Applying Schedules and Profiles in HAP

This HAP e-Help discusses the importance of properly applying schedules and profiles in HAP. We will also discuss potential misapplications of these user inputs. First, we need to understand the differences between schedules and profiles and their effect on design loads and energy simulation.

A "Schedule" is made up of one or more hourly "Profiles" and the associated day type "Assignments." A fractional schedule is used to describe how much and how often a building parameter like people, lights, and miscellaneous internal heat gains exist. These schedules are then assigned to, and modify the internal loads defined in the space input forms.

Within a schedule, an hourly profile is used to describe behavior for one 24-hour period. For example, a profile for people would show the percentage of full occupancy each hour for a 24-hour period. Schedules may contain one or more profiles that together define the behavior for the entire year. The example schedule shown in Figure 1 represents the "Lights" in a typical office application. There are four profiles associated with this schedule: one for the "Design Day", one for "Weekdays", one for "Saturday-Sunday", and one for "Holidays". Together, these profiles define the different behavior patterns for the lights in the office.

Profiles can represent behavior for different days of the week and different months of the year. In the example above, additional profiles for summer weekdays, fall/winter/spring weekdays, and weekends could be added if desired. Users may describe up to eight separate and distinct profiles depending on the usage patterns of the building.
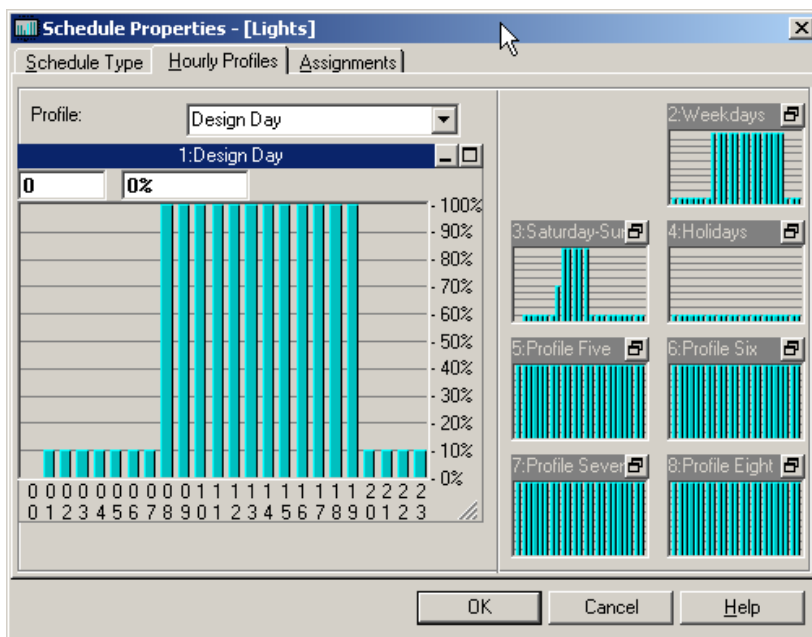

Figure 1 – Schedule Properties for Lights Incorporating Four Profiles

Software Systems Technical Support:
software.systems@carrier.utc.com
1-800-253-1794

Applying Schedules and Profiles in HAP

Three Types of Schedules

There are three types of schedules in HAP: Fractional, Fan/Thermostat, and Utility Rate Time-of-Day. Fractional and fan/thermostat schedules are used in design load and annual operating cost calculations. Utility rate time-of-day schedules are used only in annual operating cost calculations.

Fractional schedules represent hourly percentage usage of the internal heat gain value. Fractional schedules are most often used to describe the hourly variation of internal heat gains such as people, lights, and miscellaneous heat sources.

In addition to lights, people, and miscellaneous heat sources, the fractional schedule can be used for special "scheduled" control options for ventilation air, and to define hot water usage.

The fraction of 100% heat gain for each hour is described by the hourly profile. For example, the fractional profile for a lighting schedule would define the fraction of 100% light load for each hour of the day.

