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TECHNICAL REPORT

Heat-Loss Calculations for an Air Handling Assembly

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A handwritten signature in black ink that reads 'Michael Joyce'.

Michael Joyce, PE
President

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Testing Laboratory TL-566

Heat-Loss Calculations for an Air Handling Assembly

1.0 Background

Heat-loss calculations and the overall temperature drop for air moving through a duct assembly have been calculated for the assembly pictured in the attachment. The various sections of the assembly are numbered from 1-16. The sections were grouped into eight sections (A-H) since the duct size and air flow rate were the same. Group A, for example, included sections 1-7. The air entering the assembly at section 1 was at temperature 29 °C. The air outside the assembly was taken to be 22 °C. These boundary conditions were taken to be constant, so the result is an upperbound on the anticipated final interior air temperature (outlet of section 16).

2.0 Systems Evaluated

Heat loss and air-temperature drop has been evaluated for two cases. The duct insulation for the first assembly is a layer of 8 mm thick insulation with exterior surface faced with material having emittance 0.03 and interior surface faced with a material having emittance 0.9. The material was installed around the cylindrical duct with 34 mm spacer material to form a non-reflective enclosed air space between the exterior duct surface and the duct insulation. The duct insulation for the second assembly differed from the first assembly by having low emittance facers on both sides of the 8 mm thick insulation. Assemble two as a result was surrounded by an 8 mm thick enclosed reflective air space. The thermal resistance of the duct insulation assembly one was $0.335 \text{ m}^2 \cdot \text{K/W}$ (R-value $1.9 \text{ ft}^2 \cdot \text{h} \cdot ^\circ\text{F}/\text{BTU}$). The thermal resistance of the duct insulation assembly two was $0.739 \text{ m}^2 \cdot \text{K/W}$ (R-value $4.2 \text{ ft}^2 \cdot \text{h} \cdot ^\circ\text{F}/\text{BTU}$).

3.0 Calculation of Heat Loss

The heat losses from the regions A-H were calculated using the computer program 3E+ developed by the North American Insulation Manufacturers Association (NAIMA). Output from 3E+ was used to develop correlations between the duct diameter and the heat loss per hour for each group of sections for the two insulation assemblies. The temperature drops of the internal air for each group of sections was calculated by equating the calculated heat loss to the change in enthalpy of the air (a quantity that includes the temperature of the air). The air properties assumed for this calculation were $P=1.1$ atmosphere and $T=29$ °C. Table 1 shows how the sections were assigned to groups. Table 2 shows the calculated heat loss and air temperature drop for each group. The total calculated heat loss and air temperature drop for the entire system is also shown.

Table 1: The Duct Sections Assigned to Each Group

Group	Sections
A	1-7
B	8
C	9
D	10-11
E	12
F	13
G	14
H	15-16

Table 2: Calculated Heat Loss and Air-Temperature Drop for Each Group

Insulation Assembly 1					
Group	Duct Diameter (m)	Length (m)	Heat Loss (Watts)	Air (m ³ /h)	Air ΔT (°C)
A	0.630	14.347	312.086	3720	0.257
B	0.630	2.738	59.341	2920	0.062
C	0.630	0.2070	4.503	1350	0.010
D	0.400	6.655	92.248	1350	0.209
E	0.315	5.182	58.203	900	0.198
F	0.250	5.100	46.210	450	0.314
G	0.250	3.329	30.163	300	0.308
H	0.200	5.984	44.226	150	0.902
Total			647		2.3

Insulation Assembly 2					
Group	Duct Diameter (m)	Length (m)	Heat Loss (Watts)	Air (m ³ /h)	Air ΔT (°C)
A	0.630	14.347	171.369	3720	0.141
B	0.630	2.738	32.585	2920	0.034
C	0.630	0.2070	2.473	1350	0.006
D	0.400	6.655	52.976	1350	0.120
E	0.315	5.182	34.474	900	0.117
F	0.250	5.100	28.359	450	0.193
G	0.250	3.329	18.511	300	0.189
H	0.200	5.984	28.248	150	0.576
Total			369		1.4

4.0 Conclusion

The heat loss for insulation assembly one for the conditions stated is 647 watts that results in an interior air-temperature temperature drop of 2.3 °C. The heat loss for insulation assembly two for the conditions stated is 369 watts that results in an interior air-temperature temperature drop of 1.4 °C.

