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Bus Dampers

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.

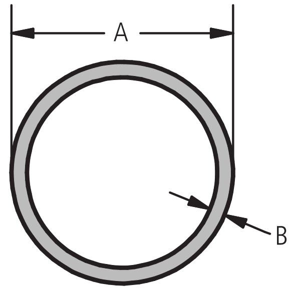
Bus vibration protection in the past has been by the method of inserting "scrap" conductor in the bus but in recent years the use of bus dampers has found increasing use of vibration protection. When the specific size of conductor is not used by a utility and has to be ordered, it is no longer "scrap" 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

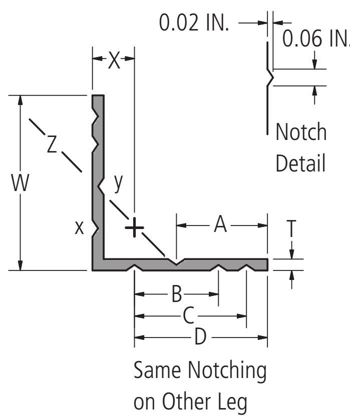
Nominal Pipe Size	Maximum Safe Span Length
1	5′ - 0″
1-1/4	6′ - 3″
1-1/2	7′ - 0″
2	9′- 0″
2-1/2	10′- 9″
3	13′ -3″
3-1/2	15′- 3″
4	17′-0″
4-1/2	19′-0″
5	21′-3″
6	25′-3″



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)

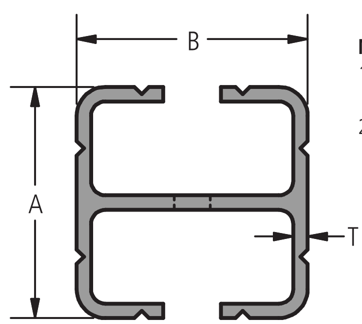
UABC Size	Maximum Safe Span Length
3 -14 x 3 -1/4 x 1/4	12′- 0″
4 x 4 x 1/4	15′- 0″
4 x 4 x 3/8	14′- 9″
4 - ½ x 4 - 1/2 x 3/8	16′ - 9″
5 x 5 x 3/8	18′ - 6″



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 Bus Conductor (IWBC)

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.

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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

Recommended Sizes of ACSR to be Inserted in Tubular Bus to Prevent Vibration

Nominal Bus Size in	Recommended Min. Size of ACSR cm
2	266,800
2 - 1/2	266,800
3	266,800
3 - 1/2	397,500
4	795,000
5	1,431,000
6	1,590,000

Notes:
1. ACSR should have a multi-strand core
2. Based on no energy absorption by supports

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DOSSERT®

TYPE 1706 SERIES

Bus Vibration Dampers

Tubular bus dampers are designed to control Aeolian or wind-induced vibration in long bus spans; the dampers have been proven both in the laboratory and in field service to be the most effective method of controlling tubular bus vibration. The dampers are faster and easier to install than the old method of inserting "scrap" cable into the tubular bus runs. Also, the dampers find applications for correcting a vibration problems in existing substations.

Determine catalog number based on the bus conductor size being used. To order a bus vibration damper for 2 1/2" bus conductor, the complete catalog number is 1706-288.

