

# Application Note 2030: Thermal Expansion of Refrigeration Piping In VRF Systems

Author **Matt Rash, PE** | Sr. Mechanical Engineer

Contributors **Cain White** | Sr. Commercial Product Manager  
**Yvette Daniel** | Document Program Manager

## Table of Contents

Introduction.....	3
Temperature Ranges in VRF Piping System.....	3
Expansion Loop Sizing & Determination of Expansion .....	5
Additional Pipe Installation Considerations .....	8
Example .....	9
Conclusion.....	9

## Introduction

This document is to serve as a general guide to the designer in determining appropriate measures for thermal expansion of refrigerant piping in City Multi® VRF system designs. This document is not to serve as a final design specification for thermal expansion loops on any specific project. All final design specifications of expansion loops or other expansion compensation devices should be completed by the engineer of record.

The official recommended type of piping material used for City Multi® systems is ACR copper; therefore, this document will be only addressing ACR copper expansion. Please reference Application note 2026 for information on restrictions when using other piping materials. In either case, expansion must be considered, and the correct expansion properties must be referenced by the engineer to determine expansion for alternate piping materials not addressed in this application note.

## Temperature Ranges in VRF Piping System

Expansion in VRF piping systems results from significant gas/liquid temperature changes in the piping network through the entire operating range of the equipment. Considering only a single mode of operation (cool/heat) is not sufficient when analyzing the temperature change the piping will be subjected to.

Some of the piping segments in a City Multi® VRF system will be subjected to lower operating temperatures from the installed piping temperature condition, causing a contraction. Some piping segments will be subjected to only a temperature increase or pipe expansion from the installed piping temperature condition. Other pipe segments will be exposed to both extremes, resulting in contraction and expansion relative to the installed temperature condition.

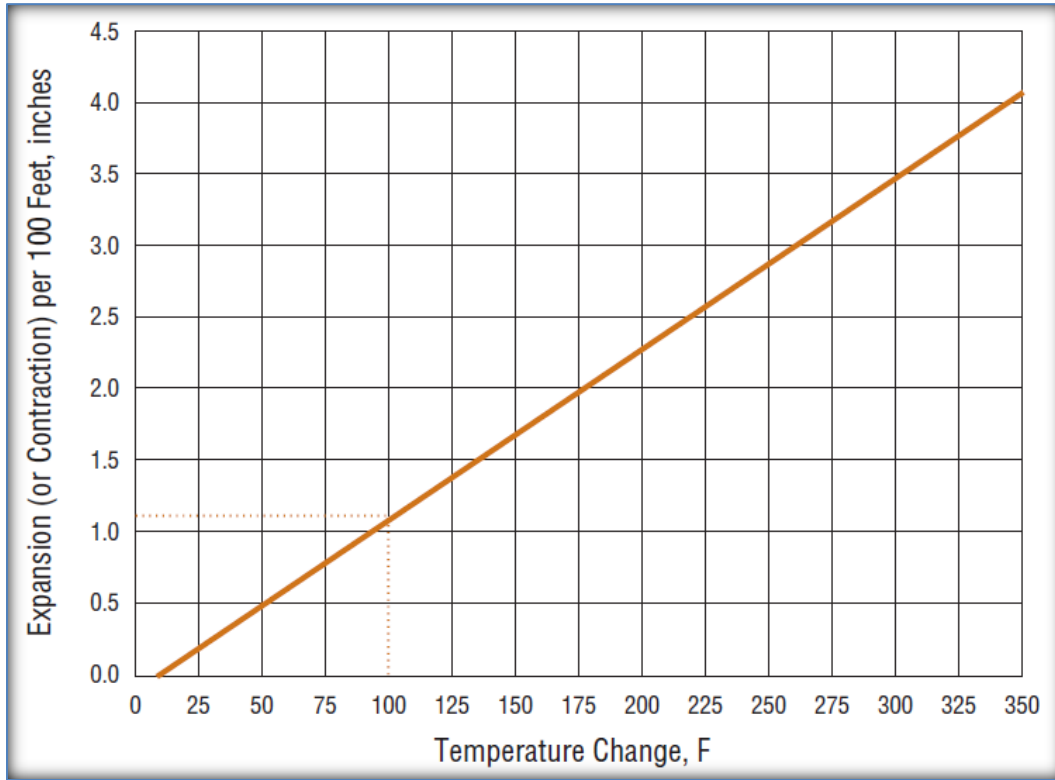
The below table summarizes the range of temperature that can be present in different piping segments throughout a City Multi® VRF system. These temperature ranges should be used in determining the net expansion and contraction of the copper piping.

