A Unique Fairlead Mechanism for Cable Handling

This space-saving cable guidance device has fast become the standard on multi-streamer seismic vessels, with applications on surface and submarine towed array systems and for specialized offshore, cable-laying, and ROV requirements.

Mark Pollock
Vice President Engineering
and
Robert Harris Stoertz
Quality Assurance Manager
ODIM Spectrum Ltd.
Peterborough, ON, Canada

Proper handling of a marine cable is often underrated. Yet vessel downtime and cable replacement resulting from damage can be extremely expensive. Whether it is tough wire rope, complex electro-optical cable, or delicate oil-filled streamer, the service life of a cable depends directly on the guidance components of its overboarding system. If these do not address the cable's physical characteristics and limitations, and the nature of its application, rapid deterioration and failure of the cable can result.

The importance of the handling system and the high cost of cable failure is not new. Pulleys of various sizes were used in ancient Roman derricks. The cables of more recent sailing ships were reeled off large capstans and paid-out through flared hawse holes to prevent damage to the manila fibres. There are few fundamental differences between these beginnings and some contemporary solutions to cable overboarding, such as the bellmouth (a fixed, trumpet-shaped guide) and the sheave (basically a pulley).

The Overboarding Problem

Overboarding equipment handles and protects a cable where it crosses the side of a vessel and enters the water. An inadequately designed overboarding system can contribute to premature cable failure in several ways.

Bend radius violation is perhaps the most common problem. For example, a large sheave that meets the minimum bend radius of the cable during routine towing may nonetheless allow it to bend excessively when the tow-off angle increases. Abrasion and weakening of the cable surface can occur anywhere there is relative motion between the cable and the handling system components it contacts, particularly when loads are high. Point loading, such as that caused by small fixed rollers, may locally deform the cable structure, weakening it and damaging internal conductors.

The well-designed sheave is a good overboarding solution if it swings to accommodate changing tow-off angles. Without the ability to swing, the cable will be pulled across the sheave flange, resulting in fatigue and abrasion. In an application with a large-diameter cable and a correspondingly large sheave, the space required for the sheave to swing becomes problematic. And on vessels towing multiple cables, space is a primary concern.

Bellmouths address the problem of tow-off angles by providing radial support in any direction. However, they allow the cable to be dragged across a fixed surface which—regardless of how well-greased it is—can cause severe abrasion and frictional heating, especially when under high tension.

A hybrid approach combines the characteristics of the bellmouth and the sheave, employing multiple small rollers mounted on a fixed curved surface. This may be the worst possible solution, because each roller applies localized high compressive stresses and cyclical bending to the cable, and the resulting wear is comparable to that caused by running the cable over a similar number of full-size sheaves. As a result, cable life can be greatly abbreviated.

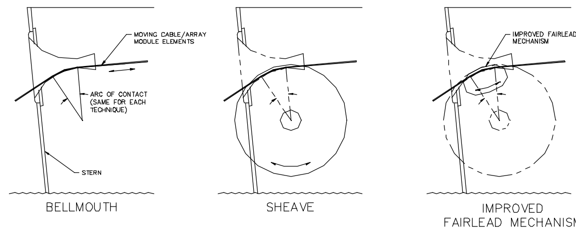
When cables include plastic sheathing, fine conductors, fibre optics, or cable-mounted equipment, the limitations inherent in these outdated techniques become prohibitive.

Improved Fairlead Mechanism

In 1991, the Canadian Navy commissioned the Ocean Systems Group of Spectrum Engineering, Inc. (now ODIM Spectrum Ltd.) to develop an entirely new approach to overboarding for the CANTASS towed array system. The result of this project was the *Improved Fairlead Mechanism*, a device used for both level-winding (uniform wrapping of a cable on a winch drum) and overboarding. The unique Fairlead Mechanism was soon in demand by the offshore seismic oil and gas exploration industry, and is now standard equipment across the backdecks on all the latest seismic survey vessels. More than 300 Fairlead Mechanisms of various types are installed.