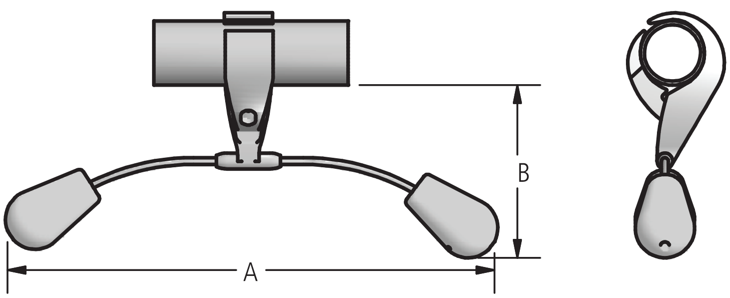

FIG. 1

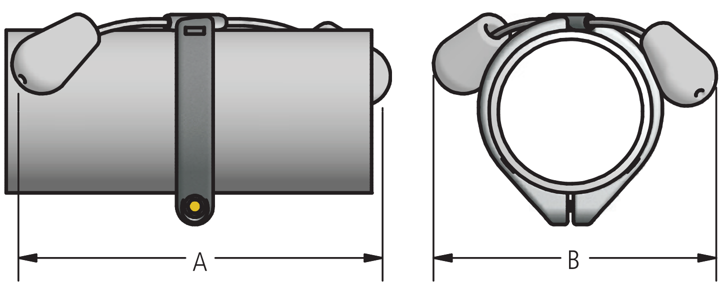

FIG. 2

Ordering Information

CATALOG NUMBER	SPS	FIG. NO.	DIMENSIONS IN INCHES		
			A	B	BOLT SIZE
1706-190	1-1/2	1	29.5	9.9	5/8-11
1706-238	2	1	29.5	9.9	5/8-11
1706-288	2-1/2	1	29.6	10.2	5/8-11
1706-350	3	1	29.6	10.3	3/4-10
1706-008	3	2	28.0	12.6	1/2-13
1706-009	3-1/2	2	27.8	13.2	1/2-13
1706-010	4	2	27.6	13.6	1/2-13
1706-012	5	2	26.8	15.4	1/2-13
1706-013	6	2	26.2	17.8	1/2-13
1706-014	8 O.D.	2	24.8	18.6	1/2-13

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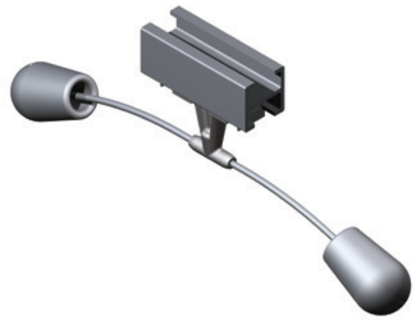
Bus Dampers

DOSSERT®

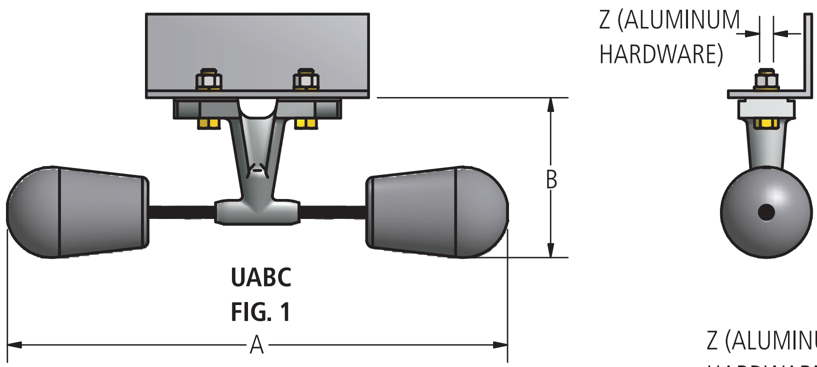
TYPE 1706

Bus Vibration Dampers

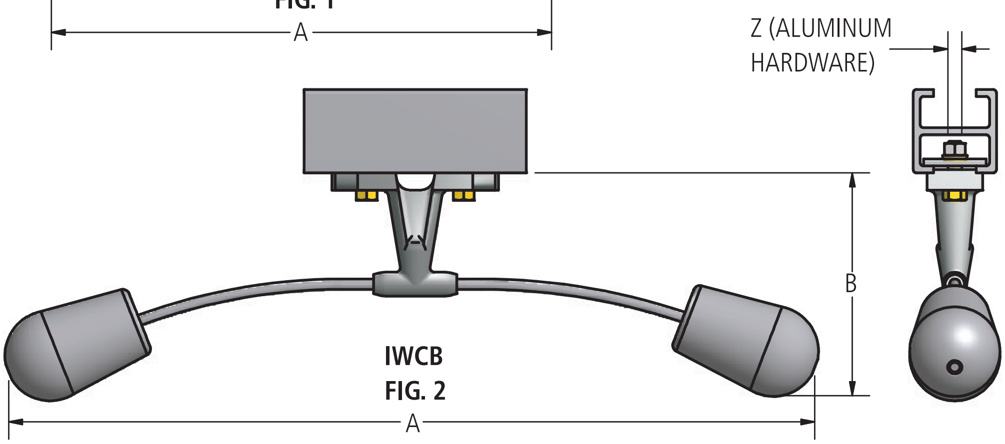


Vibration dampers for universal angle bus conductor (UABC) and integral web channel bus conductor (IWCB) are specifically designed to control Aeolian or wind-induced vibration in long bus spans. The dampers provide a fast, economical method of damping vibration. Installation is easy; the IWCB damper clamps to the bus by means of a bolt and clamp nut while the UABC damper bolts directly to the bus.

