Over/Undersizing in TRACE 700

Over/undersizing, which appears on the Checksums and Airflow Loads reports, typically occurs with constant volume system types, especially Single Zone (SZ), Fan Coil (FC), Variable Temperature Constant Volume (VTCV), and Multizone (MZ) systems.

The following airside system and rooms will be used to illustrate what over/undersizing is and how it is calculated in TRACE 700.

The sensible heat equation (see below) will be used to calculate the sensible loads, airflows, and sensible over/undersizing.

\[ Q_s = DSHP \times CFM \times (Tr - Ts) \]

\( Q_s \) is the sensible load in the space calculated based on the input walls, windows, internal loads, etc. A positive value indicates heat gains, a negative value indicates heat losses.

\( DSHP \) is the density specific heat product (1.085 at sea level), we will use 1.1 for simplification purposes. \( DSHP \) is calculated for each weather location based on the altitude of the location and can be found on the Title Page report.

\( CFM \) is the supply airflow. This can either be input on the Airflows tab of Create Rooms or calculated by TRACE using the sensible heat equation.

\( Tr \) is the room set point temperature entered on the Rooms tab of Create Rooms. We will assume 75F for cooling and 70F for heating.

\( Ts \) is supply air dry bulb (SADB) and it is input on the Temperatures tab of Create Airside Systems or calculated by TRACE using the sensible heat equation.

If only the sensible over/undersizing is considered, then the over/undersizing would be equal to the difference between \( Q_s \) and \( DSHP \times CFM \times (Tr - Ts) \).

\[ \text{Over/undersizing} = DSHP \times CFM \times (Tr - Ts) - Q_s \]

For cooling design reports:
- a positive value (+) denotes overcooling (or oversizing of the cooling coil)
- a negative value (-) denotes undercooling (or undersizing of the cooling coil)

For heating design reports:
- a positive value (+) denotes underheating (or undersizing of the heating coil)
- a negative value (-) denotes overheating (or oversizing of the heating coil)
Five scenarios will be used to calculate over/undersizing, explain why it occurs, and how to minimize it.

Scenario 1 – Over/undersizing on heating for a constant volume system with heating supply air dry bulb and airflow specified by user.

Room 1
Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
Heating Qs = -5,500 Btu (calculated by TRACE based on heat losses)
CFM = 500 cfm (input by user)
Heating Ts = 105F (input by user)

In this scenario, the over/undersizing on heating would be

\[
\text{Over/undersizing} = 1.1 \times 500 \times (70 - 105) - (-5,500) = -13,750 \text{ Btu}
\]

This would indicate overheating of 13,750 Btu's, since the space would need 143 cfm at a SADB of 105F to properly condition the space. To minimize the overheating, remove the heating supply air dry bulb and/or the supply airflow and allow the program to calculate the value(s).

Scenario 2 – Over/undersizing on cooling for a constant volume system with cooling supply air dry bulb* and airflow specified by user.

Room 1
Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
Heating Qs = -5,500 Btu (calculated by TRACE based on heat losses)
CFM = 500 cfm (input by user)
Cooling Ts = 50F (input by user)

In this scenario, the over/undersizing on cooling would be

\[
\text{Over/undersizing} = 1.1 \times 500 \times (75 - 50) - 11,000 = 2,750 \text{ Btu}
\]

This would indicate overcooling of 2,750 Btu's, since the space would need 400 cfm at a SADB of 50F to properly condition the space. Note: If the system selected has the ability to reheat at the terminal device, then this is the amount of reheat that would be done at cooling design. To minimize the overcooling, remove the cooling supply air dry bulb and/or the supply airflow and allow the program to calculate the value(s).

Scenario 3 – Over/undersizing on heating for a constant volume system with cooling supply air dry bulb* entered by user or calculated by TRACE and the heating supply air dry bulb specified by user.