The "Design Day" profile in Figure 3 represents lighting for an office area. This schedule has been named "Lights Office". Notice this profile calls for 100% of the light level between the hours of 7 a.m. and 7 p.m. and 10% of the light level for the remaining hours. As an example, suppose the light heat gain was entered as 2.5 watts/sq ft. The lighting wattage at this level would exist from 7 a.m. to 7 p.m., and lighting at 0.25 watts/sq ft would exist for the remaining hours.

For information on how heat gains are converted into cooling loads, see HAP e-Help 004 discussing the Transfer Function Methodology.
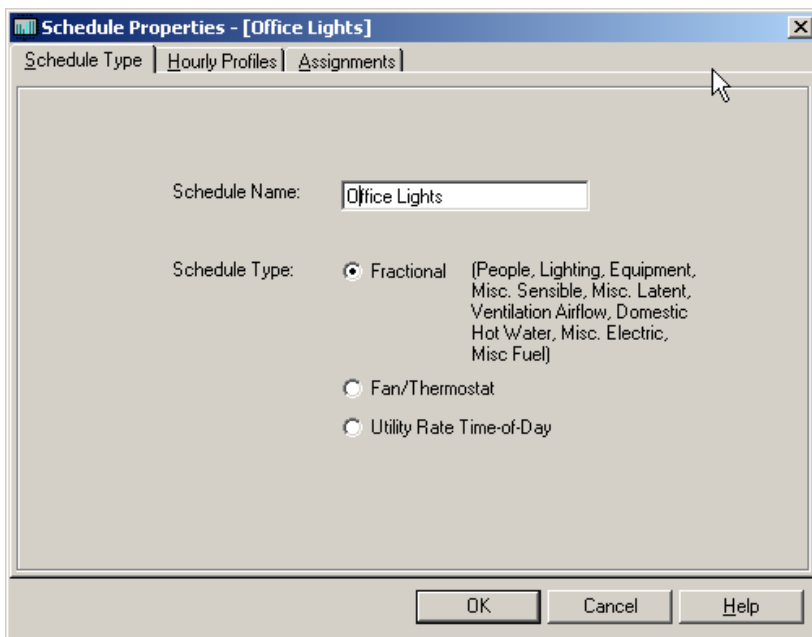

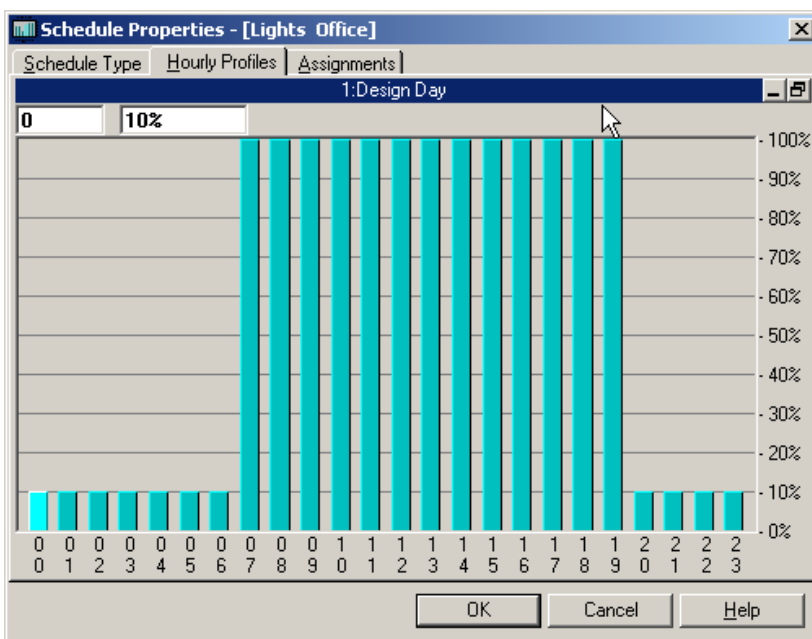**Figure 2 – Fractional Schedule Choice**

