

- Benner Pike Shops
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### **Analysis #3 – HVAC Units Reconfiguration**

#### *Overview*

The existing HVAC units located on the rooftop of the Benner Pike Shops are distributed with too many in quantity. Some of the stores have more than five HVAC units with its capacity ranging from 1000 to 3000 lbs. Having too many HVAC units would draw issues on maintenance, and equipment installation. Since the front of the shops is exposed to outside with its glass show window and doors, separate HVAC systems should be integrated between front and back of each store. The main idea is to have a small HVAC unit in the front and larger units in the back for each store. This will definitely decrease cost in equipments and labor, and also possible shortening in total duration of the project.

This analysis will focus on two large shops in the Benner Pike Shops; Bed Bath & Beyond and Ross Dress For Less. Based on current roof plans, Bed Bath has total of six HVAC units and Ross has seven of them. Since the shops have glass wall in their front entrance, they need to have two different controls for their HVAC system. Because of the large heat loss due to glass wall, it could be necessary for the shops to heat the front area while cooling the inner portions.

Since all of the existing rooftop units were provided by Lennox International Inc., it is better to have the redesigned products provided by the same company. The units are packaged air handling systems, and newly designed units will produce the same performance as the previous units.

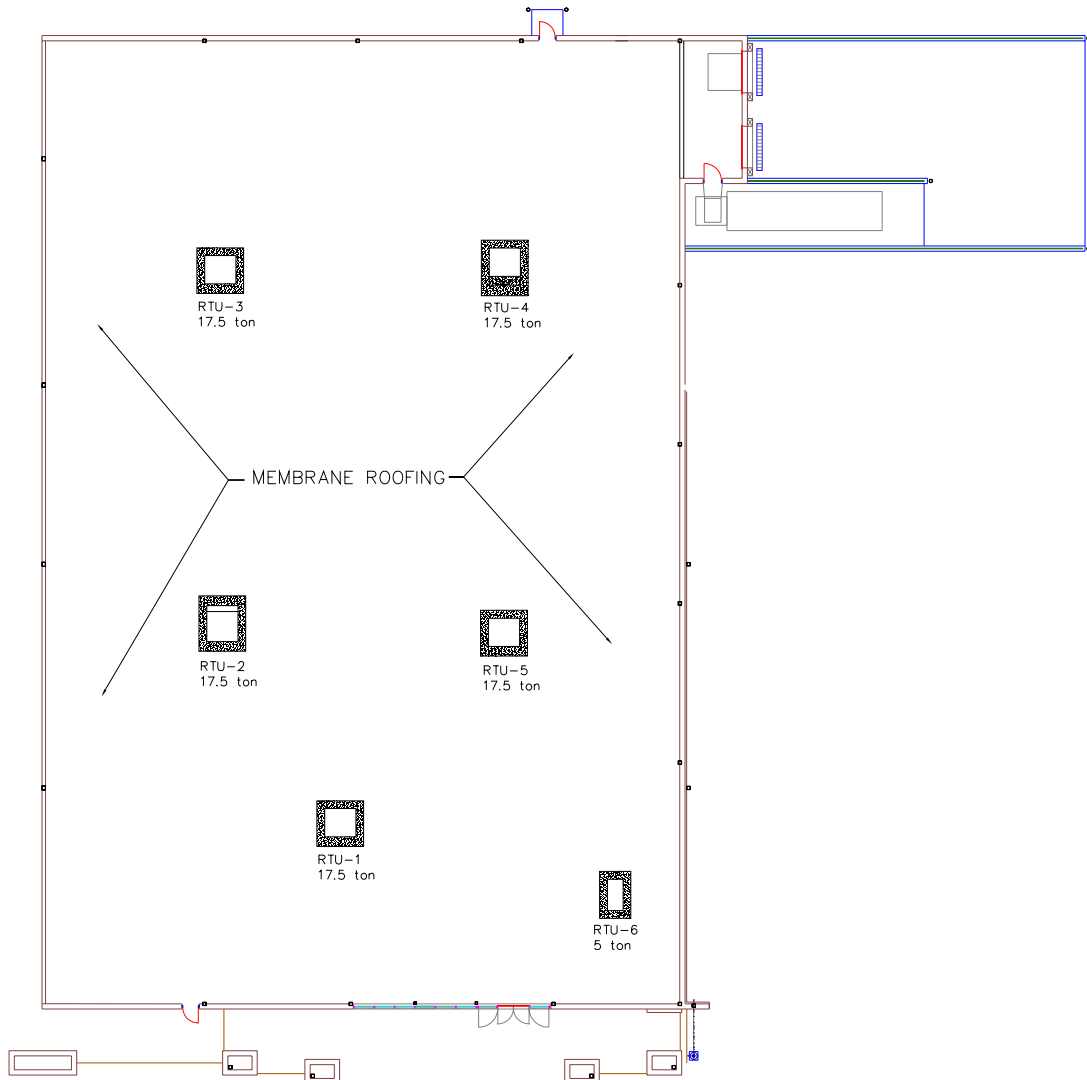
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## Bed Bath & Beyond

