Appendix H
Helpful Formulas

Computing Flow from BTU/h	
Simplified formula	GPM = BTU/h ÷ (Δt x 500)
Example: Determine the flow of 286,000 BTU/h at a 20°F differential temperature.	GPM = 286,000 ÷ (20 x 500) GPM = 286,000 ÷ 10,000 GPM = 28.6

Calculating Active Loop Length	
Note: The leader length must be added to the active loop length in order to obtain the total loop length.	Room ft^2 x 1.0 = active loop at 12" o.c. Room ft^2 x 1.2 = active loop at 10" o.c. Room ft^2 x 1.33 = active loop at 9" o.c. Room ft^2 x 1.5 = active loop at 8" o.c. Room ft^2 x 1.7 = active loop at 7" o.c. Room ft^2 x 2.0 = active loop at 6" o.c.

Amount of Joist Trak™ Panels (A5080375, A5080500)

Active loop length x 0.2125

Amount of Quik Trak® Panels (A5060701) and Returns (A5060702)

Room ft^2 x 0.386 (panels)
Room ft^2 x 0.043 (returns)

Amount of PEX Clips (F7060375, F7051258, F7057500, F7051001)

Active Loop Length ÷ 3

Floor Surface Temperature

(BTU/h/ft^2 ÷ 2.0) + Room setpoint

Supply Fluid Temp. After First Injection Point on Primary Loop

$(F_A \times T_A) + (F_B \times T_B) = (F_C \times T_C)$

F_A = Primary flow rate after injection leg
F_B = Flow rate for return injection leg
F_C = Primary flow rate after return leg
T_A = Primary temp. after injection leg
T_B = Return temp. on return injection leg
T_C = Primary temp. after return leg

Example: Given the detail above, calculate the primary loop (boiler loop) temperature after the first injection location.	(7 x 180) + (3 x 160) = 10x 1260 + 480 = 10x 1740 = 10x 174 = x The primary loop temperature after the first injection location is 174°F.

Injection Pump Flow Rates

Refer to **Appendix I** for more information
$F_V = (F_1 \times T_D) \div (T_1 - T_R)$

F_V = Flow rate (injection loop) in gpm
F_1 = Radiant (secondary loop) flow rate in gpm
T_1 = Boiler (primary loop) supply temp.
T_2 = Radiant (secondary loop) supply temp.
T_R = Radiant (secondary loop) return temp.
T_D = Radiant (secondary loop) differential temp.

Example: If values at design condition are: F_1 = 30 gpm T_1 = 180°F T_2 = 130°F T_R = 120°F T_D = 10°F	Find the injection pump flow rate. $F_V = (30 \times 10) \div (180\text{-}120)$ $F_V = (300) \div (60)$ F_V = 5 gpm

Loading for Motorized Valve Actuators (MVA)
Computed at a minimum 10% line loss

MVA draw: 0.29 amps
Amps x volts = current
0.29 x 24 = 6.96 VA per MVA

Example:
50 VA ÷ 6.96 VA = 7.18 x 0.9 = 6.5 (10%)
6 MVA per 50 VA transformer
40VAC transformer = 5 MVA
50VAC transformer = 6 MVA
75VAC transformer = 9 MVA
100VAC transformer = 12 MVA

Loadng for Thermal Actuators (TA)
Computed at a minimum 10% line loss

TA initial draw: 0.1458 amps
Amps x volts = current
0.1458 x 24 = 3.5 VA per TA

Example:
50 VA ÷ 3.5 VA = 14.29
14.29 x 0.9 = 12.83 (10% reduction)
12 TAs per 50 VA transformer
40VAC transformer = 10 TA
50VAC transformer = 12 TA
75VAC transformer = 19 TA
100VAC transformer = 25 TA

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Appendix H
Helpful Formulas

Continued...

Loadng for Thermal Actuators (TA) Computed at a minimum 10% line loss

Fuel consumption based on degree day:

$$F = \frac{HL \times 24 \times DD}{E \times P \times TD}$$

HL = Heating load (BTU/h)

24 = Hours in a day

DD = Degree day

E = Boiler efficiency (AFUE)

P = Heating value of fuel (BTU)

TD = Temperature differential

F = Annual fuel consumption

Example: A 40,000-square-foot hangar in Bangor, Maine using an 82% AFUE oil boiler (Number 2 fuel oil). The heat load for the hangar is 1,288,128 BTU/h at design. Outside design temperature is -11°F with an indoor setpoint temperature of 65°F. Number 2 fuel oil is priced at $0.80 per gallon.

$$F = \frac{1{,}288{,}128 \times 24 \times 8{,}220}{0.82 \times 138{,}000 \times 76}$$

$$F = \frac{254{,}121{,}891.840}{8{,}662{,}480}$$

F = 29,335.93 gallons of fuel oil

F = 29,335.93 x 0.80 = $23,469/season

Fuel Comparison in BTU

Natural Gas	100,000 BTU per 1 CCF (1 therm.)
Propane	91,800 BTU per gallon
No. 2 Fuel Oil	139,000 BTU per gallon
Kerosene	134,000 BTU per gallon
Electric	3,412 BTU per Kilowatt Hour (KWH)
Wood	14,000,000 BTU per cord (mixed)

Supply and Return Pipe Sizing (at a 10ºF Δt)

Tubing	BTU/h	GPM	Pipe Size (in.)
Copper	10K – 20K	2 – 4	¾"
	20K – 45K	4 – 9	1"
	30K – 80K	6 – 16	1¼"
	50K – 105K	10 – 21	1½
	100K – 225K	20 – 45	2""
Multi-layer Composite (MLC)	10K – 20K	2 – 4	¾"
	20K – 45K	4 – 8	1"
PEX (Wirsbo hePEX™ and Uponor AquaPEX®)	2.5K – 10K	0.5 – 2	½"
	5K – 15K	1 – 3	¾"
	15K – 25K	3 – 5	1"
	20K – 45K	4 – 9	1¼"
	30K – 70K	6 – 14	1½
High-density Polyethylene (HDPE)	75K – 205K	15 – 41	2"
	150K – 575K	30 – 115	3"
	250K – 1,125K	50 – 225	4"

Boiler Main Pipe Sizing (at a 20ºF Δt)

Tubing	BTU/h	GPM	Pipe Size (in.)
Copper	20K – 40K	2 – 4	¾"
	40K – 90K	4 – 9	1"
	60K – 160K	6 – 16	1¼"
	100K – 210K	10 – 21	1½"
	200K – 450K	20 – 45	2"