Figure 3 – Typical Lighting "Design Day" Profile for an Office

Applying Schedules and Profiles in HAP

Fan/Thermostat Schedules

Fan/Thermostat schedules define the hours when the HVAC equipment is operating in the "occupied" or "unoccupied" period. Hours of the day in these profiles are designated as "occupied" or "unoccupied" and not fractional as with lights and people. During occupied hours, the occupied thermostat set points are used and the air system fan operates to ventilate and condition the building. During unoccupied hours, the unoccupied thermostat set points are used and the fan systems cycle to condition the building. This type of schedule is selected in the "Air System Properties" under the "Zone Components" tab and the "Thermostats" input by clicking the "Thermostat Schedule" button.

Figure 4 – Fan and Thermostat Schedules

In the "Design Day" Fan/Thermostat profile shown in Figure 5, the HVAC system is started at 6 a.m. and the occupied thermostat set points for cooling and heating take effect at that time. At 7 p.m., the fan/thermostat enters the unoccupied period and the fan cycles to maintain set points. The Fan/Thermostat profile operates independently of when the people enter the building and the lights are turned on. However, there should be a relationship between these schedules and their profiles for the same project. For instance, it is not uncommon to start the fan/thermostat an hour or more before the people arrive, and stop the system operation and occupied set point an hour or so after people leave.

The bar for each hour indicates operation for the full hour. For example, if you have a bar for hour 09, that covers the time period 9:00:00 a.m. thru 9:59:59 a.m. And a bar for hour 18 covers the time period 6:00:00 p.m. thru 6:59:59 p.m. So, the schedule shown to the right results in an occupied period beginning at 6:00:00 a.m. and ending at 6:59:59 p.m. If this is not understood, it is easy to schedule operation 1 hour longer than intended.
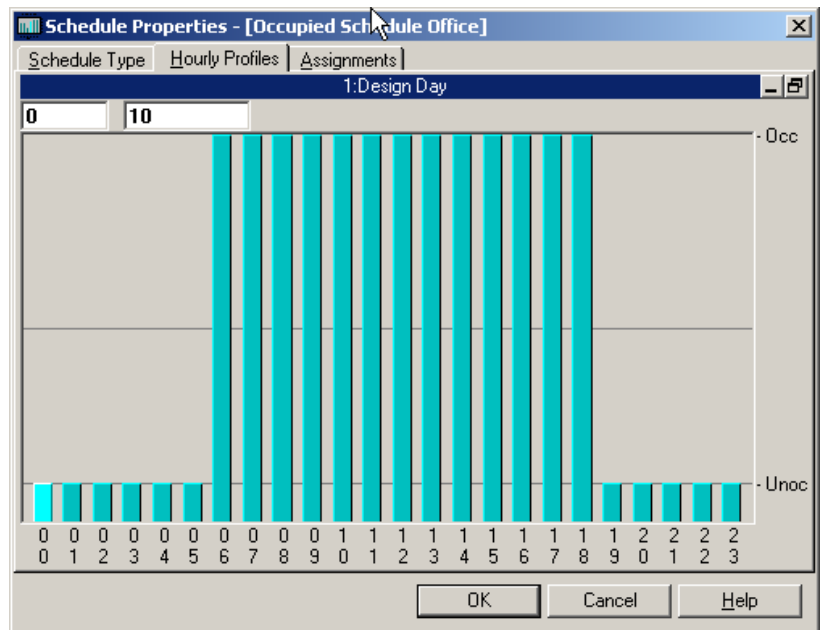

Figure 5 – Typical Fan/Thermostat Profile for Office

Applying Schedules and Profiles in HAP

The last type of schedule represents the Utility Rate Time-of-Day. It is used to define on-peak and off-peak pricing periods for the electric rate. Figure 6 shows a sample profile for this type of schedule. Notice that it is different from the fractional and the fan/thermostat profiles. This profile allows the user to input each hour into one or up to four categories; peak, mid, normal, and off-peak. In this example, the utility charges a "peak" rate starting at 8 am and extending for 10 hours per day. There are mid-peak rates for 2 hours before and after the peak times. The other hours are off-peak. The user then defines the actual rate in $/kWh for the various levels in the electric and fuel rate property input screens.