For Bed Bath, roof top units for the front and the office area will have no change. Four backside units will be combined into two large units. Since the store has rectangular shape and has its back wall exposed to the outside, it is more efficient to place two large units in the center of the shop. Also, the existing ductwork could be kept without any major modification.

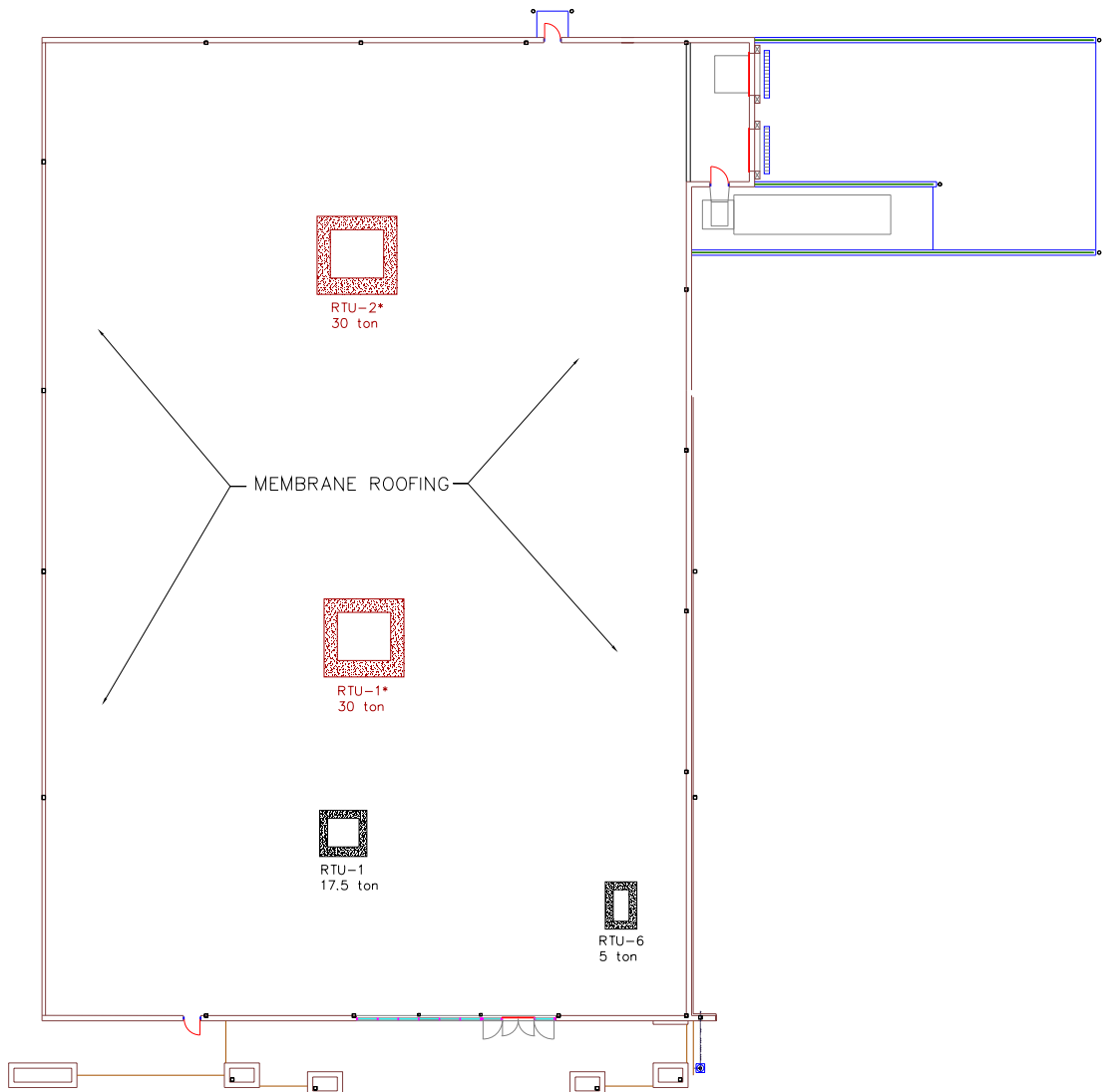
Existing Roof Plan



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Modified Roof Plan



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### Capacity Comparison

ID	Manufacturer	Area Served	Cooling Data				Heating Input				Air Flow Range			Physical Data	
			Nominal Ton	Gross Cap	Net Cap (Btuh)	ARI Rated CFM	Low	Standard	Medium	High	CFM Min. Cool	CFM Min. Heat	CFM Max.	Dim. HxWxD (in)	Weight (lbs)
<b>Existing units to be kept</b>															
RTU-1	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-6	Lennox	Office	5	63,000	60,000	2,000	-	78,000	-	125,000	1,400	1,050-1,320	2,400	37x45x86	860
<b>Combination of the existing units</b>															
RTU-2	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-5	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-1*	Lennox	Retail	30	351,000	336,000	10,500	-	260,000	360,000	480,000	8,400	4,815-7,110	14,400	65x81x145	3,340