Military applications also expanded, and the Fairlead Mechanism has been employed to handle towed sonar systems on naval surface ships, including the Thomson Marconi LFAPS system for the Royal Australian Navy's FFG-7 and ANZAC frigates. It is currently being developed for towed array guidance aboard submarines, where its space savings will be particularly welcome.

The most important innovation of the Fairlead Mechanism is the flight chain concept. A segmented belt of "flights" cradles the cable through an arc meeting its minimum bend radius requirement. At the end of the maximum arc of contact with the cable—determined by the actual application—the flights return directly under the unit to the beginning of the arc. Space reduction compared to a sheave with the same effective radius typically approaches 75 percent. This savings equates to room for more equipment on the back deck.



A comparison of different overboarding techniques; the bellmouth, sheave, and Fairlead Mechanism.

The improvement in unit size leads to the considerable tow-off capabilities of the Fairlead Mechanism. When mounted to swing freely, the most extreme angles can be accommodated without violating the minimum cable bend radius. While similar mounting of a sheave is possible, its larger size means it will swing through a much larger space.

The flights slide over a smooth track surface on proprietary low-friction bearing pads. Each flight supports the cable on a wear-resistant urethane cushion that is profiled to match the cable and maintain control at the largest fleet angles (the cable angle between the winch and the Fairlead Mechanism). By conforming to the surface of the cable, the urethane distributes axial loads more uniformly over the cable surface and minimizes point loading. Varying diameters on a single cable (due to instrumentation, connectors, the combination of different cable sizes, and so forth) are handled successfully. Large diameter items can ride on the tops of the flights.

The effectiveness of the Fairlead Mechanism is maximized when it is mounted with three degrees of freedom. This allows it to support and protect the cable while responding to sea conditions, vessel motions, and tow-off angles. A ball joint mounting rated at 17 tonnes vertical safe working load (SWL) was developed to provide free movement in a compact space. For applications where this amount of freedom is not required, hanging brackets with one or two discrete rotating joints are used.

Hanging brackets also work as "keepers", preventing the cable from lifting away from the Fairlead Mechanism as a result of ship movement in high sea-states. In these dynamic conditions, the cable may “hunt” within a zone limited entirely by the flights and keeper.

The simplicity of the basic Fairlead Mechanism design leads to its high reliability and low maintenance

Technical Challenges

Transferring cable loads to the unit structure without hindering easy rotation of the flight chain was the greatest technical challenge in the Fairlead Mechanism development. Tension loads of many tonnes impart large radial loads as the cable wraps over the unit, yet the application of axial loads to the moving cable by friction in the mechanism must be minimized to prevent damage to the cable.

An obvious first concept for the mechanism involved wheels under the flights. Load concentration, however, becomes extreme at each wheel, making the device sensitive to particulate contamination and wear. In the tough marine environment, this was not acceptable.

Various alternatives to wheels were investigated, and the research led to sliding interfaces. The best solution was determined to be a low-friction pad of proprietary material attached to the bottom surface of each flight. The flights slide on their bearing pads over a smooth, hardened steel track surface. Grease is applied through orifices in the track surface.

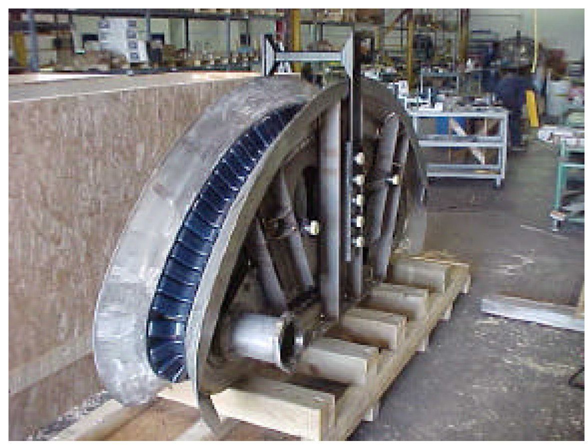
Internal friction in the mechanism is manageable for units with operating vertical load ratings up to 10 metric tonnes. In this range the cable can drive the flight chain without experiencing excess shear forces at the cable surface.

