



WHITE PAPER:

Cable management under adverse conditions:

e-loop® as a versatile problem solver

igus®



Picture 1
Service loops used to be the standard solution to supply energy to top drive drilling rigs.

Source: igus® GmbH



Picture 2
The robust, durable alternative: e-loop®.

Source: igus® GmbH



Picture 3
The high-tensile composite design principle for strain relief used in the e-loop® series has already proven itself in a heavy-duty e-chain system® for offshore wind turbine installations.

Source: igus® GmbH

Introduction

A power and signal supply system for heavy-duty applications is an example of the creativity of design engineers and how quickly they implement their ideas in the heavy machinery industry. Originally developed for a very special application in deep-drilling rigs, the system was used just a short time after its market launch in such applications as bucket wheel excavators, ship unloaders, and offshore wind turbines. These systems require energy supply systems that are extremely resistant to wind, shocks, impacts, and tensile forces.

The task was clear: the user wanted a more robust, durable alternative to the "service loops" in common deep drilling rigs (picture 1).

These loops are wrapped, molded cable packages connected to a fixed point on the drilling rig, freely suspended in the mast. In "top drive" design drilling rigs, they supply energy, signals, and fluid media to the top drive. They do this under extremely adverse conditions, such as vibrations, irregular mechanical stresses and heavy contamination.

Development goal: greater reliability for hanging energy supply systems

The aim of the new development, which igus® presented for the first time at a trade show in 2019, was the durability and reliability of the energy supply. The drilling rigs work 24/7, and every unscheduled downtime results in losses in the availability and productivity of the rig.

Durable and movable in three dimensions: the e-loop®

igus® design engineers have developed a new system of energy supply for just this application: the e-loop® (picture 2). One of its main features is the separation of the guide and housing elements from tensile force absorption. The designers were able to borrow ideas from the e-chain system® for offshore applications, which has already proven itself in demanding offshore wind farm applications and with long cable lengths (picture 3). This e-chain system® has a rectangular cross-section and a high-tensile plastic rope in the middle for strain relief.

A basic principle was adopted in the e-loop®. The rope absorbs tensile forces and transfers them via the mounting brackets to the support structure. The suspension points do not bear the entire weight of the chain during every movement (picture 4).

High resistance to mechanical loads

The e-loop® is suitable for multi-axis movements and can absorb high forces from all directions. This is necessary because cable package weights can be considerable (13.4 to 20.2 lb/ft [20 to 30 kg/m]). The chain must withstand corresponding loads in all directions: the plastic chain with its high-tensile rope as the "core" can guide large single-core cables with cross sections of 0.62in² (400mm²) in three dimensions.

Quickly proven – for good reason

The e-loop® first proved itself in the igus® test field (picture 5), then in pilot applications, and later in deep drilling rigs. The system met with great interest in the target market. There was clearly potential for improvement in the energy supply system on drilling rigs, as until then the prevalent service loops had no guide and no defined bend radius. They move without control and, in the worst case, can break. The individual cables inside the hoses also move in relation to each other, leading to premature wear, including cable breakage. Furthermore, in extremely windy conditions, the loosely hanging service loops can get caught in the mast or lighting system and even tangle with each other and break. The entire cable or hose assembly must then be replaced because the individual cables are molded to the hose. This increases cable service life, but also means that the entire loop must be replaced if a cable breaks, for example.



Picture 4:
The e-loop® consists of circular basic elements. Clearly visible in the middle is the guide for the rope.
Source: igus® GmbH



Picture 5:
igus® test laboratory
Source: igus® GmbH

Use cases in unexpected application areas

The first application uses an 11.81" (300mm) chain with a travel of 111.5 ft. (34m). It moves at a maximum speed of 7.2 ft/s (2.2m/s) and carries a fill weight of 12.8 lb/ft (19kg/m).

The igus® designers had developed the e-loop® for precisely such an application. The widely varying applications that arose shortly after launch, however, surprised the designers.



Picture 6
Ship unloader
Source: www.istock.com

Use case 1: Ship unloader

Ship unloaders for bulk material are equipped with a telescoping, multi-dimensionally movable suction nozzle that can be used to completely empty the hold. Sensors on the nozzle prevent such mishaps as collisions with struts and supports in the hold. Cable packages leading to the sensors were usually laid loosely because there was no energy supply system for this application. One operator has now equipped an initial ship unloader with several e-loops® and is satisfied with the solution. (picture 6)

Use case 2: Bucket wheel excavator

Semi-mobile bucket-wheel excavators in open-cast mining are supplied with electricity by means of a large-dimensioned cable package ("power cable"). In the case described here, the cables are guided on a conveyor belt for material removal. In practice, this caused problems and failures, especially when there was frost. The cable package lies on the ground, which can suffer damage when moved.