RTU-3	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-4	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-2*	Lennox	Retail	30	351,000	336,000	10,500	-	260,000	360,000	480,000	8,400	4,815-7,110	14,400	65x81x145	3,340

It is obvious that redesigned unit has less capacity in ton than the previous two units (17.5+17.5>30). It is still acceptable to have smaller nominal tons. Following load calculations show that redesigned units are suitable to cover the space.

Since the shop has medium condition for density of people,  $1.3 \frac{CFM}{ft^2}$  is needed.

$$\text{Area} = (122\text{ft})(185\text{ft}) = 22,570 \text{ ft}^2$$

$$\text{CFM needed in the space} = 22,570 \text{ ft}^2 \cdot 1.3 \frac{CFM}{ft^2} = 29,341 \text{ CFM}$$

$$\text{Total CFM in Units} = 6,600 + 2,000 + 10,500 + 10,500 = 29,600 \text{ CFM}$$

Since the total CFM in units fall under 5% range of CFM needed in the space, the redesigned units are acceptable for the shop.

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Load Bearing Roof Slab

Based on the joist catalog from Vulcraft, load capacity for the roof joists was calculated to match the weights of each HVAC unit. Minor load increase in the units did not affect roof slab for any critical failure. Allowable loads are calculated by multiplying units' dimension with the load capacity given in the catalog.