Determine catalog number based on the bus conductor size being used. Ex: A bus vibration damper for 4"x4" IWCB, the complete catalog number is: 1706-129.



UABC
FIG. 1



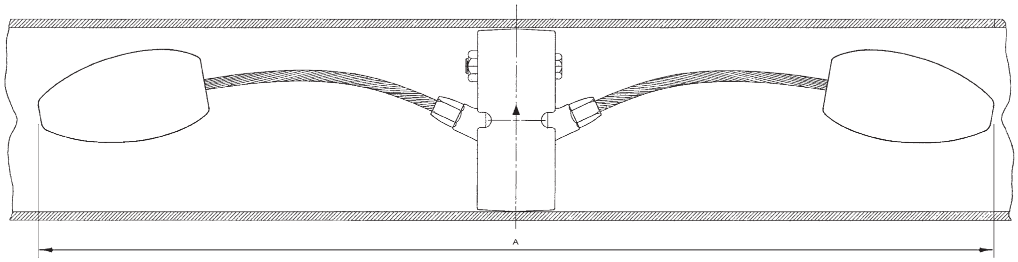
IWCB
FIG. 2

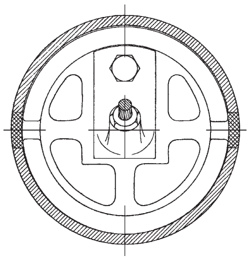
Ordering Information

CONDUCTOR SIZE	FIG. NO.	CATALOG NUMBER	DIMENSIONS IN INCHES		
IN			A	B	BOLT SIZE
3-1/4 x 3-1/4 Thru 5 x 5 UABC	1	1706-123	15.5	5.7	1/2-13
4 x 4 Thru 9 x 9 IWCB	2	1706-129	29	10.1	1/2-13

Bus Vibration Dampers—Tube

Internal, Welded 345 kV, 500 kV and 765 kV

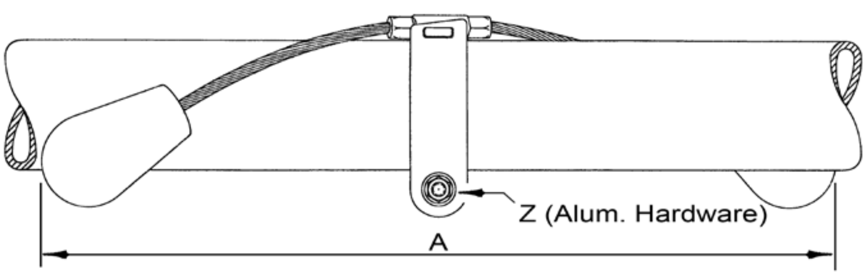


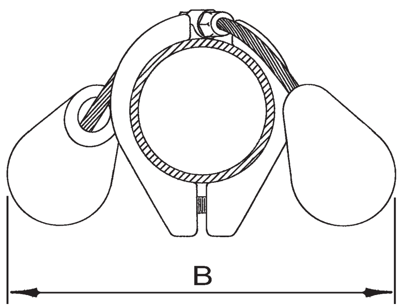


Internal damper is designed to be corona-free up to 765 kV service. Damper is designed to be welded inside bus, to be corona-free, and to present a "clean" appearance to the substation.

Conductor Size	Catalog Number	Dimensions A		Nominal Weight Aluminum		Nominal Weight Total	
		in	mm	lb	kg	lb	kg
5″ SPS	1705-504	36.88	937	2.7	1.22	13.3	6.03
6″ EHPS	1705-576	35.25	895	3.3	1.50	14.0	6.35
6″ SPS	1705-607	35.25	895	4.0	1.81	14.7	6.67
8″ EHPS	1705-762	36.88	937	3.3	1.50	13.9	6.30
8″ SPS	1705-798	36.88	937	3.4	1.54	14.0	6.35
8″ O.D. x 1/2 wall	1705-700	36.88	937	3.2	1.45	13.8	6.26
8″ O.D. x 3/8 wall	1705-725	36.88	937	3.2	1.45	13.8	6.26