In units rated up to 35 tonnes, the flight chain may be powered independently or assisted by a hydraulic motor. Various power arrangements are possible, such as synchronizing the Fairlead Mechanism motor to the rotation of the winch, or applying slightly less power than that required to rotate the flight chain, allowing the cable to control the actual speed and direction of rotation.

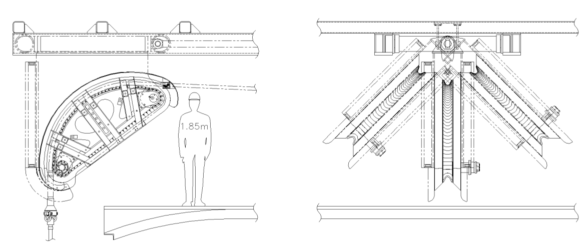
Fairlead Mechanism Applications

Aside from acting as an overboarding and towing device, the Fairlead Mechanism has also returned to its roots, serving in level-wind systems. This is particularly useful when a winch is located in a confined space or at an angle to the cable path, and space limitations do not allow incorporation of a full-sized sheave in the level-wind device, or when the fleet angle from winch to overboarding hardware is greater than can be accommodated by a sheave.

A demanding application for the Fairlead Mechanism is deployment and recovery of ocean bottom seismic cables. As it traverses the stern of the vessel and travels straight down to the seafloor, the cable may undergo a change of direction of 90 degrees or more. In deep water with a large diameter cable, the loads wrapped over such a large angle lead to enormous loads at the sliding bearing interface. These overboarding units must be routinely tested to more than 70 tonnes at the factory.



A Cable Overboarding Unit with 105 degree wrap angle undergoing 70 tonne static load testing.



A typical Fairlead Mechanism installation for laying ocean bottom seismic cable.

Another challenging task is the handling of cables with ODIM Spectrum's hydrodynamic drag-reducing fairings installed. Flexible *TufLine*™ fairing systems—now commonly used for drag reduction—travel relatively easily through a handling system, and wrap onto a winch without difficulty. However, the rigid *TufNose*™ fairing system, popular for its maximum drag reduction, requires special care. ODIM Spectrum addressed the demand for Fairleads capable of handling fairings by designing a Fairing Uprighter. As its name implies, the Uprighter guides each fairing into a tail-up position as it approaches the handling system, preventing it from snagging.

Future Growth

In 1974, when ODIM supplied its first towed streamer winch system to Geco-Prakla, a typical seismic survey vessel towed a single streamer cable. The number of streamers towed from today's larger 3-D/4-D seismic vessels is typically between eight and 12, with companies planning in the near future to achieve 16 to 20 array configurations, each about eight kilometres long with spreads approaching two kilometres. The backdeck systems required to handle these sensitive electro-optical tow cables and streamers must be sophisticated and extremely reliable.

ODIM Spectrum's Fairlead Mechanisms guiding hairy-faired cables in close quarters with high tow-off angles.

ODIM Spectrum

ODIM Spectrum Ltd. (originally Spectrum Ocean Systems Ltd.) has been designing unique towing and handling products since the mid-1980's. The company is now part of the ODIM group of companies, headquartered in Norway. ODIM is the leading supplier of cable handling systems to the marine seismic industry. The group supplies cable handling and hydrodynamic systems to all of the major oil and gas exploration companies, including Aker-Geo, CGG, Geco-Prakla, PGS, Veritas, Western Geophysical, and several others.

Mark Pollock has been with ODIM Spectrum since 1990 and has 20 years experience in mechanical and electromechanical engineering, design, and manufacturing. He obtained his B.A.Sc and M.A.Sc from the University of Waterloo in Ontario.

Robert Harris Stoertz is ODIM Spectrum's technical writer. He has 19 years of technical experience, primarily in high-reliability manufacturing.