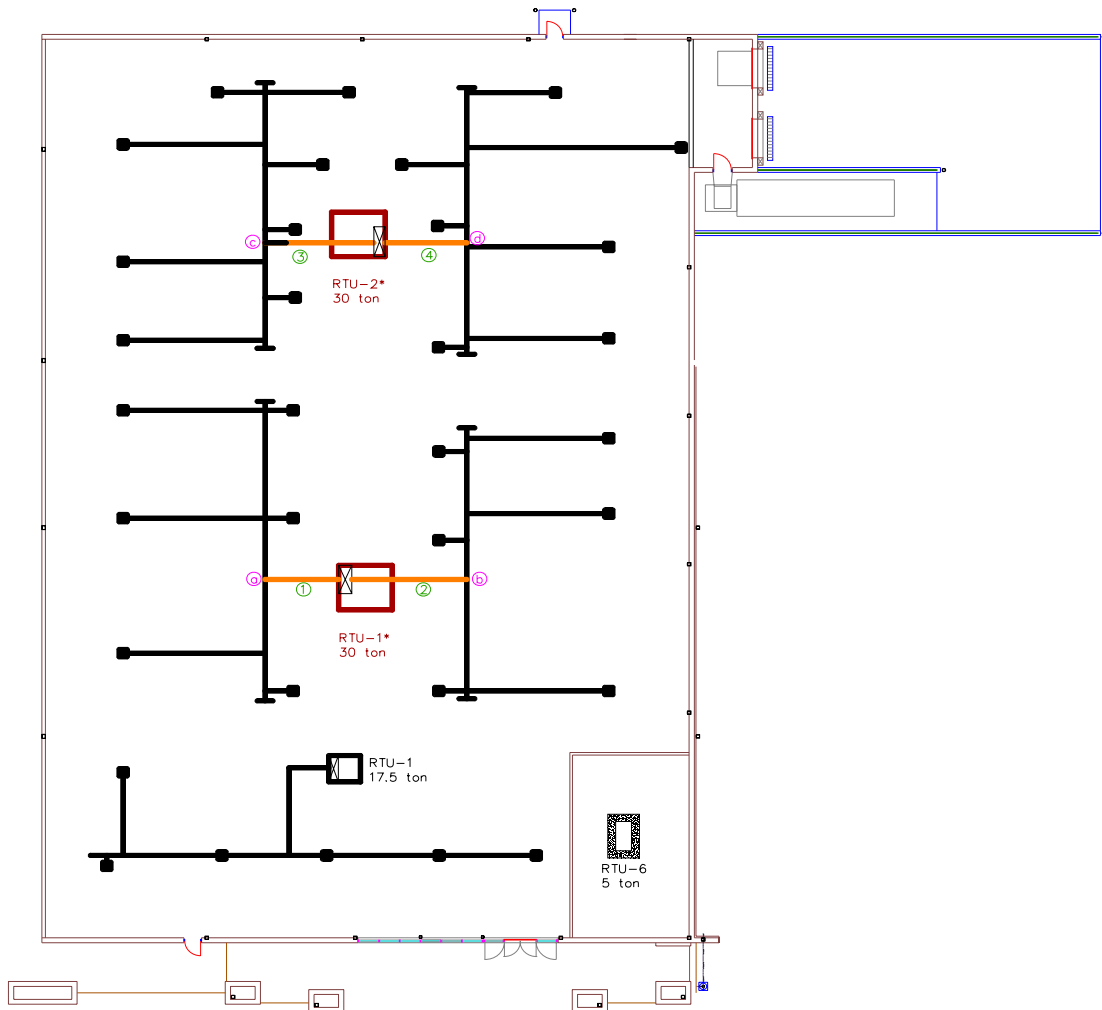
ID	Dim. HxWxD (in)	Dim. in ft	Joist type	Span (ft)	Load Capacity (lb/ft)	Allowable load (lb)	Actual load (lb)
<b>Existing Units</b>							
RTU-1	55x91x133	4.5x7.5x11	28K10	12	550	45,375	2,685
RTU-6	37x45x86	3x3.5x7	28K10	12	550	13,475	860
<b>Modified Units</b>							
RTU-1*	65x81x145	5.5x7.5x12	22K4	12	550	49,500	3,340
RTU-2*	65x81x145	5.5x7.5x12	22K4	12	550	49,500	3,340

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Ductwork Modification

Most portion of the existing ductwork plan can be used with the newly designed HVAC units. Only a major duct stem is needed to be designed for each unit in order to serve the space with the existing ductwork system. In the following drawing, existing ducts are shown in black and new ducts in orange. Each duct and duct accessory are numbered to be taken off for cost estimate.



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Cost Estimate

Description	Size	Quantity	Unit	Unit Cost			Total Cost
				Material	Labor	Equipment	
<b>Existing System</b>							
Rooftop HVAC	17.5 ton cooling, 330KBtuh	5	each	13,495.00	1,717.00		\$76,060
	5 ton cooling, 112KBtuh	1	each	4,050.00	1,050.00		\$5,100
Crane Rental	120 ton hydraulic	1	each				\$7,550
<b>TOTAL</b>							<b>\$88,710</b>
<b>Modified System</b>							
Rooftop HVAC	30 ton cooling, 540KBtuh	2	each	24,600.00	2,675.00		\$54,550
	17.5 ton cooling, 330KBtuh	1	each	13,495.00	1,717.00		\$15,212
	5 ton cooling, 112KBtuh	1	each	4,050.00	1,050.00		\$5,100
Crane Rental	120 ton hydraulic	1	each				\$7,550
Additional Ductwork	Galvanized steel, 1,000 to 2,000	1204	lbs	0.38	2.97		\$4,033
Turning Vane	Double thick, 14" high set	8	L.F.	6.40	1.76		\$65
<b>TOTAL</b>							<b>\$86,511</b>

All of the cost was calculated based on RS Means. Crane rental cost came out to be the same since the rental is executed on a weekly base. Take off for duct system is given below and calculation for its weight is based on RS Means (refer to the Appendix). Only additional duct system was estimated for cost because the modified system uses the previous duct system.

