YORK	LOAD CALCULATION GUIDELINES FOR UNDERFLOOR HVAC	
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LOAD ESTIMATING GUIDELINES

SPACE LOAD

An air distribution system is designed and sized to handle the space sensible load in a building. The cooling coil in the AHU removes the latent loads as well as the sensible loads from the space. All of the sensible loads in the space are removed by the cooling coil, but they do not all become part of the space sensible air load in an under floor air distribution system. This is key in designing UFAD systems.

Space sensible cooling loads are only a portion of the sensible heat generated in a space. Some of the sensible heat generated in any space is assigned directly to the return air, or cooling coil, without ever becoming part of the space sensible load. For the purposes of this manual, space sensible loads are defined as follows:

Internal loads:

- People
- Lights
- Small Power
  - Computers
  - Copiers
  - Printers
  - Task lighting
  - Coffee pots, refrigerators, microwave ovens, vending machines, etc.

Skin Loads:

- Solar
- Glass Transmission
- Infiltration
- Wall Transmission

INTERNAL LOADS

When designing an overhead distribution system, all of the people and small power loads are used in the airflow calculation, as well as a portion of the overhead lighting load. Typically, 50% of the overhead lighting load is assigned to the space air load with an overhead system. This is to account for the fact that a portion of the heat generated by the overhead lights occurs above the acoustical ceiling, and not in the space. The coil will account for 100% of the overhead lighting load in the overhead system.

When designing an underfloor distribution system, all of the sensible heat generated by people and small power are considered part of the space sensible load, because they all occur in the breathing zone. YORK recommends using 20% of the overhead lighting load in these calculations. Again, a portion of the heat generated is above the ceiling, but the entire lighting fixture is located above the breathing zone. In this case, the cooling coil will need to remove the entire overhead lighting load.

Because of the 60º–65ºF air in the supply plenum, and the space temperature directly above the carpeting is normally 72º–73ºF, some heat from the space will be transferred by conduction through the floor to the plenum directly. This portion of heat therefore, can be removed from the space sensible load. Testing has shown that this is between 0.6 and 1.0 watt per square foot. This portion can be subtracted from the space sensible load. The following chart indicates the load adjustments for a FlexSys™ system:

Remember that these loads reduce the supply air load but are part of the system coil and chiller load.

LOAD ITEM	TRADITIONAL OVERHEAD SPACE SENSIBLE LOAD	FLEXSYS SPACE SENSIBLE LOAD
Lights 1.2 watt/ft^2	0.84 watts/ft^2 (70%)	0.24 watts/ft^2 (20%)
People 0.8 watts/ft^2	0.8 watts/ft^2 (100%)	0.8 watts/ft^2 (100%)
Small Power 3.0 watts/ft^2	3.0 watts/ft^2 (100%)	3.0 watts/ft^2 (100%)
Raised Floor Credit	N/A	(0.6 watts/ft^2)
Total 'Internal' Space Sensible Load	4.64 watts/ft^2 *or* 15.8 Btu/ft^2	3.44 watts/ft^2 *or* 11.7 Btu/ft^2

SKIN LOADS

Skin loads are also handled somewhat differently with a FlexSys™ system. With an overhead distribution system, all of the skin loads below the ceiling plenum typically become part of the space sensible load. This is because an overhead "well mixed" system by definition is conditioning the entire space from the floor to the ceiling.

Since the FlexSys™ system is only conditioning the breathing zone, or the first 6' of the space, we can again transfer some of the skin loads from the space air load to the return air. YORK recommends that 60% of the skin load be accounted for in the space and the remaining 40% be transferred directly into the return air (back to the cooling coil).

Since the goal of an underfloor distribution system is to condition only the breathing zone, all of the transmission, and infiltration that occurs above the breathing zone can be transferred directly to the return air. In an overhead design, solar radiation penetrates the space, warms the concrete slab and is then radiated back into the space. With an underfloor system, the solar radiation that penetrates the space warms the raised access floor. A portion of the heat becomes a space air load and the other portion conducts into the supply air plenum. The portion that conducts into the supply air plenum does not become part of the space load. Also the heat from conduction, infiltration, and solar radiation warms the air adjacent the skin which convects upward warming the return air and a significant portion does not become a space air load. Since we are supplying air from below, we can take advantage of this natural convection. An overhead system will mix this heat back into the space air load. The chart below indicates the load adjustments for a FlexSys™ system.

YORK International has completed a significant number of tests to validate these conclusions.

AIRFLOW REQUIREMENTS

In general, airflow requirements for the FlexSys™ VAV system are slightly less than a traditional overhead VAV system.

Thermal decay is a situation that occurs in all air distribution systems, overhead or underfloor. Thermal decay is the loss of cooling ability of air as it travels through the distribution system, i.e.: the gain of heat, or temperature rise of the supply air. This occurs in an overhead system, but adding insulation to the ductwork minimizes this loss. In an underfloor system adding insulation is not practical, so we design the airflows to accommodate the rise in temperature.