Picture 7
In this application, the e-loop® is sometimes hanging and sometimes on the ground, depending on the excavator boom condition.
Source: Holcim/igus® GmbH

In a pilot application in northern Germany, an open-cast excavator was retrofitted with an e-loop®, with the loop not only hanging but also lying on the ground, depending on excavator location. The system is proving so successful that two more heavy bucket wheel excavators are to be equipped with e-loops® soon. (picture 7)

Use case 3: Installation vessels for offshore wind farms

Offshore wind farm construction involves installation vessels with "pile grippers": complex, heavy grippers that guide and hold the mast under extreme conditions, while it is fixed in the foundation. They must compensate for wave movements and drift, so they are equipped with automated "heave compensation", which aligns the gripping element properly in all moving axes. igus® is currently planning a project for customized e-loops® for two manufacturers of these "pile gripper" installation ships. (picture 8)

Use case 4: Heavy-duty storage and retrieval unit

A manufacturer of concrete foundations and prefabricated concrete parts stores the heavy, large-format components in an outdoors XXL rack. In or above the 40-meter-long racking aisle, a storage and retrieval unit similar in design to a gantry crane travels. Energy and signals are supplied to the load suspension device on the Z-axis by means of an e-loop® freely suspended below the SRU. A standard e-chain system® cannot be used here because there is no way of providing guidance. The e-loop® allows reliable energy supply on long travels and without additional components such as guide troughs or guide rails.

Use case 5: Offshore solar plant

These four projects have already been discovered and others are currently in the project planning phase. In one example the solar modules could be mounted offshore on floating pontoons in order to gain additional space to generate solar power, and because the waves move them relative to each other, the power and signal lines would be connected by e-loops®.

A closer look at the e-loop®: safe and weather-resistant cable protection

All five applications briefly described here—plus the original target application in deep drilling rigs—involve outdoor operations under varying but always adverse conditions.

This is as it should be, as the entire e-loop® design is thoroughly weather-proof. The chain material is corrosion-free and chemical-resistant. The movable chain link connections are also designed for long service life under extreme conditions. The rope at the center consists of a synthetic plastic fiber and is therefore extremely durable, weather-resistant, flexible, and corrosion-free.



Picture 8
Another field of application for the e-loop® is "pile grippers" on installation vessels for offshore wind farms.

Source: www.istock.com

Reliable cable protection, simple installation

The e-loop® is also optimally protected against mechanical loads. It consists of individual chain links with a shock-resistant outer body attachment made of PU foam and cable-friendly inner parts made of a high-performance polymer (see picture 4).

The modular e-chain system® can be opened from the outside and easily filled. Individual cables can be inserted quickly and replaced during maintenance. The chain links can also be replaced at any time.

"Tried and tested": Crash testing for e-loops®

Typical of all igus® products are the comprehensive tests conducted in the development phase. For example, a completely assembled e-loop® with cable filling for a 500t top drive was run in endurance tests outdoors, with all environmental influences plus simulated wind and vibrations. The chain has now completed around 120,000 double strokes. The results show that all the weather-related influences have no effect on e-loop® function. Even lateral impacts, shocks, and constant vibrations do not impair the function of the e-loop® and cables.



Picture 9
The testing to which the e-loop® was subjected prior to launch included break tests involving impact on a steel safe.

Source: igus® GmbH

An impact test was also enlightening. It involved an e-loop® being hung from a safe height of 32.8 ft. (10m), and hitting it with full force. The chain system survived the test without any problems (picture 9).

Suitable cables, developed for mobile applications

It goes without saying that the best moving cable carrier (multi-axis movement in this case) can be used constructively only if the cables can also withstand the relevant loads. Conventional cables do not meet these requirements. This is why igus® has added cables designed specifically for power supply to top drives to the chainflex® motor cable product range. These cables were developed for moving applications and are now available with large cross-sections. The CFSPECIAL range includes single cores with cross-sections from .37 to 0.62 in² (240 to 400mm²) and pair-shielded cables (picture 10).

Product seeks application: many more projects and ideas

The e-loop® is currently available in various versions and three outer diameters: 8.66", 11.81", and 16.93" (220, 300, and 430mm). The largest variant, with a diameter of 16.93" (430mm), was added to the two existing series on the basis of a customer application.

Besides the implemented or designed applications presented here, there are many other ideas for using the e-loop® as an energy and data supply system outdoors and under adverse conditions.

For igus®, the e-loop® example shows that it's worthwhile to carry out intensive development work, even for niche markets. If the design is mature and the product proves itself, additional areas of application can be opened up. With the e-loop®, the new series could establish itself as the standard solution for heavy-duty applications in the broad e-chain system® product range from igus®. This is not surprising because deep drilling rigs are not the only systems that need their energy supply to be extremely resistant to wind, shocks, impacts, and tensile forces. The basic e-loop® design—cable guide as strain relief, robust chain that can move in multiple dimensions, bolted chain links and protectors on the outer jacket—fits this application profile and is therefore suitable for a wide variety of areas of use.



Picture 10
Another new development is suitable CFSPECIAL cables with large cross-sections (up to 400mm²) for the e-loop®.
Source: igus® GmbH

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