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Duct No.	Description	Duct Size (in x in)	Quantity	Length (ft)	Weight (lbs)
	1	60 x 14	1	10	215
	2	60 x 14	1	18	387
	3	60 x 14	1	17	365.5
	4	60 x 14	1	11	236.5
total				56	1204
Turning Vane	a	14" high set	1	2	
	b	14" high set	1	2	
	c	14" high set	1	2	
	d	14" high set	1	2	

\*\* according to RS Means reference table, for 60 x 14 duct, the weight is 21.5 lbs per foot

### Crane Configuration

Through out the entire project, only one crane rental was performed for a week. 120 ton mobile crane was used for a week just to erect the existing rooftop HVAC units. The crane has enough capacity to hold the newly designed HVAC units. Therefore, there is no need for any change in crane configuration. General conditions estimate for crane rental will stay the same since the rental is performed on weekly basis. Delivered units will stage in the open area near the shop and erected starting from the back of the store.



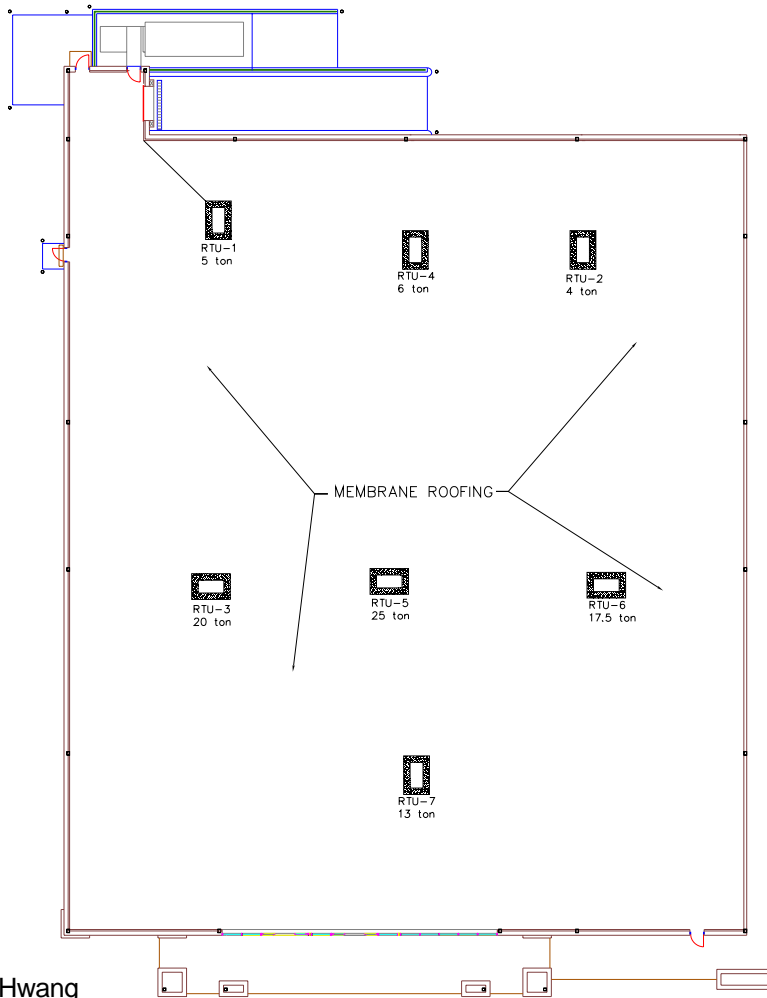
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## Ross Dress For Less

Ross Dress For Less one main retail store area and a much smaller space for storage and office purpose. The center HVAC unit will remain the same since it is the largest and it covers large portion of the store. Just like the Bed, Bath & Beyond, front of the shop is needed to be considered as separate space for heat loss due to window wall in the front. Front unit is replaced with slightly larger unit to cover the stockroom that is located at the side of the front portion. With the current center unit and the modified front unit, two symmetrical large units are redesigned to serve the store uniformly. Those two units are two equal systems with the same capacity.