External, Bolted 345 kV or 500 kV

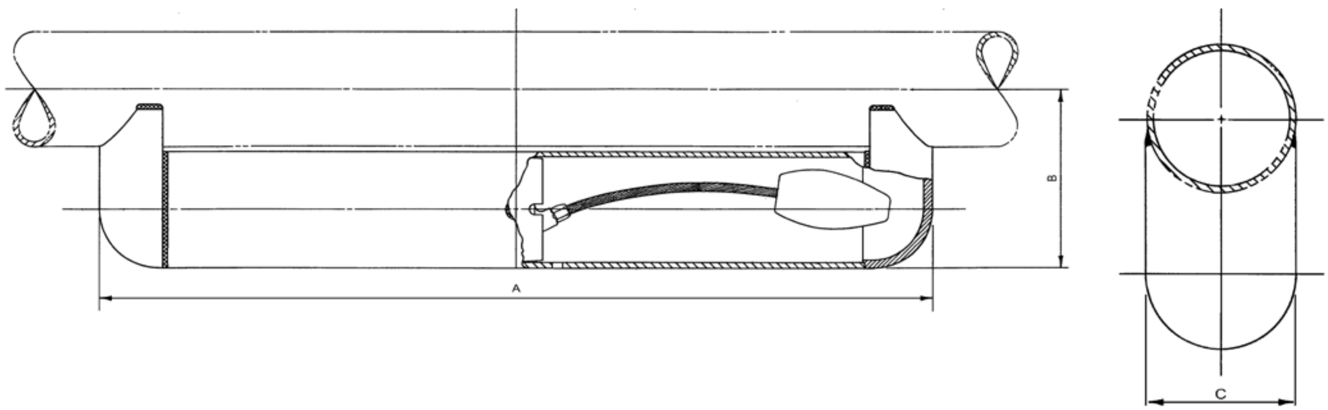




External damper is designed to be corona-free for 345 kV or 500 kV service as noted in table. Damper is designed to be bolted to outside of tube. Damper can be installed during construction or at a later time to correct vibration problems not originally anticipated.

CONDUCTOR SIZE SPS & EHPS	CATALOG NUMBER	DIMENSIONS A		DIMENSIONS B		DIMENSIONS Z	VOLTAGE RATING	NOMINAL WEIGHT ALUMINUM		NOMINAL WEIGHT TOTAL	
		IN	MM	IN	MM			LB	KG	LB	KG
3″	1706-008 EHV	28.0	711	12.6	320	1/2 - 13	345 kV	1.9	0.86	15.6	7.08
3-1/2″	1706-009 EHV	27.8	706	13.2	335	1/2 - 13	345 kV	2.0	0.91	15.7	7.12
4″	1706-010 EHV	27.6	701	13.6	345	1/2 - 13	345 kV	2.1	0.95	15.8	7.17
5″	1706-012 EHV	26.8	681	15.4	391	1/2 - 13	345 kV	2.5	1.13	16.2	7.35
6″	1706-013 EHV	26.2	665	17.8	452	1/2 - 13	345 kV	2.7	1.22	16.4	7.44
8″ O.D.	1706-014 EHV	24.8	630	18.6	472	1/2 - 13	500 kV	3.9	1.77	17.6	7.98

External Bus Vibration Damper for Tubular Bus
Recommended for Voltages up to 756 kV



External damper is designed to be corona-free for 765 kV operation. Damper is designed to be welded to outside of bus in order to correct vibration problems not originally anticipated.

Ordering Information: Contact AFL Technical Support for appropriate part number for this application.

Assembly Dwg. & Letter	Conductor Size		Dimension						Nominal Weight			
	Tubular Bus		A		B		C		Aluminum		Total	
	SPS & EHPS or O.D.	mm (O.D. Ref.)	in	mm	in	mm	in	mm	lb	kg	lb	kg
B7384-A	5″	141.3	40.0	1016	8.50	216	5.56	141	23.9	10.84	34.5	15.65
B7384-B	6″	168.3	40.0	1016	10.12	257	6.62	168	28.9	13.11	39.5	17.92
B7384-C	8″ O.D.	203.2	40.0	1016	12.19	310	8.00	203	37.4	16.96	48.0	21.77

Bus Vibration Test Data

Table 1 and Figures 1 thru 3 provide information on test conducted on an outdoor test span on 4,5 and 6 inch NPS.

Figure 1 illustrates the effect of conventional support vs. wire supports on the vibration amplitude of 4 inch tubular bus in a 50 foot span. The supporting arrangement does have some effect on the vibration amplitudes.

