Bus Vibration

Bus vibration is caused by a low steady wind blowing across the bus at approximately right angles to the span. Under certain low velocity wind conditions, eddies will break off alternately from the top and bottom surfaces causing the bus to vibrate in a vertical plane. The bus will vibrate at its natural frequency provided that this frequency is within the range that can be excited by the wind. All shapes of bus will vibrate provided the following conditions are present: 1) suitable winds are present, 2) span lengths are long enough to vibrate and 3) support losses are less than input by wind.

Winds causing vibration are low steady winds under 15 mph; winds over 15 mph are generally too gusty to induce vibration. A span that is "sheltered" from the wind not be as prone to vibrate as an exposed span. This shelter can be caused by trees around the station, equipment in the station or by the location of the station such as being in a valley.

Long spans are more prone to vibrate than short spans. In fact, a long span can have one, two or three (in the case of extremely long spans). A loop of vibration is the portion of a vibrating body between two node points. The "node" being the point of a vibrating body that is free of vibration (a support would be a node point). Size of the bus tube increases span length that will be free of vibration, however, whether a bus tube is Schedule 40 or Schedule 80 has relatively little effect with respect to determining if a span will vibrate or not. See tables "Maximum Vibration-Free Span Lengths" for maximum bus length that will require no vibration protection.

The support losses are an indeterminable factor which depends on support type, insulator type, structure flexibility and other related factors. In some substations the losses are high enough to provide adequate damping but in other stations the support losses are less and the bus vibrates.

In general, we can only say that a span greater than some minimum length can vibrate, not that it will vibrate (see table "Maximum Vibration-Free Span Lengths"). There are too many variables involved to definitely state that a given span will vibrate. However, due to the fact of its length it has the potential to vibrate.

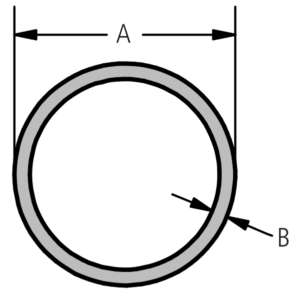
Bus vibration protection in the past has been by the method of inserting "scrap" conductor in the bus but in recent years the use of bus dampers has found increasing use of vibration protection. When the specific size of conductor is not used by a utility and has to be ordered, it is no longer "scrap" and becomes costly, particularly in the short lengths required for damping purposes. When the cost of installation is added to the purchase cost, the total cost of inserted cable becomes expensive. For this reason, the use of dampers is increasing. Dampers also have the advantage of being able to be installed in an existing station where vibration problems have occurred.

The following tables are supplied for bus vibration references:

1. Maximum vibration - free span length – Tubular Bus
2. Maximum vibration - free span length – UABC
3. Maximum vibration – free span length – IWCB
4. Damper spacing – Rigid Bus
5. Recommended sizes of ACSR to be inserted in Tubular Bus to prevent vibration

Bus Dampers

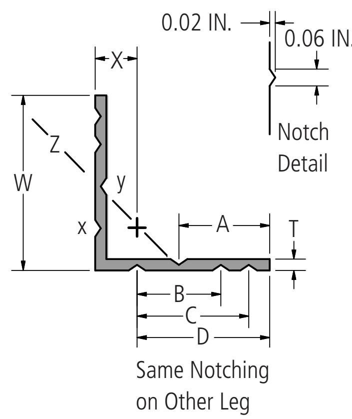
Nominal Pipe Size	Maximum Safe Span Length
1	5’ - 0”
1-1/4	6’ - 3”
1-1/2	7’ - 0”
2	9’- 0”
2-1/2	10’- 9”
3	13’ -3”
3-1/2	15’- 3”
4	17’-0”
4-1/2	19’-0”
5	21’-3”
6	25’-3”



Notes:
1. Lengths based on loop of vibration
2. Lengths apply to both Schedule 40 and Schedule 80 tubular bus.
3. Lengths can be increased approximately 20% with reasonable certainty that there will be no vibration.

