

FARGO[®]

4-R DAMPERS

Advanced Vibration Protection



Connecting & Protecting Transmission Conductors

Introduction

Fargo 4-R vibration dampers are designed and applied to protect conductors, shield wires OPGW cables and tower guys from fatigue damage resulting from bending strains, at conductor attachment points, caused by aeolian vibration.

Aeolian vibration is the resonant, small amplitude vibration caused by low velocity wind blowing across cables under tension. The mechanism causing conductor vibration is the rhythmic aerodynamic force created by eddies of air, or vortices, in the wake of the air on the leeward side of the conductor, as shown in Figure 1.

The frequency of this vibration is directly proportional to the wind velocity and inversely proportional to the conductor diameter, as expressed by the formula:

$$f = 3.26V/d \text{ where,}$$

f is the frequency in Hz

V is wind velocity in miles per hour

d is conductor diameter in inches

As the frequency of these rhythmic forces approaches that of one of the natural modes of vibration of a conductor span, traveling waves are initiated. These waves move away from the source of the energy imposed by the wind and toward the end of the span. These traveling waves reflect back from the span ends and superimpose upon each other, creating standing waves having frequencies that are multiples, or harmonics, of the fundamental frequency of the conductor span. The length of these harmonic waves is directly proportional to the square root of the tension of the conductor and inversely proportional to the square root of its mass. It can be expressed by the formula:

$$L = 1/f \times (T/M)^{0.5} \text{ where,}$$

L is the wavelength in feet

f is the frequency in Hz

T is the conductor tension in pounds

M is the mass of the conductor (lb/ft / 32.2 ft/sec²)

Wind-induced standing waves in a vibrating conductor contain kinetic energy. Some of this energy is dissipated by the conductor strands as they flex with the sinusoidal wave, and in the conductor support system. Increased tension on a stranded conductor increases its tendency to vibrate as it increases the radial forces between the strands, minimizing the dissipation effects of inter-strand friction.

The conductor at the ends of the span is subjected to bending, and resulting strain, in proportion to the amplitude of the standing sinusoidal wave of vibrating conductor. Testing has shown that at approximately 10⁸ cycles, fatigue is quite likely to occur in aluminum strands subjected to bending strains from 150 to 300 microinches/inch. The fatigue-causing strain for steel strands is 300 to 600 microinches/inch. In order to eliminate aeolian vibration as a possible source of damage to the conductor/cable, it is necessary to take steps to ensure that, under all possible wind-induced frequencies, bending strains at the span extremities are maintained below 150 microinches/inch for aluminum cable strands and below 225 microinches/inch for steel strands. The design and application of the 4-R Damper is based on attaining this goal.

Damper Design

Original Stockbridge-type dampers, first introduced in 1928 and still in use today, are effective damping devices at two resonant frequencies of conductor vibration. These “2-R” damper designs are easily recognized by their symmetrical shape with two identically-sized damper weights.

The Fargo 4-R damper is an improved Stockbridge-type damper introduced in Italy in 1967 and in the U.S. in the 1970s. 4-R indicates the design has four resonant frequencies at which vibration energy absorption (damper efficiency) is maximized. The result is improved cable protection across the aeolian vibration frequency range.

