phases are load, design, system simulation, equipment simulation and economic analysis.

The building heating/cooling load calculations, used in the load phase of the program for annual energy consumption analysis, are of sufficient detail to permit the evaluation of the effect of building data such as orientation, size, shape and mass, heat transfer characteristics of air and moisture, as well as hourly climatic data.

Beyond this, the calculations used to simulate the operation of the building and its service systems through a full-year operating period, are of sufficient detail to permit the evaluation of the effect of system design, climatic factors, operational characteristics and mechanical equipment operating characteristics on annual energy usage. Manufacturers' data is used in the program for the simulation of all systems and equipment.

The calculation procedures used in TRACE are based upon 8,760 hours of operation of the building and its service system. These procedures use techniques recommended in the appropriate ASHRAE publications or produce results which are consistent with such recommended techniques.

This document shows the calculation procedures used in the TRACE program. The calculations explicitly cover the following items:

- Climatic data, including coincident hourly data for temperature, solar radiation, wind and humidity of typical days of the year, representing seasonal variations. In total, the TRACE program calculates building heat gains and losses, by zone, for 1152 hours of the year, representing seasonal variations. TRACE has the ability to import hourly climatic data and calculate building heat gains and losses for all 8760 hours in a year.

- Building and orientation, size, shape, mass and heat transfer characteristics of air and moisture.
- Building operational characteristics, accounting for temperature, humidity, ventilation, illumination and control modes for occupied and unoccupied hours.
- Mechanical operational characteristics, which take into account design capacity, part load performance and ambient dry bulb and wet bulb depression effects on equipment performance and energy consumption.
- Internal heat generation from illumination, equipment and the number of people in occupied spaces during both the occupied and unoccupied hours.

Load Phase

In the Load phase of the program, conventional load data describing the building construction, orientation and location are required entries. In addition, the utilization profile of the building, including lighting schedules, occupancy schedules and miscellaneous load schedules, are required.

The program obtains weather data from its library for the city designated by the program user. Building loads are then actually calculated by zone and by hour, from information provided from the weather library (in the case of weather-dependent loads). It takes into account the coincident loading scheduled by the program user for items such as lights, people and miscellaneous loads.

Beyond this, the program accounts for energy consumed by systems that do not contribute loads to the air conditioning system. These energy consumptions have an effect upon the overall energy demand of the building and the associated energy costs.

Design Phase

The second major phase of the program is the Design phase. The purpose of this phase is to establish the building load model at design conditions. Entries required by the Design phase include the type of mechanical system, as well as the percentage of wall, lighting and miscellaneous loads assigned to the return air. In addition, the design outside air quantities are required.

The program then determines design cooling load, heating load, outside air quantity, total air quantity and the supply air dry bulb temperature. The air quantities and supply air dry bulb in the cooling mode are determined psychrometrically using standard procedures outlined in the ASHRAE Handbook of Fundamentals. Design loads determined in this phase are based on 100% of design entered values, even though the coincident design values of weather-affected loads may not actually occur during the weather year. The aforementioned design values are determined for both the perimeter and interior system from entries by the user.

Airside System Simulation

The next major phase of the program is the Airside System Simulation phase. Its key function in the program is to translate building heat gains and losses into equipment loads by system and by hour, utilizing all of the building variables that affect the system operation. In this phase, the program tracks an air particle around the complete airside system loop, picking up loads and canceling simultaneous gains and losses along the airflow path of each system.

The final output from the system simulation phase is the equipment loads by system and by hour. This consists of air-moving loads, heating loads, cooling loads, and humidification loads where applicable. This is perhaps the most complicated phase of the program. Complication arises from the fact that each major system or system combinations and hybrids thereof, must utilize separate individual system programming subroutines to reflect the actual operation and control of that system.

The program contains system simulation programming subroutines for 32 different system types. These can be combined to form innumerable variations for the building under study.

Equipment Simulation

The equipment loads, by system and by hour, are then provided to the equipment simulation phase, along with a description of the equipment to be used in the system.

The previously described weather information is also input into this phase. Regardless of whether the equipment has air-cooled or water-cooled condensing, the weather affects the overall part load efficiencies.

The essential function of the equipment and simulation phase is to translate equipment loads, by system and hour, into energy consumption by source. The loads are translated into kilowatt-hours of electricity, therms of gas, oil, district hot water or chilled water, even to the extent of calculating the total gallons of make-up water required by a cooling tower or the energy consumed by the crankcase heaters of a reciprocating compressor. The entry requirements of this phase consist only of the equipment types for heating, cooling and air-moving as well as pumping heads and pump motor efficiency for each system where hydronic pumping is involved.

This data is utilized within the program to call for the equipment library, which is the performance information for the various pieces of equipment. This information is used to convert system loads into energy consumption for subsequent processing to the economic analysis phase.

It is important to note it is not necessary for the user to enter the part load performance of equipment accessories into the program. They are already contained in the equipment library and are accessed when called for by the user.

Economic Phase

The next and final major phase of the program is the economic analysis phase. This phase utilizes user entries, such as the utility rates and system installed cost data, along with other economic information such as mortgage life, cost of capital, etc., to compute annual owning and operating costs. It also calculates the various financial measurements of an investment such as cash flow effect, profit and loss effect, payout period and return on additional investment between alternatives.

In very simple terms, the program determines how much it costs to operate one system compared with another. It then computes the present worth of the savings and the incremental return on the additional investment. It is keyed to provide information the owner needs to make his or her final economic decision, including monthly and yearly utility costs over the life of the HVAC system.