Room 1
Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
Heating Qs = -5,500 Btu (calculated by TRACE based on heat losses)
Cooling Ts = 55F (Input by user or calculated by TRACE )
Heating Ts = 100F (input by user)

Since constant volume systems supply the same airflow for both heating and cooling conditions, TRACE calculates the design cooling and heating airflows separately then selects the larger of the two airflows as the system’s design supply airflow. This same supply airflow is then used for heating design and for cooling design.

\[
\begin{align*}
\text{Cooling:} & \quad \quad \text{Heating:} \\
11,000 &= 1.1 \times \text{CFM} \times (75 - 55) & -5,500 &= 1.1 \times \text{CFM} \times (70 - 100) \\
\text{CFM} &= 500 \text{ cfm} & \text{CFM} &= 167 \text{ cfm}
\end{align*}
\]

In this scenario, the over/undersizing on heating would be

\[
\text{Over/undersizing} = [1.1 \times 500 \times (70 - 100) - (-5,500)] = -11,000 \text{ Btu}
\]

This would indicate overheating of 11,000 Btu's, since the space would need 167 cfm at a SADB of 100F to properly condition the space. Typically, rooms do not need as much airflow for heating as for cooling, therefore oversizing occurs because there is too much airflow for the design heating load. The program tries to reduce the design supply air dry bulb for heating, but cannot reduce it below the Minimum Heating Supply Air Dry Bulb
Temperature or the Room Design Heating Dry Bulb Temperature. To minimize the overheating, remove the heating supply air dry bulb and allow the program to calculate the value(s).

**Scenario 4 – Over/undersizing on heating for a variable volume system with cooling supply air dry bulb* entered by user or calculated by TRACE and the heating supply air dry bulb specified by user.**

**Room 1**
- Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
- Heating Qs = -5,500 Btu (calculated by TRACE based on heat losses)
- Cooling Ts = 55F (Input by user or calculated by TRACE)
- Heating Ts = 100F (input by user)
- VAV min stop = 50% of cooling supply airflow (entered on Airflows tab of Create Rooms)

The cooling supply cfm would be calculated using the sensible heat equation. The heating supply cfm would be calculated using the cooling supply cfm and the minimum stop

- **Cooling:**
  \[ 11,000 = 1.1 \times CFM \times (75 - 55) \]
  \[ CFM = 500 \text{ cfm} \]

- **Heating:**
  \[ CFM = 500 \times 50\% \]
  \[ CFM = 250 \text{ cfm} \]

In this scenario, the over/undersizing on heating would be

- Over/undersizing = 1.1 x 250 x (70 – 100) – (-5,500) = -2,750 Btu

This would indicate overheating of 2,750 Btu's, since the space would need 167 cfm at a SADB of 100F to properly condition the space. Any time a heating supply air dry bulb is entered for a variable volume system, oversizing or undersizing of the coil should be expected. To minimize the overheating, remove the heating supply air dry bulb and allow the program to calculate the value.

**Scenario 5 – Over/undersizing on heating for a constant volume system with cooling supply air dry bulb* entered by user or calculated by TRACE.**

**Room 1**
- Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
- Heating Qs = -8,250 Btu (calculated by TRACE based on heat losses)
- Cooling Ts = 55F (Input by user or calculated by TRACE)

The heating supply air dry bulb will typically be calculated from the sensible heat losses and the supply cfm calculated during the cooling calculations.

- **Cooling:**
  \[ 11,000 = 1.1 \times CFM \times (75 - 55) \]
  \[ CFM = 500 \text{ cfm} \]

- **Heating:**
  \[ -8,250 = 1.1 \times 500 \times (70 - Ts) \]
  \[ Heating Ts = 85F (calculated by TRACE) \]

**Room 2**
- Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)
- Heating Qs = -2,750 Btu (calculated by TRACE based on heat losses)
- Cooling Ts = 55F (Input by user or calculated by TRACE)
- Heating Ts = 85F (calculated by TRACE based on worst case room assigned to system)

- **Cooling:**
  \[ 11,000 = 1.1 \times CFM \times (75 - 55) \]
  \[ CFM = 500 \text{ cfm} \]

In this scenario, the over/undersizing on heating would be

- Over/undersizing = 1.1 x 500 x (70 – 85) – (-2,750) = -5,500 Btu

This would indicate overheating of 5,500 Btu's, since the space would need 167 cfm at a SADB of 85F to properly condition the space.
Constant volume systems supply the same airflow for both heating and cooling conditions. TRACE calculates the design cooling and heating airflows separately then selects the larger of the two airflows as the system’s design supply airflow. This same supply airflow is used for heating design and for cooling design.