Piping Segment	Mode	System Type	Temperature
Main High Pressure Pipe to BC Controller	Heat	R2/WR2	190 F
Main Suction Line From BC Controller	Heat	R2	Ambient - 15 Deg F
Main Suction Line From BC Controller	Heat	WR2	Min EWT - 15 Deg F
Main Suction Line From BC Controller	Cool	R2/WR2	32-40 F
Main Gas/Suciton Line	Heat	Y/PUMY	190 F
Main Gas/Suction Line	Cool	Y/PUMY	32-40 F
Main Liquid Line	Cool/Heat	Y/PUMY	140 Deg F
Branch Liquid Line To Indoor Unit (Liquid Return)	Heat	R2/WR2/Y/PUMY	90 - 130 F
Branch Suction Line To Indoor Unit (Hot Gas Supply)	Heat	R2/WR2/Y/PUMY	120 - 150 F
Branch Suciton Line To Indoor Unit (Gas Return)	Cool	R2/WR2/Y/PUMY	32-40 F

**Figure 1 (Above) – Max/Min Working Temperature of VRF Pipe Segments**

## Expansion Loop Sizing & Determination of Expansion

A multitude of industry standard / guidelines exist for proper sizing of expansion loops and determining expansion under the known temperature changes. “ASHRAE Systems and Equipment” discusses methods of sizing of expansion loops and provides tables summarizing expansion at given temperature ranges. “The Copper Tube Handbook” also provides resources as to the expected expansion/contraction of copper piping and guidance on sizing of expansion loops as shown below in figure 2 & 3.



**Figure 2 (Above) – Thermal Expansion of Copper Piping, “The Copper Tube Handbook”**

Expected Expansion, inches	Radius "R", inches, for Nominal or Standard Tube Sizes Shown Length "L", inches, for Nominal or Standard Tube Sizes Shown													
		1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5
1/2	R	6	7	8	9	11	12	13	15	16	18	19	20	23
	L	38	44	50	59	67	74	80	91	102	111	120	128	142
1	R	9	10	11	13	15	17	18	21	23	25	27	29	32
	L	54	63	70	83	94	104	113	129	144	157	169	180	201
1 1/2	R	11	12	14	16	18	20	22	25	28	30	33	35	39
	L	66	77	86	101	115	127	138	158	176	191	206	220	245
2	R	12	14	16	19	21	23	25	29	32	35	38	41	45
	L	77	89	99	117	133	147	160	183	203	222	239	255	284
2 1/2	R	14	16	18	21	24	26	29	33	36	40	43	45	51
	L	86	99	111	131	149	165	179	205	227	248	267	285	318
3	R	15	17	19	23	26	29	31	36	40	43	47	50	55
	L	94	109	122	143	163	180	196	224	249	272	293	312	348
3 1/2	R	16	19	21	25	28	31	34	39	43	47	50	54	60
	L	102	117	131	155	176	195	212	242	269	293	316	337	376
4	R	17	20	22	26	30	33	36	41	46	50	54	57	64
	L	109	126	140	166	188	208	226	259	288	314	338	361	402