Assignments

Now that we have described the three types of schedules and their profiles, we will discuss the final input for schedules: the assignment of the various profiles to the days of the week and months of the year. Individual profiles in a schedule can be assigned to different months of the year or days of the week. This permits modeling of different internal load behavior patterns at the different times of year or on different days of the week. The "Assignments" tab in the Schedule Properties input is used for this purpose.

For the example shown in Figure 7, we have assigned a separate lighting profile for the "Design Day", "Weekdays", "Weekends", and "Holidays". Profile 2, "Weekdays" has been assigned to the Monday, Tuesday, Wednesday, Thursday, and Friday day types for each month of the year.

Assignments for the "Design" row of the table are only used for the design cooling calculations. Assignments for the days of the week are only used for energy simulation calculations. As a note, when operating HAP in the System Design mode to calculate cooling and heating loads, only the "Design" row in the table is enabled. All other rows (weekdays, weekends, and holidays) are removed from view.
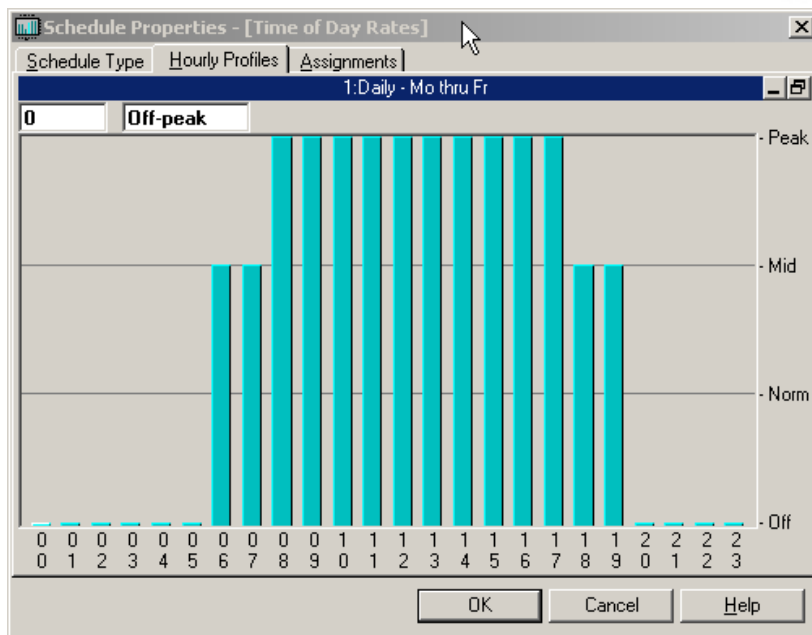

