VIBRATION & DAMPING
GUIDELINES

MADE IN SWITZERLAND
SINCE 2000

DNV TYPE APPROVED
AS 9100D AEROSPACE & DEFENCE CERTIFIED

Carbo Link

01
VIBRATION

What causes vibration?

The leading cause of vibration in rigging cables is vortex shedding.

Vortex shedding occurs when wind flows past a cable, causing vortices to form on the downwind side. These vortices are alternating low pressure zones. As the wind flows past a cable, it attempts to fill these low pressure areas. This subtle shift in wind direction encourages the rigging cable to move in this new direction. See this in reality to the right; vortices (low pressure zones) in the clouds can be seen on the downwind side of the island chain.

As the cable moves, it builds up kinetic energy and when the vortex shedding frequency aligns with the cable's natural frequency, vibration sets in. Vibration can be seen visually in cable oscillation and heard as resonance occasionally.

Think of it like a swing.

Pushing a person in time with the natural interval of the swing (its natural frequency) makes it go higher and higher (increasing energy). Pushing the swing at faster or slower speeds to its natural frequency reduces the energy, resulting in a loss in swinging speed and height.

When is vortex shedding most likely to occur?

Cable vibration is a complex phenomenon and can occur in any rigging, no matter the material. It is also found in tensioned halyards. Any uniform-shaped cable held under tension in an environment exposed to wind flow is susceptible.

An assessment of the likelihood of vibration can only be made once a rigging configuration is installed and structurally active. It is impossible to declare any cable system free of vibration as numerous factors must be taken into account, all of which differ from yacht to yacht. Factors such as cable tension, hull material, mast interface, consistency of shape along the rigging length, wind speed, density and angle of attack, and alternate energy sources all modify the likelihood and extent of vibration.

If vibration does occur, damping is the solution.

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02
ISOLATION & DAMPING

What is damping?

Damping is the reduction or elimination of energy in a system. There are two main approaches to this; (a) vibration isolation and (b) vibration damping. In both cases, the movement and noise associated with vibration will be reduced or removed.

- Isolation changes the frequency of a system, ensuring the natural frequency is 'out-of-sync.'
- Damping reduces or removes the energy from a system.

Inherent damping

Some systems have inherent damping, allowing the cable to dissipate a certain amount of vibrational energy. Often this inherent damping is insufficient, especially when vortex shedding coincides with the natural frequency. Therefore it becomes necessary to add supplementary damping.

Supplementary isolation & damping

1. The simplest method is to create a disturbance on the cable to prevent the formation of vortices.
   - A widely used solution is to add a spiral, known as a helical strake, to disrupt wind flow (as seen on many chimneys.)
   - Adding an elliptical flap, able to align with the wind direction, has also proven to be an effective disruptor on TP52's & AC50's.

2. The cable itself can be designed to reduce or remove vortices and to encourage 'out-of-sync' frequencies.
   - Varying the cross-section shape along the cable length (CL ELLIPSE) has proven to be effective.
   - Easing load will alter the frequencies and reduce the likelihood of vibration.

3. An external passive damping device.
   - When a cable begins to vibrate, the damper will move with the cable and dissipate any energy leading to vibration.
   - The CL DAMPER has been successfully installed and proven on several CL SOLID rigging projects.

Spirals

CL DAMPER

CL ELLIPSE - shaped rigging

03
CL DAMPER

CL DAMPER: Energy dissipation

- In collaboration with ETH Zurich, a range of relative displacements were explored to optimise damper geometries & mass.
- The damping efficiency is independent of the acceleration and mode of cable vibration.
- The damper does not impede the free movement of any rigging cable nor affect the structural integrity.
- The damper can be easily installed and adjusted at any stage.
- The damper is effective on any rigging type.

Identify the cable(s) driving vibration

Usually, it is only one or two cable/s that drive vibration. It is essential to identify which cable/s are causing vibration.

The first step is to anchor the yacht in conditions which usually result in vibration or sit at the dock in troublesome conditions. Once the yacht is experiencing vibration, ease off the backstays to see what effect this has. If vibration stops, the backstays are the driving factor, and a damper should be installed. If the vibration continues, isolate each diagonal by holding the cable firmly until the individual cables stop. If the system still vibrates, this cable is not the driving factor. Continue until you have isolated the cable/s which stop the entire system from vibrating. Once this cable, or group of cables, can be identified, it is possible to install a damper/s.

Installation Overview

1. Once the cable/s is identified, a corresponding damper will be made available to suit the cable weight and diameter.
2. The damper is delivered fully assembled. Split into two halves, clamp around the cable and fasten (a wrap of amalgamating tape below the end is encouraged.)
3. Install in a region where the level of displacement/acceleration is high. Around 1.5m away from a node (mast or deck termination.)
4. It may be necessary to move the damper up or down the cable by 1–2m to improve the overall effectiveness.