When multiple spaces are conditioned by the same coil, a single supply air dry bulb is calculated. This often will cause one room to set the heating supply air dry bulb and other rooms to be overheated. Rooms that have very different thermal properties (internal Vs external rooms) will see large amounts of overheating, as is shown in scenario 5.

**Scenario 6 – Over/undersizing on cooling for a variable volume system.**

**Room 1 - East Facing**

Cooling Qs = 11,000 Btu (Maximum sensible load calculated by TRACE based on heat gains at time of space peak - 9am for this example)

Cooling Qs = 5,000 Btu (Sensible load calculated by TRACE based on heat gains at time of system (cooling coil) peak - 3pm for this example)

Cooling Ts = 55F (Input by user or calculated by TRACE)

VAV min stop = 50% of cooling supply airflow (entered on Airflows tab of Create Rooms)

The cooling supply cfm would be calculated using the sensible heat equation and the loads at the time of space peak – 9am for this east facing office. The minimum supply cfm would be calculated using the cooling supply cfm and the minimum stop.

```
Cooling:                      Minimum CFM supplied to space:
11,000 = 1.1 x CFM x (75 - 55)  CFM = 500 x 50%
CFM = 500 cfm     CFM = 250 cfm
```

When sizing the cooling coil, oversizing would appear in this example based on the minimum airflow requirements

\[
\text{Over/undersizing} = 1.1 \times 250 \times (75 - 55) - (5,000) = 500 \text{ Btu}
\]

This would indicate overcooling of 500 Btu's, since the space would need 227 cfm, but the minimum stop on the VAV box is 250 cfm. Any time the minimum airflow is more than what is required to condition the space, oversizing of the coil should be expected.

**Scenario 7 – Over/undersizing on cooling for a system with cooling supply air dry bulb specified by user and a ventilation rate greater than the supply airflow need to condition the space.**

**Room 1**

Cooling Qs = 11,000 Btu (calculated by TRACE based on heat gains)

Ventilation CFM = 600 cfm (input by user)

Cooling Ts = 55F (input by user)

Required supply airflow to condition the space

\[
11,000 = 1.1 \times CFM \times (75 - 55) \\
\text{CFM} = 500
\]

Since the user input ventilation rate is larger than the airflow required to cool the space, TRACE will use the ventilation rate as the supply airflow for the space. In this scenario, the over/undersizing on cooling would be

\[
\text{Over/undersizing} = 1.1 \times 600 \times (75 - 55) - 11,000 = 2,200 \text{ Btu}
\]

This would indicate overcooling of 2,200 Btu's, since the space would need 500 cfm at a SADB of 55F to properly condition the space. Note: If the system selected has the ability to reheat at the terminal device, then this is the amount of reheat that would be done at cooling design. To minimize the overcooling, remove the cooling supply air dry and allow the program to calculate the value.
Summary Points / Additional Items:

1. For cooling design reports:
   · a positive value (+) denotes overcooling (or oversizing of the cooling coil)
   · a negative value (-) denotes undercooling (or undersizing of the cooling coil)

For heating design reports:
   · a positive value (+) denotes underheating (or undersizing of the heating coil)
   · a negative value (-) denotes overheating (or oversizing of the heating coil)

2. Over/undersizing is an actual load on the coil, it cannot simply be ignored.

3. There are many other situations that can cause Over/undersizing. These situations are all caused by a space being either over or under-conditioned due to the system selected, user inputs, or both.

Additional questions about Over/undersizing should be directed to the C.D.S. Support Center at 608-787-3926 or cdshelp@trane.com.

* Inputting the leaving cooling coil temperature will cause the situations to occur as inputting the supply air dry bulb. The relationship between the two inputs is shown below:

Supply Air Dry Bulb = Leaving Cooling Coil Temperature + Duct Heat Gain + Fan Heat Gain (draw thru fan configurations only)