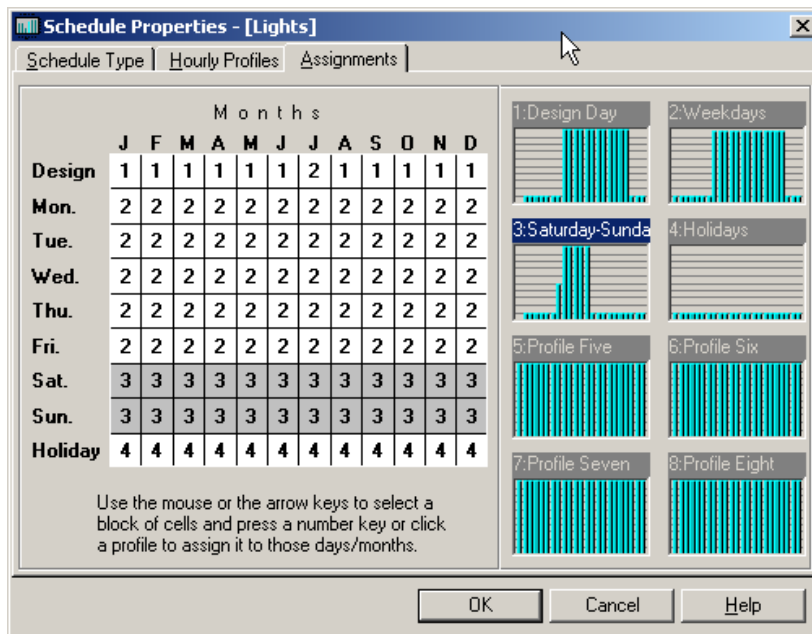**Figure 6 – Utility Rate Time-of-Day Profile**

Figure 7 – Assignments

Applying Schedules and Profiles in HAP

Important! Always Use Representative Profiles When Creating Schedules

Some HAP users question the relevance of inputting actual fractional profiles. Some may think they are simply being conservative by leaving the profile multipliers at 100% for the entire 24-hour period. But what is the consequence of doing this in the HAP program?

First and foremost, the hourly variations in heat gain from lights, people, and other internal sources should be used for each project. Also, only real life internal heat gains that exist during known hours should be used. Granted, using 100% for all hours in a profile is the easiest to input. However, heat gain in one hour has an effect on the loads in subsequent hours because of the thermal storage effect modeled by the ASHRAE Transfer Function Method.

A 100% internal gain in all hours will essentially result in a situation where the internal gain = internal cooling load for stage 1 Transfer Function calculations. Stage 1 calculations are used to calculate zone and space airflows.

In stage 2 calculations, HAP makes adjustments to the stage 1 values, and then calculates the coil capacity based on "actual" system operation. If the profiles for internal gains are set at 100% for both the occupied and unoccupied hours, enormous heat storage in the building mass will occur during the unoccupied hours. This can happen because the cooling setup temperature is higher during the unoccupied times and/or the cooling equipment is off at night.
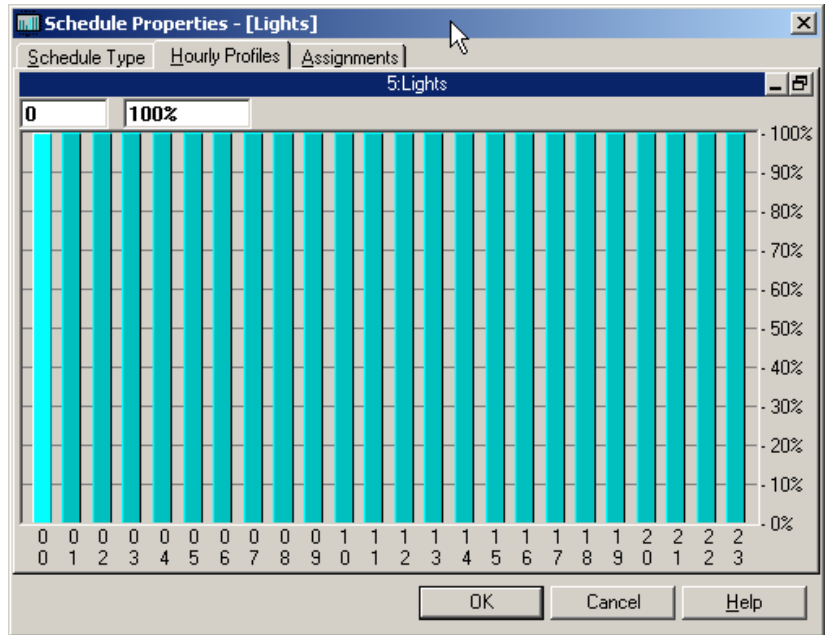

Figure 8 – 100% Values Not Recommended Unless Applicable to Actual Building Usage

The above described condition will result in a very large pull down load. This extremely large pull down load could result in the peak coil load occurring in the morning instead of the late afternoon, which would have been the case with a more realistic schedule. So, the actual time and magnitude of the peak cooling coil load has been skewed by the large pull down load. This load would not exist if the internal gains were not present during the unoccupied periods.