The heat gain in an underfloor system comes from two places. If the facility is a multi-story structure, heat from the warm return below is transferred to the supply plenum above through the slab. Heat from the occupied space above the access floor is transferred through the access floor to the supply plenum. The amount of heat gain is dependent on several factors, including height of the supply plenum, airflows to the interior and perimeter of the building, and characteristics of the slab. A general rule of thumb is that the temperature of the supply air will rise approximately 3ºF from the point of supply to the plenum, in a distance of 50'. This is based on a 12" raised access floor, with a return plenum below, and typical office cooling loads. If the distance to the furthest diffuser is more than 50', it is recommended that some stub ductwork be placed in the plenum. The chart on the following page shows some of the specific parameters associated with t\hermal decay.

If the supply air temperature is 60ºF at the discharge to the plenum, it will be nominally 63ºF at the furthest MIT terminal (normally at the perimeter with a traditional building design with a center core area). The temperature

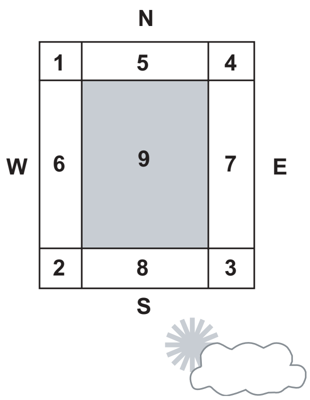
LOAD ITEM	TRADITIONAL OVERHEAD SPACE SENSIBLE LOAD	FLEXSYS SPACE SENSIBLE LOAD
Glass Solar 77 watts/lf (with blinds)	77 watts/lf (100%)	46.2 watts/lf (60%)
Glass Transmission 15 watts/lf	15 watts/lf (100%)	9.0 watts/lf (60%)
Wall Transmission 5.3 watts/lf	5.3 watts/lf (100%)	3.1 watts/lf (60%)
Infiltration 3.7 watts/lf	3.7 watts/lf (100%)	2.0 watts/lf (60%)
Total 'Skin' Load	101 watts/lf *or* 345 Btu/lf	60.3 watts/ lf *or* 206 Btu/ lf

Air Travel Distance under raised floor as function of supply air temperature rise

Air temp rise, °F (°C)		1° (0.6°)		2° (1.1°)		3° (1.7°)		4° (2.2°)		5° (2.8°)		6° (3.3°)	
% cfm inc.		8		17		27		40		56		75	
Raised floor carpet status		with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet
Base*	Feet	21	20	35	32	47	44	58	55	70	66	84	77
	Meters	6.4	6.1	10.7	9.8	14.3	13.4	17.7	16.8	21.3	20.1	25.6	23.5
Base with 18" (45.7 cm) floor	Feet	25	23	42	38	55	54	72	68				
	Meters	7.6	7	12.8	11.6	16.8	16.5	22	20.7				
Base with 14 cfm/ft (21.7 l/s/m) to perimeter	Feet	19	17	31	28	42	39	53	49	63	59	73	70
	Meters	5.8	5.2	9.4	8.5	12.8	11.9	16.1	14.9	19.2	18	22.3	21.3
Base with no cfm (l/s) to perimeter	Feet	16	14	26	24	35	33	44	42	54	51	62	60
	Meters	4.9	4.3	7.9	7.3	10.7	10	13.4	12.8				
Base with 0.4 cfm/ft² (5 l/s/m²) internal load	Feet	20	18	33	30	45	42	56	53	67	64	80	75
	Meters	6.1	5.5	10	9.1	13.7	12.8	17.1	16.1	20.4	19.5		
Base with 0.4 cfm/ft² (5 l/s/m²) and 14 cfm/ft (21.7 l/s/m) to skin	Feet	18	16	29	27	39	36	49	46	60	56	70	66
	Meters	5.5	4.9	8.8	8.2	11.9	11.0	14.9	14.0	18.3	17.1		
Base with 55°F (12.8°C) air under slab	Feet	53	42	81	70								
	Meters	16.2	12.8	24.7	21.3								
Base with neutral slab effect	Feet	40	33	62	54	80	72						
	Meters	12.2	10.1	18.9	16.5	24.4	21.9						

*Base includes:
60°F (15.6°) 80% RH air condition entering space
80°F (26 7°C) air beneath slab
73°F (22.8°C) air at carpet surface in conditioned space
Nominal 12 in. (30.5 cm) raised floor with 10.75 in. (27.3 cm) height of subfloor plenum
Internal cooling load = 0.6 cfm/ft² (3.0 l/s/m²)
Skin cooling load = 27 cfm/ft (41.8 l/s/m)
6 in. (15.2 cm) concrete structural slab

at the top of the breathing zone will be approx. 77ºF (this is not the return air temperature to the AHU). We will use these temperatures to calculate the CFM for the space.



The standard building is broken up into 9 distinct cooling zones. There will be 4 corners, 4 perimeter areas and an interior zone. The interior zone simply has interior loads (people, lights and small power). Perimeter and corner zones will have interior loads as well as skin loads. We will calculate the interior loads separately from the skin loads, and then combine them to create a perimeter zone. These distinct thermal zones are often broken down into smaller zones depending on specific use of space and office layout.