The test conducted on the 4 and 5 inch schedule 40 aluminum bus (ref. figures 2 and 3) were conducted on the spans supported by steel wires to eliminate the support "variable" and to provide the severest condition for the bus damper tests. These tests indicate that one Cat. 1706 external bus dampers reduced the vibration amplitude to a level considered safe for the bus.

Tests were conducted at the outdoor vibration lab at Massena and represent values which eliminate such variations such as bus support type, insulator type and structure type. The spans are supported by wire loops at each end and therefore the test conducted on the dampers are extremely severe in relationship to that which would actually be encountered by any substation where there would be structural damping through the insulator supports, etc.

Table 1

NPS Size	Span Length (feet)	Frequency in Cycles Per Second	Amplitude (inches)	
			Undamped	Damped
One Loop				
4" Sched 80	46	1.5	4.1	0.660
6" Sched 40	68	1.1	6.5	2.100
Two Loop				
4" Sched 80	46	6.1	2.0	0.045
6" Sched 40	68	4.0	2.2	0.050
Three Loop				
4" Sched 80	46	—	—	—
6" Sched 40	68	10.0	0.25	0.020

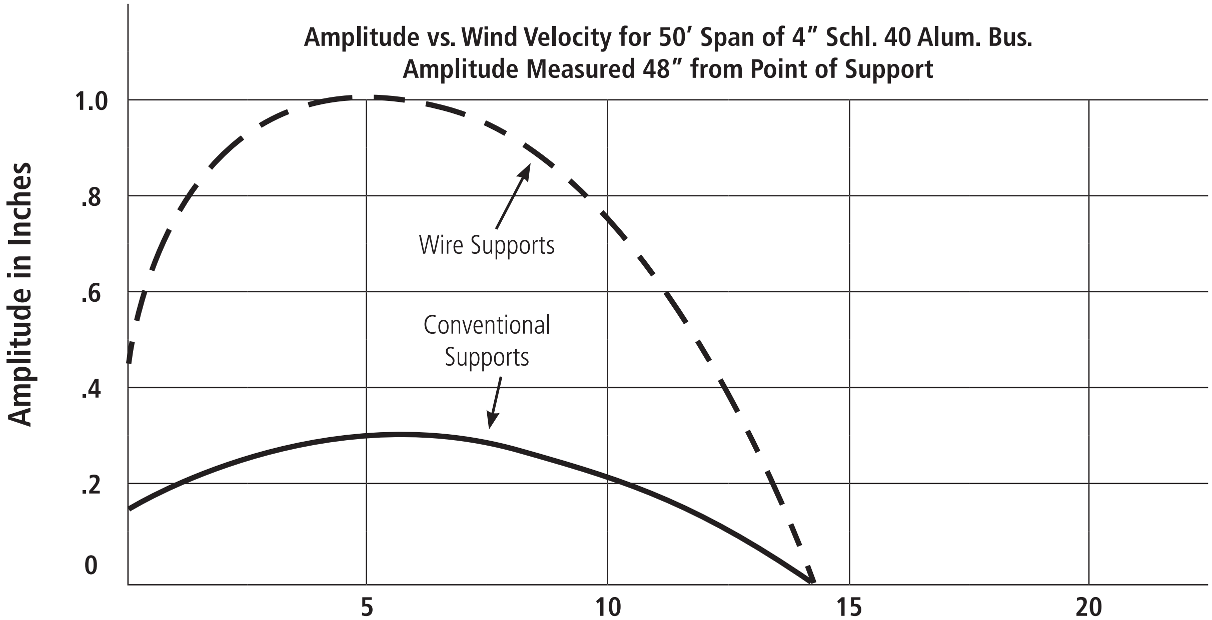


Figure 1 — Effective Wind Velocity - MPH

Bus Vibration Test Data (cont.)