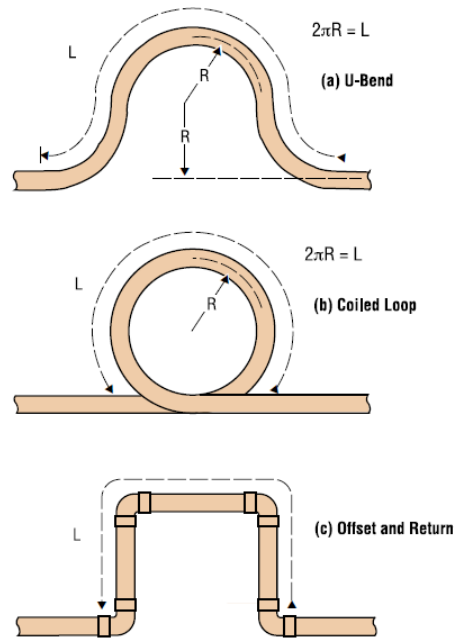


Figure 3 (Above) – Expansion Loop Dimensions, “The Copper Tube Handbook”

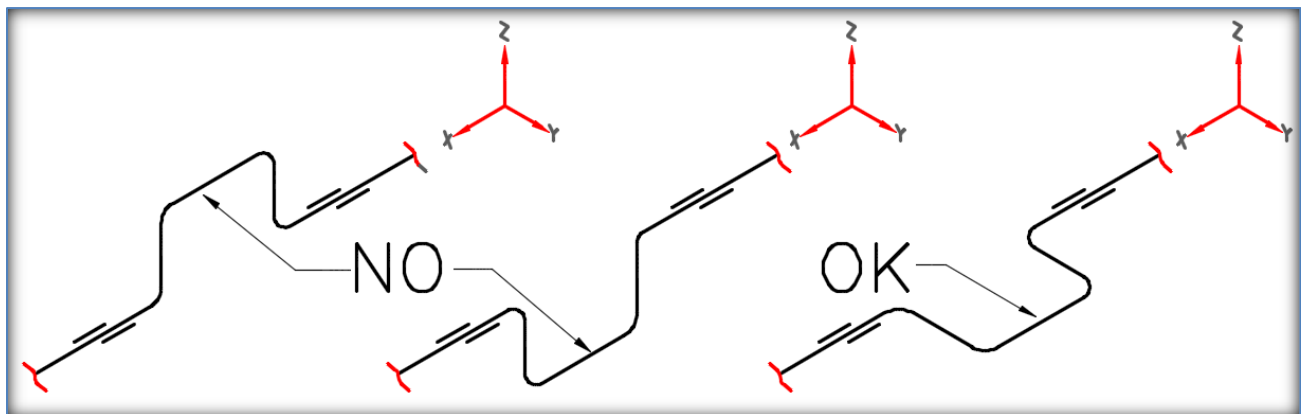
In general long straight lengths of copper, specifically hard drawn ACR tube, should always consider expansion compensation. For shorter runs, specifically with soft ACR tube line sets, such as downstream of the BC controller where sufficient bends/offsets exist, specific expansion loops may not be required. This should ultimately be determined by the engineer of record.

Long straight lengths of copper, where expansion loops are included, should be anchored at both ends of the pipe segment with the expansion loop installed near the mid-section of the run. Pipe hangers in between rigid anchor locations should allow for movement during expansion/contraction with proper guides, specified by the engineer of record, in order to ensure full range motion of any installed expansion loops/bends.

Expansion of long vertical runs is equally important to consider, such as vertical risers down shafts where the pipe/riser is rigidly anchored/supported at the top/bottom of shaft. Similar provisions should be provided with expansion bends in between the top and bottom of the shaft to allow for proper pipe expansion.

Any alternate field installed pre-manufactured flexible expansion compensation devices, if used, should be R410A rated with a minimum of a 650PSI max working pressure rating.

Also, do not orientate expansion loops/bends for horizontal piping runs in the vertical orientation as this will create unnecessary trapping in the refrigeration piping, inhibiting proper oil return:



**Image 1(Above) – Proper orientation of expansion loop/bends in horizontal pipe.**

## Additional Pipe Installation Considerations

It is encouraged in general to always allow for pipe movement at the majority of pipe support locations. Both lateral and longitudinal movement allowance is encouraged to accommodate expansion/contraction of piping, then only strategically anchor pipe movement at ends of segments where expansion loops are installed, where such paths would otherwise not allow for calculated net expansion/contraction as stated in previous section.