Interior Loads — CFM = BTU/(1.085 x T)

$$CFM = (11.7/(1.085 \times 77 – 61.5) = 0.70\ cfm / ft^2$$

A supply air temperature of 61.5ºF was used because these are interior spaces and the supply air temperature will be between 60º and 63ºF.

$$CFM = (11.7/(1.085 \times 77 – 63) = 0.77\ cfm / ft^2$$

In this calculation, we are accounting for thermal decay, so a supply air temperature of 63ºF was used.

$$CFM = (11.7/(1.085 \times 77 – 65) = 0.90\ cfm / ft^2$$

In this calculation, a supply air temperature of 65ºF was used to indicate the CFM requirements at an elevated temperature, to accommodate extended use of airside economizer. Using this method to calculate the number of terminals to use will result in an increased number of terminals, but the air handling system would only supply the increased CFM when operating in extended economizer mode.

In comparing the interior airflows to a traditional overhead design,

$$CFM = (15.8/(1.085 \times 75 – 55) = 0.73\ cfm / ft^2$$

The airflow requirements are nearly equal (depending on the proximity to the point of supply air discharge into the plenum).

Skin Loads — CFM = BTU/(1.085 x T)

$$CFM = (206/(1.085 \times 77 – 63) = 13.6\ cfm / lf$$

In this calculation, we are again accounting for thermal decay, so a supply air temperature of 63ºF was used.

In comparing the building skin airflows to a traditional overhead design,

$$CFM = (345/(1.085 \times 75 – 55) = 15.9\ cfm / lf$$

In this case, the airflow requirements for the FlexSys™ system are approximately 14% less than for a traditional overhead system.

Perimeter zones are typically 12–16 feet deep. A good rule of thumb is to multiply the height of the exterior wall by 1.5 for an all glass façade. The cooling requirements for a perimeter zone include the ‘interior loads’ (people, lights and small power), as well as the skin loads. We will calculate the perimeter zone airflows based on a linear foot of perimeter. A 14-foot deep perimeter zone would then have 1 linear foot of skin and 14 square feet of floor space. Calculating the CFM requirements for the perimeter zone:

$$1\ linear\ foot\ of\ skin\ @\ 13.6\ cfm / lf + 14ft^2\ @\ 0.77\ cfm/ft^2 = 24.4\ CFM / lf$$

Perimeter zones are normally laid out using pairs of MIT terminals. One would be placed at the building skin (in the first full floor panel), and the other would be placed at the interior boundary of the perimeter zone. MIT terminals are rated at 150 CFM each, so a pair delivers 300 CFM. To find the spacing of the pairs of terminals, divide 300 cfm/pair by the airflow requirement.

300 cfm/pair / 24.4 cfm/lf = 12.3 lf

In this case we would space the pairs every 12 feet around the perimeter.

Calculating the number of interior, cooling only terminals is simply a matter of multiplying the cfm/ft2 calculated above by the square footage of the interior area, and then dividing by 150 CFM/MIT box.

If the interior space was 10,000 ft^2,

$$10{,}000\ ft^2 x0.7\ cfm/ft^2 = 7{,}000\ cfm\ total/150\ cfm/terminal = 47\ MIT\ terminals$$

The initial layout of the interior terminals should be made on an even grid. In the above example, one MIT terminal would serve an area of approximately 210 square feet. This would equate to a grid of 14 feet on center. As the design of the facility progresses, and the furniture layout is completed, the grid may need to shift to accommodate furniture, and may become 12' x 16' for example.

YORK does not recommend placing an MIT terminal in every workstation, unless the load in the space warrants this. Generally the terminals should be placed in the aisles between the workstations, where one terminal may serve 2–3 workstations or approximately 200–225 sq. ft. for interior zones. In some situations, an owner or designer may want to place a terminal in each workstation. In this case a half size terminal should be used.

PERIMETER HEATING LOADS

Perimeter heating loads are calculated by adding up the skin heating loads, the heat conducted through the raised access floor in the perimeter zone, and any minimum ventilation heating load. These heating requirements are then divided by the total length of the perimeter, yielding a Btu/linear foot value. Using the same cfm calculation, we can find the cfm per linear foot required for heating. YORK recommends sizing the heating coils based on a 40ºF temperature difference, although the designer can adjust this temperature difference.

Additional heat may be needed to accommodate roof losses and/or night setback.

The heating load includes the skin heating loads, the floor-cooling effect, the ventilation requirement, and morning warm-up (typically 5 degrees or less). If the total heating requirement on the MFT was 550 Btu/lf, then:

CFM = BTU/(1.085 x T)

CFM = (550/(1.085 x 40) = 12.7 cfm / lf

The MIT terminal spacing was set above at 12' on center, so in heating mode, each terminal located at the building skin will deliver approximately 150 cfm each and the corresponding return terminal will return 150 cfm. In this case, an MFT-A will cover 12 linear feet of skin, an MFT-B will cover 24 linear feet of skin and an MFT-C will cover 48 linear feet of skin.

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