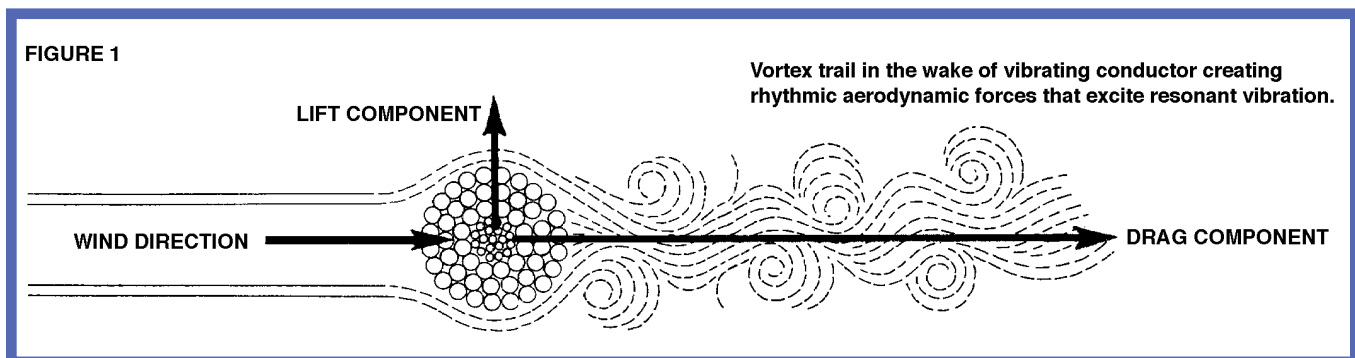
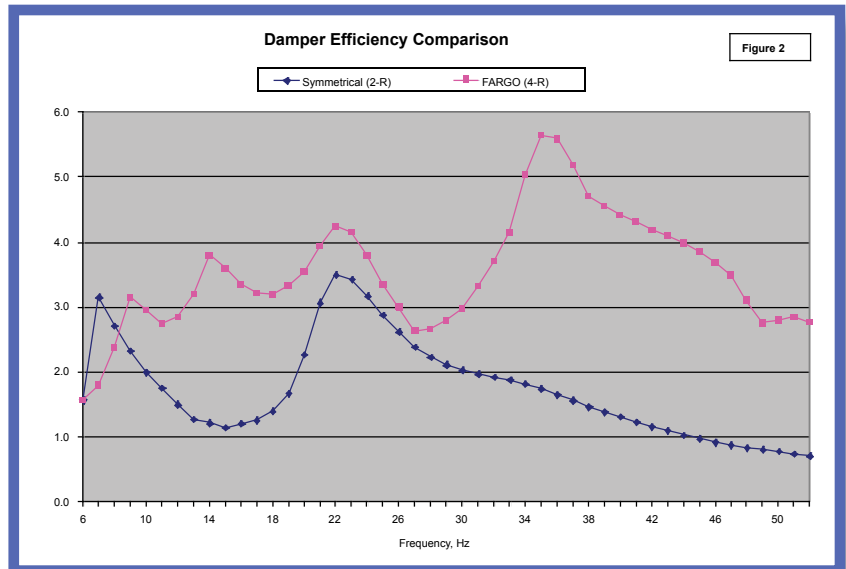


Figure 2 compares efficiency of the Fargo 4-R and the symmetrical 2-R damper designs, over the aeolian vibration frequency range of a typical transmission conductor.

Stockbridge-type dampers, including the 4-R design, function by converting a portion of the kinetic energy of a vibrating conductor into heat energy and dissipating it.

Conductor motion is transferred to the damper clamp. This causes motion of the weights which lags behind the damper clamp and conductor motion – due to the flexing of the messenger cable supporting the weights.



Vibration energy is dissipated as heat due to inter-strand friction in the stranded steel messenger. This energy dissipation is at a maximum when the phase displacement of damper force is 90 degrees from that of the conductor motion.

Aeolian vibration frequency of a conductor under tension varies directly with wind velocity and inversely with conductor diameter. Thus, for a given conductor, the wind velocity determines the vibration frequency range and the damper must dissipate energy over the same frequency range to be effective.

The additional two resonant peaks were designed into the 4-R Damper by utilizing unequal weights on unequal lengths of stranded steel messenger. The configuration of the weights is such that the moment of inertia provides a torsional movement of the weights in relation to the messenger as movement is induced at certain frequencies. The result is increased damper efficiency over a broad frequency range.

Damper Application

Fargo dampers are applied using Tecnosoft™ Analysis Program, a computer modeling analysis program developed in Italy by Dr. Rodolfo Claren, Tecnodin S.r.L. and used for damper applications around the world for the past 30 years.

A damper is properly applied when, for any aeolian vibration frequency of the conductor, strain levels do not exceed the safe limits defined above – at both the support points and damper clamp.

Damper location in the span is a key factor for effective

conductor protection. The Tecnosoft analysis program performs several iterations to determine optimum damper placement over the vibration frequency range for the conductor being analyzed. The recommended placement is that which results in maximum protectable span length.

To ensure long service life, damper energy duty is limited by analysis program limits on vibration wave amplitude at the damper.

Figure 3 shows how bending strain at the attachment points varies with vibration frequency at various conductor tension levels. Higher conductor tensions require dampers that are efficient over a wider frequency range.

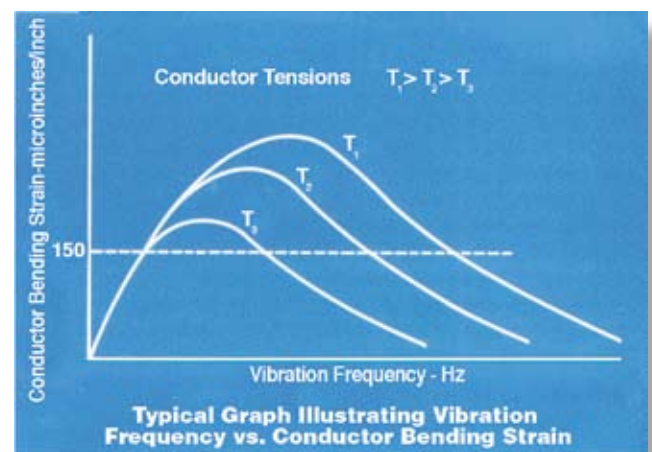


Figure 3

Aeolian vibration frequencies and bending strain data for a typical undamped conductor span are shown in Table I. Note that damaging strain levels (above 150 $\mu\text{in/in}$) are likely under the tension levels used. Also shown are the frequency and associated wind velocity at which these strain levels are likely.