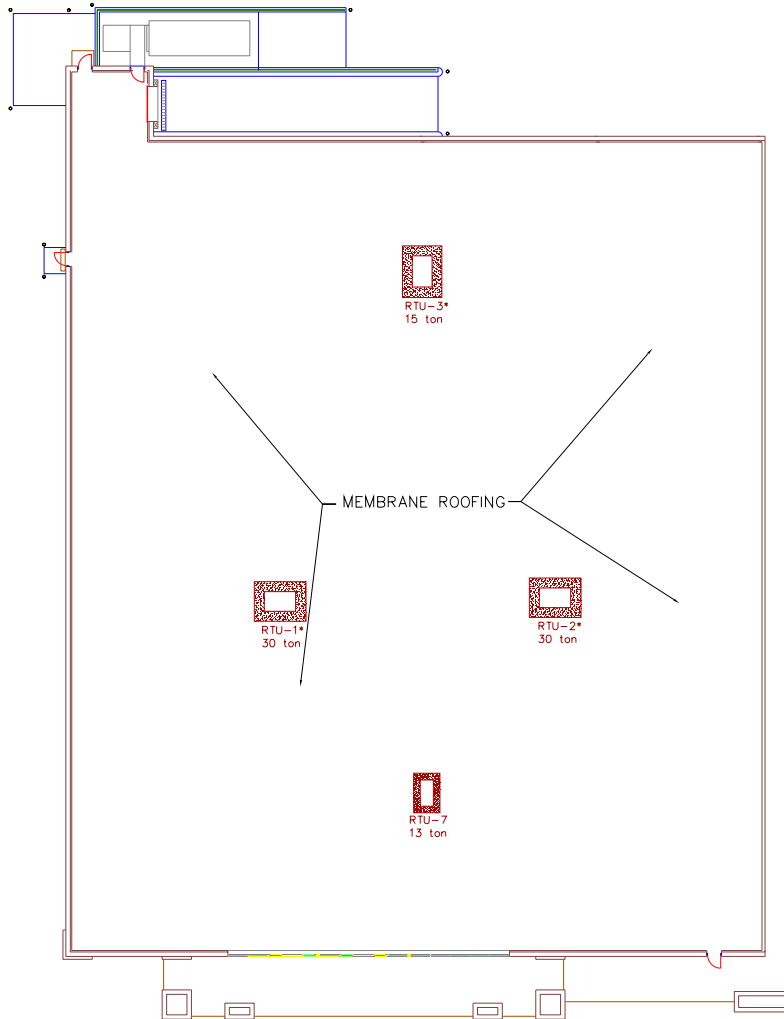
Existing Roof Plan



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Modified Roof Plan



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### Capacity Comparison

ID	Manufacturer	Area Served	Cooling Data				Heating Input				Air Flow Range			Physical Data	
			Nominal Ton	Gross Cap (Btuh)	Net Cap (Btuh)	ARI Rated CFM	Low	Standard	Medium	High	CFM Min. Cool	CFM Min. Heat	CFM Max.	Dim. HxWxD (in)	Weight (lbs)
Existing units to be kept															
RTU-7	Lennox	Retail	13	160,000	156,000	5,100	169,000	260,000	360,000	-	3,640	2,780-4,445	6,240	55x91x133	2,555
Combination of the existing units															
RTU-5	Lennox	Retail	25	311,000	300,000	9,500	-	260,000	360,000	480,000	7,000	2,780-7,110	12,000	65x91x145	3,340
RTU-3	Lennox	Retail	20	252,000	242,000	7,500	-	260,000	360,000	480,000	5,600	2,780-5,080	9,600	55x91x133	2,735
RTU-6	Lennox	Retail	17.5	218,000	210,000	6,600	169,000	260,000	360,000	480,000	4,900	2,780-5,080	8,400	55x91x133	2,685
RTU-1*	Lennox	Retail	30	351,000	336,000	10,500	-	260,000	360,000	480,000	8,400	4,815-7,110	14,400	65x91x145	3,340
RTU-2*	Lennox	Retail	30	351,000	336,000	10,500	-	260,000	360,000	480,000	8,400	4,815-7,110	14,400	65x91x145	3,340
RTU-1	Lennox	Retail	5	63,000	60,000	2,000	-	78,000	-	125,000	1,400	1,050-1,320	2,400	37x45x86	860
RTU-2	Lennox	Office	4	50,500	48,000	1,450	-	78,000	-	125,000	1,120	1,050-1,320	1,920	37x45x86	850
RTU-4	Lennox	Office	6	74,000	71,000	2,100	-	78,000	-	125,000	1,680	1,050-1,320	2,880	37x45x86	885
RTU-3*	Lennox	Office	15	188,000	182,000	5,700	169,000	260,000	360,000	480,000	4,200	2,780-5,080	7,200	55x91x133	2,685

It is obvious that redesigned units have smaller total capacity than the previous units (17.5+13>17.5). It is still acceptable to have smaller nominal tons. Following load calculations show that redesigned units are suitable to cover the space.