David W. Yarbrough

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July 3, 2024

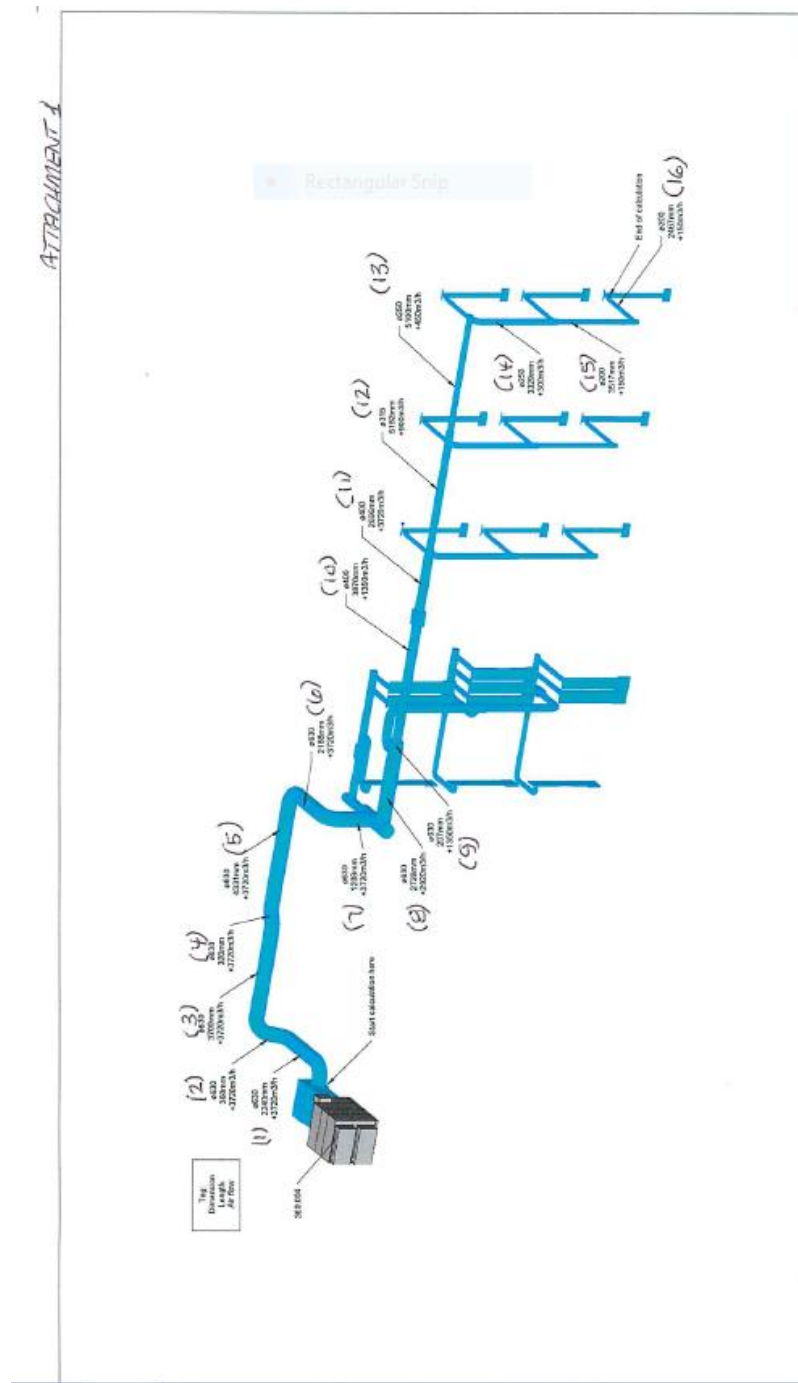


Figure 1. Attachment