Mechanical Breadth

Introduction

Due to the addition and deletion of several transformers in each electrical room, I will be resizing the required cfm and all associated ductwork and VAV boxes. Although not detailed here, this should save the hospital money by decreasing the duct sizes and VAV boxes in most cases.

Goal

I will determine the impact Alternate 1 of the Electrical Depth has on the mechanical system in all four electrical rooms of the North Addition.

Assumptions

- 2% energy loss for all transformers
- Design for duct loss of 0.10 friction/100ft
- Use round duct 6" or below when possible
- Design temperature for room is 75° F
- Inlet temperature is 55° F
- All VAV boxes are DESV (digital control)
- Power Factor = 0.90

Calculations

Using the equation for sensible heat:

$$\mathbf{Q = 1.08 * CFM * \Delta T}$$

I determined the sensible heat gain for each transformer as shown in the table below:

Heat Gain Calculations				
Room	Transformer			Heat Gain
	Designation	Size (KVA)	Gain (W)	(BTU-hr)
Elec. Rm - 1st Floor	T-1	45	810	2764
	T-5	15	270	921
	T-9	45	810	2764
	T-11	75	1350	4606
Elec. Rm - 2nd Floor	T-2	45	810	2764
	T-6	15	270	921
	T-L	225	4050	13819
Elec. Rm - 3rd Floor	T-3	45	810	2764
	T-7	15	270	921
	T-8	30	540	1843
Elec. Rm - 4th Floor	T-4	45	810	2764

- denotes deleted transformer (green)
- denotes added transformer (yellow)

From that information, I could determine the new CFM required in each room and compare the results to the designed CFM:

CFM Calculations				
Room	Initial		Corrected	
	Sensible Load (BTU-hr)	CFM	Sensible Load (BTU- hr)	CFM
Elec. Rm - 1st Floor	11055	215	921	45
Elec. Rm - 2nd Floor	3685	215	14740	650
Elec. Rm - 3rd Floor	5528	95	2764	145
Elec. Rm - 4th Floor	2764	145	0	*45

* Room will be designed for 45 CFM since anticipated growth will require an additional emergency transformer on that floor (it is currently a shell and not fit-out for its desired use at the present time).

From the Leach Wallace standards and Titus Catalog for VAV box design, the following size VAV boxes are typically specified with the characteristics shown:

Size 4 box: 0-100 CFM max
45 CFM min
Size 5 box: 100-300 CFM max
65 CFM min
Size 6 box: 300 – 650 CFM max
105 CFM min

VAV Box Sizing				
Room	CFM	Box Size	Air Flow	
			Max	Min
Elec. Rm - 1st Floor	45	4	100	*0
Elec. Rm - 2nd Floor	650	6	650	*0
Elec. Rm - 3rd Floor	145	5	145	*0
Elec. Rm - 4th Floor	45	4	100	*0

* All VAV boxes are specified as 0 shut-off

To size the duct, I used TRANE Company Commercial Application "Ductulator". The Ductulator gave me an air flow rate and size of duct when friction loss (stated above in the assumptions) and max CFM are input. The following table summarizes the duct sizing:

Duct Sizing			
Room	CFM	Duct Size	Air Speed* (ft/min)
Elec. Rm - 1st Floor	45	4" Φ	550
Elec. Rm - 2nd Floor	650	12"x10"	850
Elec. Rm - 3rd Floor	145	6" Φ	650
Elec. Rm - 4th Floor	45	4" Φ	550

* 500-900 ft/min is typically a safe range for air speed, but this value can vary depending on the size of the duct (the larger the duct, the faster tolerable air speed).

Conclusions

The mechanical redesign seems to be an overall success. Only one VAV box and associated ductwork needed to be upsized to accommodate for the addition of the 225 KVA transformer in the 2nd floor electrical room. The rest of the VAV boxes were downsized as well as their associated supply and return air ducts. However, I do not expect much of a savings with this change due to the shear magnitude of the project compared to this small analysis.