Since the shop has medium condition for density of people,  $1.3 \frac{CFM}{ft^2}$  is needed.

$$\text{Area} = (157ft)(162ft) = 24,624 \text{ ft}^2$$

$$\text{CFM needed in the space} = 24,624 \text{ ft}^2 \cdot 1.3 \frac{CFM}{ft^2} = 32011 \text{ CFM}$$

$$\text{Total CFM in Units} = 5,100 + 10,500 + 10,500 + 5,700 = 31,800 \text{ CFM}$$

Since the total CFM in units fall under 5% range of CFM needed in the space, the redesigned units are acceptable for the shop.

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### Load Bearing Roof Slab

Like Bed, Bath & Beyond, the roof framing for Ross Dress For Less is based on the joist catalog from Vulcraft. Load capacity for the roof joists was calculated to match the weights of each HVAC unit. Minor load increase in the units did not affect roof slab for any critical failure. Allowable loads are calculated by multiplying units' dimension with the load capacity given in the catalog.

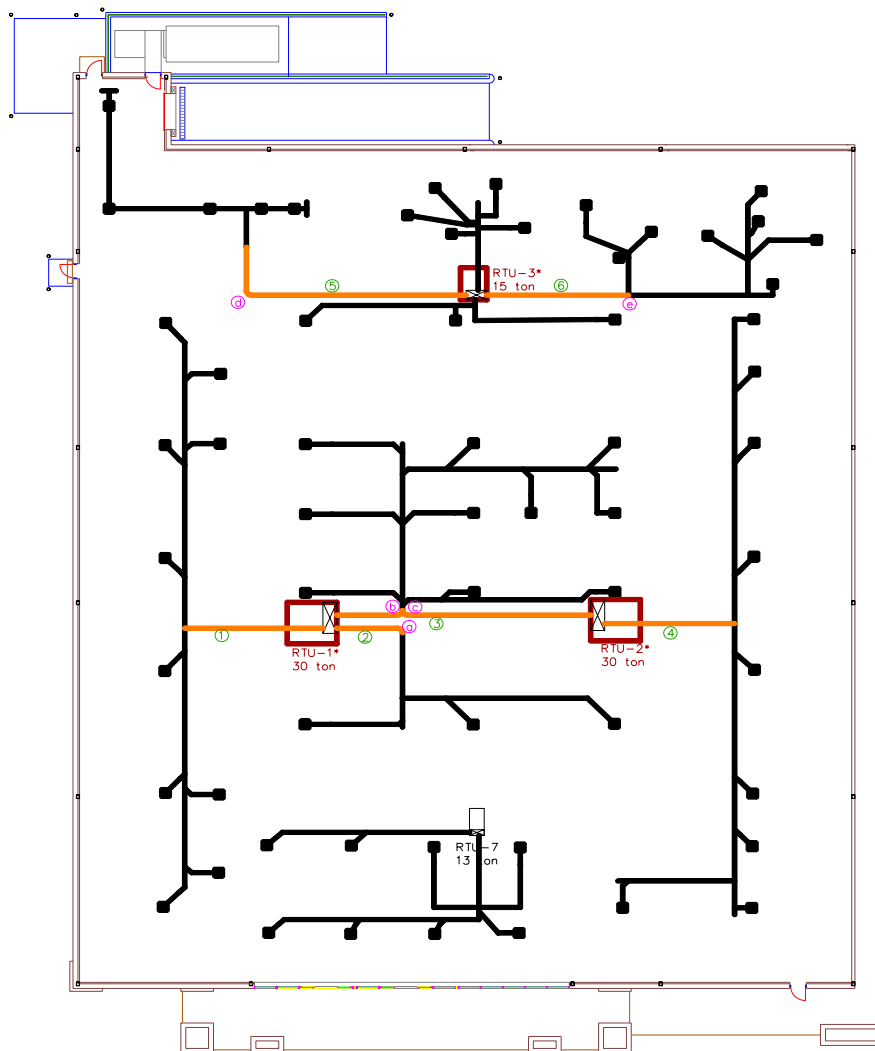
ID	Dim. HxWxD (in)	Dim. in ft	Joist type	Span (ft)	Load Capacity (lb/ft)	Allowable load (lb)	Actual load (lb)
<b>Existing Units</b>							
RTU-7	55x91x133	4.5x7.5x11	26K9	16	550	45,375	2,555
<b>Modified Units</b>							
RTU-1*	65x91x145	5.5x7.5x12	28K10	16	550	49,500	3,340
RTU-2*	65x91x145	5.5x7.5x12	22K7	16	550	49,500	3,340
RTU-3*	55x91x133	4.5x7.5x11	22K7	16	550	45,375	2,685