Conductor Strain Levels Without Dampers							
795 kcmil 26/7 (Drake) ACSR Without Armor Rods							
Tension							
% RBS	%	20	22	24	26	28	
Pounds	lbs	6300	6930	7560	8190	8820	
Maximum Strain on Conductor	µin/in	391	509	664	772	866	
Frequency at which Maximum Strain Occurs	Hz	12	16	21	25	27	
Wind Velocity at which Maximum Strain Occurs	mph	4.1	5.4	7.1	8.5	9.1	

Table I

For this conductor, under these unloaded tensions, damper protection is needed.

Table II shows the maximum strain levels with the recommended damper installed at the optimum spacing location shown for span lengths up to the maximum span lengths listed. In this example, application of one 4-R Damper will reduce possible strains to acceptable levels.

Armor Rods & Formed-Wire Suspensions

Armor rods as used with bolted suspension clamps, or the shorter rods in formed-wire suspension (AGS) units generally provide significant aeolian vibration damping at relatively low cable tensions. This is especially true with the smaller diameter cables.

However, at higher conductor tension and vibration frequencies, the mass and stiffness of the supporting rods present increasing mechanical impedance which begins to reflect, rather than dampen, vibration wave motion. Thus, larger conductors tensioned above 20% RBS will vibrate with more standing wave energy when formed-wire rod supports are used; and under those tension levels, dampers will provide reduced protection in terms of maximum protectable span length.

In this regard, damper application programs that adjust maximum protected span lengths, when armor rods or formed-wire supports are used, by some constant factor, regardless of tension and cable type, are introducing errors into their recommendations.

Fargo's damper analysis program sets optimum damper placement on the bare cable, beyond any support rod ends. This approach prevents the damper mass from interfering with rod-to-conductor interface; and allows the utility to protect any given conductor with the same damper regardless of conductor suspension type.

Conductor Strain Levels							
with 60710-12 Damper at One End of Span							
795 kcmil 26/7 (Drake) ACSR without armor rods							
Tension							
% RBS	%	20%	22%	24%	26%	28%	
Pounds	lbs	6300	6930	7560	8190	8820	
Maximum span length protected	ft	3000	3000	1965	1542	1391	
Damper spacing from span attachment	in	47	42	33	31	31	
Maximum Conductor strain at support farthest from damper	µin/in	77	132	150	140	135	
Maximum Conductor strain at support nearest damper	µin/in	48	88	111	150	150	
Maximum Conductor strain - at damper clamp	µin/in	40	61	86	23	22	
Frequency at which maximum conductor strain occurs	Hz	23	48	50	11	12	
Wind velocity at which maximum conductor strain occurs	mph	7.8	16.2	16.9	3.7	4.1	

Table II

Terrain & Wind Velocity

Aeolian vibration can occur at winds in the 2.4-20 mph range. As the wind velocity increases above 15 mph, the air vortices in the leeward wake of the conductor become more random or turbulent. This has the effect of reducing wind energy input so that the standing wave energy at 20 mph is lower than at 15 mph. Wind speeds above 20 mph continue to increase leeward wake turbulence until aeolian vibration ceases. In this regard, damper application programs that reduce maximum protected span length with wind speeds above 15-20 mph are introducing errors into their recommendations.

Within the aeolian vibration wind range of 2.4-20 mph, terrain is far more important than actual wind velocity. "Flat, Open, Open Water" terrain is the most severe application because the wind on the conductor will be more steady with little or no terrain-induced turbulence.

Damper Recommendations

Fargo has damper application data available for many conductor and static wire applications. For non-standard conductors or cables, the computer program can be utilized to model the cables and prepare recommendations.

To obtain Fargo 4-R damper recommendations for your specific line project, submit your request to your Hubbell Power Systems representative using our Damper Proposal Request worksheet available online at:

http://www.hubbellpowersystems.com/powertest/literature/library/pdflib_lit_Fargo.html



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TB-107R3

RGS 2M 6/06