Because of the large pull down load, the system will struggle to reduce the zone temperature to the cooling set point in a reasonable time during the occupied period. This can result in unsatisfied and higher than expected zone temperatures. (See HAP e-Help 007 for additional information on Zone T-Stat Check.) This struggle occurs because the airflow being used to pull down the load at the onset of the occupied cycle has, in fact, been sized based on stage 1 calculations. These calculations do not account for the unrealistic pull down requirements. However, the size of the cooling coil does take into account pull down if it exists. So, a larger cooling coil load will be sized versus a scenario where less or no pull down is required.

Applying Schedules and Profiles in HAP

So, why not use continuous internal heat gains at 100% and run the fan/thermostat schedule for 24 hours? This way, no pull down loads exist, right?

This is not advisable. HAP may undersize the cooling coil since no pull down loads exist because the system does not have an occupied period with a lower set point temperature. At that point, many engineers would attempt to apply a suitable safety factor to account for the pull down load. However, the magnitude of the pull down load can be accurately calculated by HAP with suitable attention to realistic profiles representing the internal loads.

What is the energy consumption and operating cost penalty if the internal loads are not correctly profiled?

The energy use and operating costs will be higher. In addition, the exaggerated heat gains can also offset heat losses in the transition seasons and in winter, further skewing results. Hours of cooling operation will be larger than they should be. Hours of heating operation will be less than they should be. In some cases, all hours of heating operation will disappear due to overestimating the hours when heat gains occur. As a result, answers can not only be overstated, but seriously skewed (all cooling operation, no heating operation, for example). Lastly, since alternative designs are often compared on the basis of % savings, the % value will be unreliable because the totals are inflated. Demand charges could also be skewed.

Pre-Defined Schedules with the Building Wizard

The new Building Wizard feature in HAP version 4.3 provides a quick method of entering space, schedule and construction data. The Building Wizard is useful when developing schematic designs, performing preliminary design work and creating screening studies. Pre-defined schedules have been incorporated into the Building Wizard and include occupancy, overhead lighting, and electrical equipment in a ready-to-go quick select format that is based on the type of building under consideration. All of the pre-defined schedules in the Building Wizard can then be customized by the user if desired.

The validity of the building model for load estimating and energy simulation depends on representative inputs relative to internal loads. Since a large part of the total load and operating cost in a building involve internal loads like people and lights, Carrier recommends utilizing realistic and representative profiles in order to maintain accurate results.
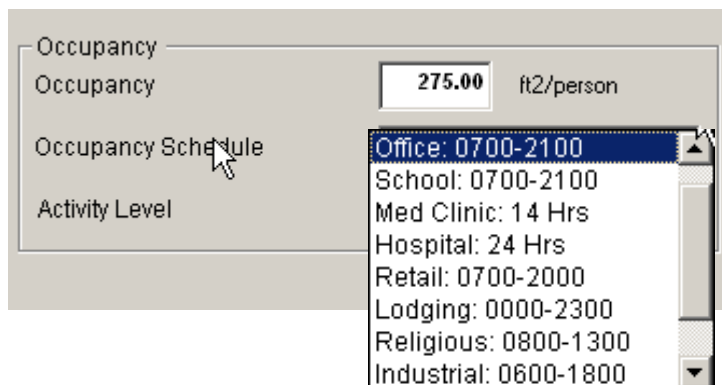

Figure 9 – Building Wizard Pre-defined Occupancy Schedules