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Ductwork Modification

Several ductwork systems will be modified based on the existing plan. It is designed so that the reorganized HVAC system serves the store just the same as the previous system. Existing ductwork system could be recycled to fit the new HVAC units in order to minimize any additional cost in ductwork system. In the following drawing, existing ducts are shown in black and new ducts in orange. Each duct and duct accessory are numbered to be taken off for cost estimate.



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Cost Estimate

Description	Size	Quantity	Unit	Unit Cost			Total Cost
				Material	Labor	Equipment	
<b>Existing System</b>							
Rooftop HVAC	25 ton cooling, 450KBtuh	1	each	19,500.00	2,250.00		\$21,750
	20 ton cooling, 360KBtuh	1	each	15,800.00	1,875.00		\$17,675
	17.5 ton cooling, 330KBtuh	1	each	13,495.00	1,717.00		\$15,212
	13 ton cooling, 230KBtuh	1	each	9,255.00	1,483.00		\$10,738
	6 ton cooling, 140KBtuh	1	each	4,750.00	1,125.00		\$5,875
	5 ton cooling, 112KBtuh	1	each	4,050.00	1,050.00		\$5,100
	4 ton cooling, 95KBtuh	1	each	3,700.00	975.00		\$4,675
Crane Rental	weekly rental covered in Bed, Bath & Beyond						
<b>TOTAL</b>							<b>\$81,025</b>
<b>Modified System</b>							
Rooftop HVAC	25 ton cooling, 450KBtuh	2	each	19,500.00	2,250.00		\$43,500
	17.5 ton cooling, 330KBtuh	2	each	13,495.00	1,717.00		\$30,424
Crane Rental	weekly rental covered in Bed, Bath & Beyond						
Additional Ductwork	Galvanized steel, 1,000 to 2,000 lb	1716.7	lbs	0.38	2.97		\$5,751
Turning Vane	Double thick, 14" high set	13	L.F.	6.40	1.76		\$106
<b>TOTAL</b>							<b>\$79,781</b>

All of the cost was calculated based on RS Means. Crane cost was eliminated because it was put into consideration in the cost estimate of Bed Bath & Beyond. Take off for duct system is given below and calculation for its weight is based on RS Means (refer to the Appendix). Only additional duct system was estimated for cost because the modified system uses the previous duct system.

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Duct No.	Description	Duct Size (in x in)	Quantity	Length (ft)	Weight (lbs)
	1	50 x 10	1	16	240
	2	22 x 14	1	12	93.6
	3	50 x 10	1	47	705
	4	48 x 16	1	10	160
	5	22 x 12	1	53	386.9
	6	28 x 10	1	16	131.2
total				154	1716.7
Turning Vane	a	14" high set	1	2	
	b	14" high set	1	4	
	c	14" high set	1	4	
	d	14" high set	1	2	
	e	14" high set	1	1	

\*\* according to RS Means reference table, for 50 x 10 duct, the weight is 15.0 lbs per foot

for 22 x 14 duct, the weight is 7.8 lbs per foot

for 48 x 16 duct, the weight is 16.0 lbs per foot

for 22 x 12 duct, the weight is 7.3 lbs per foot

for 28 x 10 duct, the weight is 8.2 lbs per foot

### Crane Configuration

As said in the above, 120 ton mobile crane will easily hold and erect HVAC units for Ross Dress For Less. Since it does not take much time to erect units, one crane rental is enough for the erection process of the entire mall. Delivered units will stage in the open area near the shop and erected starting from the back of the store.