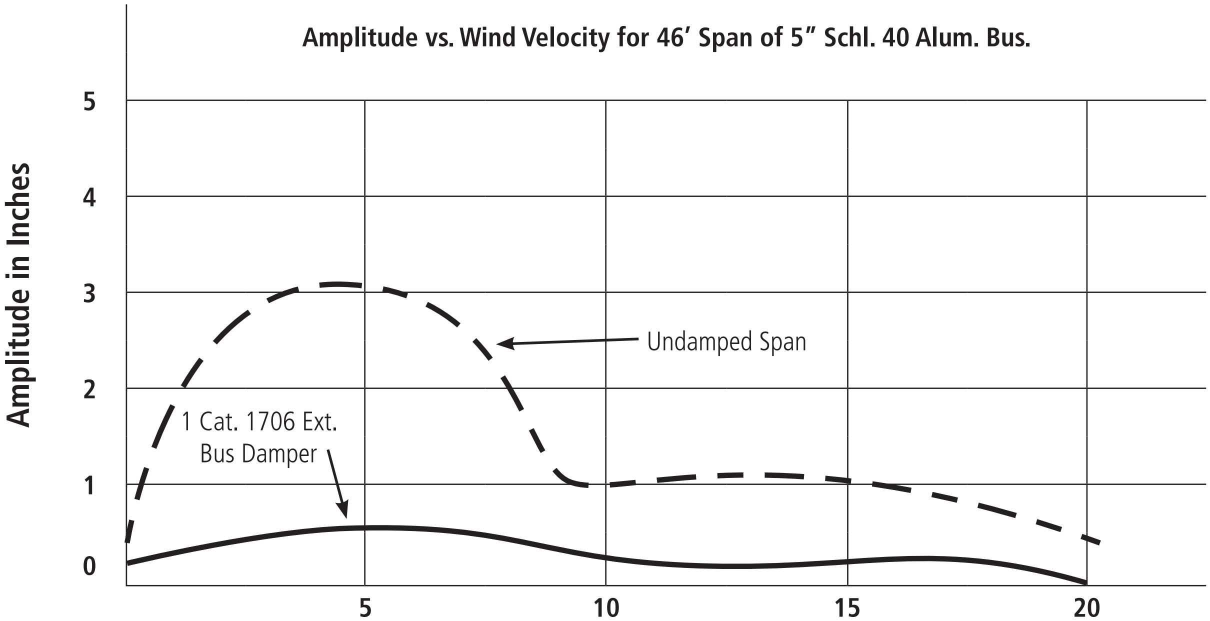


Figure 2 — Effective Wind Velocity - MPH

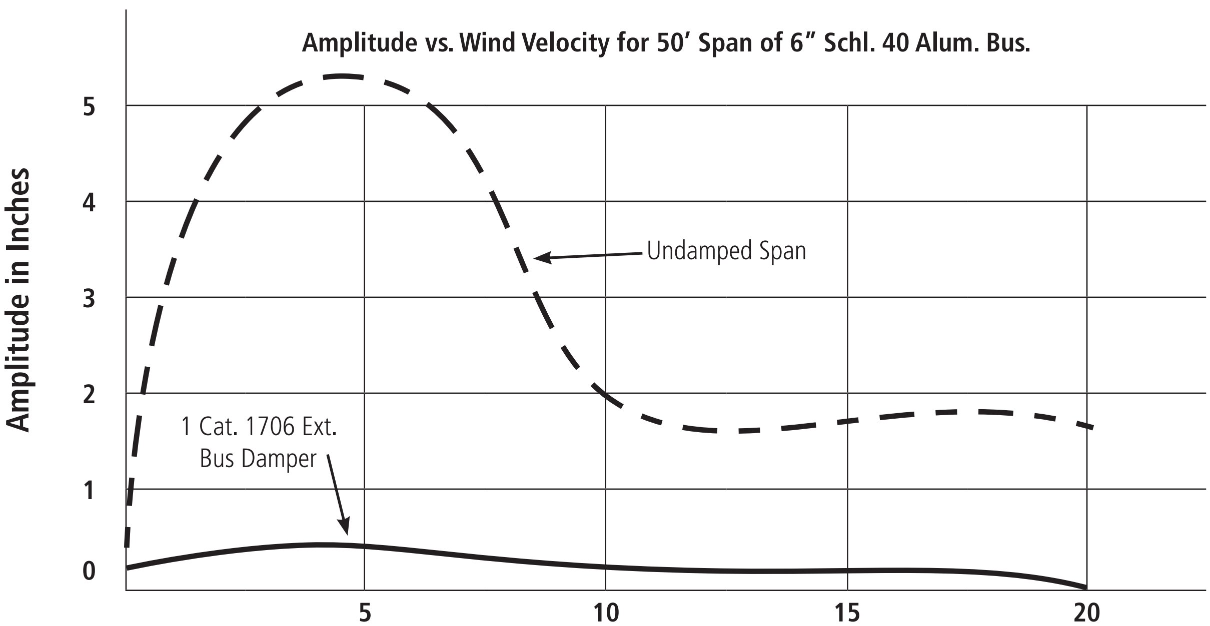


Figure 3 — Effective Wind Velocity - MPH