This can be especially important with multiple pipes mounted on common supports / trapeze hangers when changing direction, especially around corners near building walls. Leave space between individual pipes and between pipe and wall and any trapeze hanger rods to allow for pipe movement.

All VRF piping should be insulated (outdoor piping also jacketed) and shields should be placed beneath the piping at support location to prevent insulation damage as piping moves from expansion and contraction. Cush style clamps in general can be problematic as insulation is often damaged as pipe expands and contracts. Trapeze and Clevis type hangers with pipe shields are preferred.

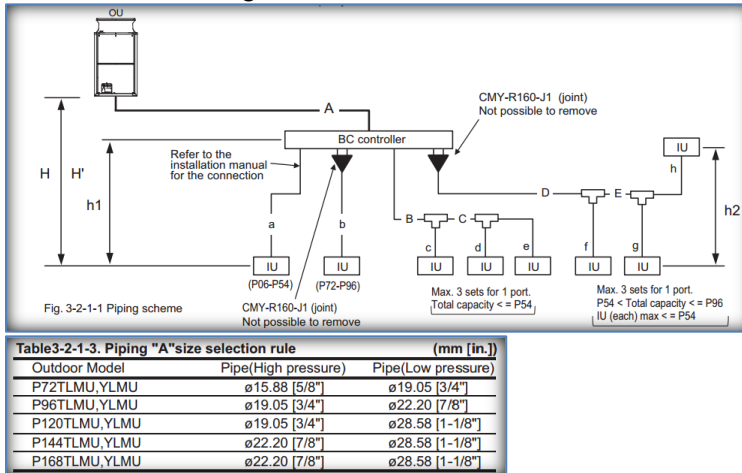
Avoid the use of 45 deg elbow ACR fittings as the corners can be prone to stress concentrations under expansion and contraction, instead use standard long radius ACR elbows. Alternately, for pipe sizes 1-1/8" and below soft rolled ACR tube UL listed to 700 PSIG working pressure is readily available and can be used when making pipe routing direction changes to minimize stress developed at these locations. Please note however, this is not to replace the necessity for proper expansion loops where net expansion of any routing path cannot accommodate the natural expansion calculated.

With outdoor piping, avoid mounting / rigidly clamping to outside walls as this allows for little to no movement (especially if clamped to outside walls around corners). Instead provide horizontal supports with all piping insulated and jacketed with shields that allow for movement. Keep piping elevated on supports above grade to prevent ice/snow accumulation from inhibiting movement on supports.



## Example

- Consider the installation of 10 Ton R2 air cooled system.
- The Main High Pressure line from the R2 outdoor unit to BC controller is 85 Ft. after penetrating through the outside wall to the BC controller connection.
- The piping is installed on a 70° day and rigidly clamped at both ends of the 85 Ft. run.
- The Main High Pressure line is a hard ACR tube copper line, size 3/4", per Engineering manual-below image:



From Figure 1 above, the high pressure pipe peak operating temperature is 190° F. The initial temperature is 70° F, with a (190-70) =120° F total temperature change.

From Figure 2 above, with a 120° F change, the total expansion per 100 Ft. = Approx. 1.25 inches.

The total expansion for the 85 Ft installed run is then (1.25 inches/100 Ft.) x 85 Ft. = 1.06 inches.

**From Figure 3 above, for a 3/4" line, with a total expansion of roughly 1", the "L" dimension of the expansion loop would be at least 83" total length in the Main High Pressure Line. This loop should be placed mid-length between rigid anchor points.**

## Conclusion

Thermal expansion consideration is important in any piping system. VRF piping systems, especially of a dual temperature service, warrant careful consideration of expansion affects. Failure to consider expansion upfront in the project can lead to costly repairs after installation and potential discharge of large quantities of refrigerant into the building envelope from failed fittings due to stress from inadequate expansion compensation considerations.