Universal Angle Bus Conductor (UABC)

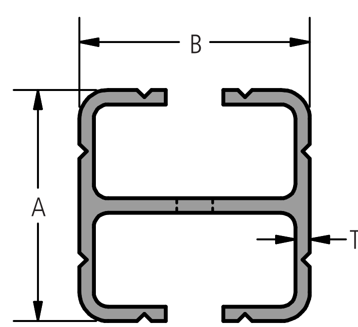
UABC Size	Maximum Safe Span Length
3 -14 x 3 -1/4 x 1/4	12’- 0”
4 x 4 x 1/4	15’- 0”
4 x 4 x 3/8	14’- 9”
4 - ½ x 4 - 1/2 x 3/8	16’ - 9”
5 x 5 x 3/8	18’ - 6”



Notes:
1. Lengths based on one loop of vibration
2. Lengths can be increased approximately 20% with reasonable certainty that will be no vibration.
3. Does not apply for double angles in back-to-back configurations

Integral Web Channel Bus (IWCB)

UABC Size	Maximum Safe Span Length
3 -14 x 3 -1/4 x 1/4	12’- 0”
4 x 4 x 1/4	15’- 0”
4 x 4 x 3/8	14’- 9”
4 - ½ x 4 - 1/2 x 3/8	16’ - 9”
5 x 5 x 3/8	18’ - 6”



Notes:
1. Lengths based on one loop of vibration
2. Lengths can be increased approximately 20% with reasonable certainty that will be no vibration.

Damper Spacing - Rigid Bus

SPAN	SPACING	SPAN	SPACING	SPAN	SPACING	SPAN	SPACING
15’ - 0	7’ - 0	26’ - 6	10’ - 10	38’ - 0	14’ - 8	49’ - 6	18’ - 6
15’ - 6	7’ - 2	27’ - 0	11’ - 0	38’ - 6	14’ - 10	50’ - 0	18’ - 8
16’ - 0	7’ - 4	27’ - 6	11’ - 2	39’ - 0	15’ - 0	50’ - 6	18’ - 10
16’ - 6	7’ - 6	28’ - 0	11’ - 4	39’ - 6	15’ - 2	51’ - 0	19’ - 0
17’ - 0	7’ - 8	28’ - 6	11’ - 6	40’ - 0	15’ - 4	51’ - 6	19’ - 2
17’ - 6	7’ - 10	29’ - 0	11’ - 8	40’ - 6	15’ - 6	52’ - 0	19’ - 4
18’ - 0	8’ - 0	29’ - 6	11’ - 10	41’ - 0	15’ - 8	52’ - 6	19’ - 6
18’ - 6	8’ - 2	30’ - 0	12’ - 0	41’ - 6	15’ - 10	53’ - 0	19’ - 8
19’ - 0	8’ - 4	30’ - 6	12’ - 2	42’ - 0	16’ - 0	53’ - 6	19’ - 10
19’ - 6	8 ‘ - 6	31’ - 0	12’ - 4	42’ - 6	16’ - 2	54’ - 0	20’ - 0
20’ - 0	8’ - 8	31’ - 6	12’ - 6	43’ - 0	16’ - 4	54’ - 6	20’ - 2
20’ - 6	8’ -10	32’ - 0	12’ - 8	43’ - 6	16’ - 6	55’ - 0	20’ - 4
21’ - 0	9’ - 0	32’ - 6	12’ - 10	44’ - 0	16’ - 8	55’ - 6	20’ - 6
21’ - 6	9’ - 2	33’ - 0	13’ - 0	44’ - 6	16’ - 10	56’ - 0	20’ - 8
22’ - 0	9’ - 4	33’ - 6	13’ - 2	45’ - 0	17’ - 0	56’ - 6	20’ - 10
22’ - 6	9’ - 6	34’ - 0	13’ - 4	45’ - 6	17’ - 2	57’ - 0	21’ - 0
23’ - 0	9’ - 8	34’ - 6	13’ - 6	46’ - 0	17’ - 4	57’ - 6	21’ - 2
23’ - 6	9’ - 10	35’ - 0	13’ - 8	46’ - 6	17’ - 6	58’ - 0	21’ - 4
24’ - 0	10’ - 0	35’ - 6	13’ - 10	47’ - 0	17’ - 8	58’ - 6	21’ - 6
24’ - 6	10’ -2	36’ - 0	14’ - 0	47’ - 6	17’ - 10	59’ - 0	21’ - 8
25’ - 0	10’ - 4	36’ - 6	14’ - 2	48’ - 0	18’ - 0	59’ - 6	21’ - 10
25’ - 6	10’ - 6	37’ - 0	14’ - 4	48’ - 6	18’ - 2	60’ - 0	22’ - 0
26’ - 0	10’ - 8	37’ - 6	14’ - 6	49’ - 0	18’ - 4	–	–

Notes:
1. Spacing based on 1/3 span length plus two feet
2. Damper may be located at either end of the span