WHITE PAPER:

Cable guiding in vertical drilling rigs: From service loop to e-loop

A newly developed alternative to service loops on vertical drilling rigs, offering significantly longer service life under extreme environmental conditions.

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igus®

Figure 1: Top drive with service loops and flushing hose on an oil drilling platform
(Source: Adobe Stock, Alexandr, 211146059)

Mobile and semi-mobile (deep) drilling rigs in the oil and gas industry are among some of the most heavy-duty applications in engineering. They drill holes up to several kilometres deep into the earth's crust, their drill pipes can weigh up to 1,000 tonnes, and the central components are exposed to extremely adverse conditions such as vibrations, irregular mechanical stresses (impact and shock loads) and heavy contamination.

This also applies to the energy supply systems that are suspended here. They convey electrical current, signals and, if necessary, hydraulic media to the "top drive", i.e. to propel the drill pipe (Figure 1).

- For top drive drilling systems, energy and signals must be conveyed to the (movable) top drive.
- The energy transmission takes place under adverse conditions.

Availability in focus

When selecting the energy and signal supply to the top drive, the designers attach great importance to durability and reliability. This is because the drilling rigs work in 24/7 operation and any unscheduled downtime results in losses in the availability and productivity of the rig.
The required high availability is not easy to achieve under the adverse environmental conditions described above. A central factor is the avoidance of "set-up times" during which production, i.e. drilling and pumping cannot take place. Therefore, the "rig-moving times" should be kept as short as possible: the rigs should be designed in such a way that they can be quickly dismantled and reassembled at another location.

- Productivity and minimisation of downtime are central criteria in the design of top drive drilling rigs and in the selection of components such as energy supply systems.
- In addition to temporarily fixed installations, there are also mobile "walking units" that can move automatically.

State of the art: the service loop

Traditionally, service loops were used for the energy supply of the top drive. These consist of cable packages which are coiled inside a rubber hose casing, and suspended from a fixed point of the drill rig, i.e. they are freely suspended in the mast.
Depending on the drive concept (electric/hydraulic), the cables are divided into several "loops": for the electrical energy, for the signal cables and for the hydraulic system. Combined loops are also common.
This type of energy and signal supply to the drill pipe is often very problematic an unreliable, especially under the conditions just described. The cables/hoses are not guided and do not have a defined bend radius. They can move out of control and, in the worst case, break. In addition, the individual cables inside the hoses move in relation to each other, this leads to premature wear and tear and even to cable breakage. The loosely hanging service loops in the mast can get caught in the sensors and lighting system, or get entangled in each other and tear off under extremely windy conditions. In these cases the complete cable or dress pack must be replaced because the individual cables are moulded to the hose. This then affects the availability of the entire drilling rig.

- Service loops are the state of the art technology for energy transmission to the top drive.
- Service loops can affect the availability of the drilling rigs.

Even better: the energy chain

These problems led leading manufacturers of vertical drilling rigs to use energy chains instead of service loops. This development is also logical because (steel or plastic) energy chains are used in other moving sub-systems of the drilling rigs, for example, in pipe handling (handling of drill pipes).

Some manufacturers use steel energy chains here because the ambient conditions are unfavourable and a high mechanical stability of the chain is required. For the same application conditions, igus® has developed polymer energy chains in heavy-duty designs, which also achieve a significantly longer service life than the service loops (Figure 2). The reasons for this are the structured interior separation and the clearly defined travel, which also has the advantage that

Figure 2: Energy chain system for top drive and pipe handling on a land drilling rig
(Source: igus® GmbH)

collisions of the cable strand with the drilling rig or drill pipe are excluded. Snap-in clamp separators, specially designed for the application, guarantee a secure hold of the crossbars. Compared to metal chains, polymer chains also offer the advantages of corrosion resistance and significantly lower weight - and they are also stable and durable.

- Users of top drive systems are looking for alternatives to the service loop.
- Polymer energy chains in heavy-duty applications provide a solution and are already proving themselves.

Developed for the application: the e-loop

In order to be able to offer the optimum solution for this extremely demanding (niche) application, the igus® designers have intensively studied the requirements and developed a fundamentally new system: the e-loop (Figure 3).

In addition to concrete stresses with regard to the mechanical properties, the specifications included the three-dimensional mobility of the new energy chain and the compact type. Ease of service also played an important role, as did the smallest possible bend radius - and all this in one system that operates under adverse environmental conditions and is subjected to everything but careful handling during operation.

Figure 3: The e-loop system combines all cables into a compact and modular system
(Source: igus® GmbH)

- New development specifically for top drive systems
- Design features are: compact, robust design, three-dimensional mobility.
- The interchangeability of all modular components saves costs in service and time in procurement.

Basic idea: borrowing from robotics

A central design feature of the e-loop is the separation of the guide or housing elements from the absorption of the tensile forces. The designers were able to "borrow" conceptually from the e-chain® for offshore applications, which has proven itself for years in demanding applications for offshore wind farms and with long cable lengths (Figure 4). In this energy chain with a rectangular cross section, there is a high tensile strength plastic rope in the middle as strain relief.

This basic principle was adopted in the e-loop. The rope absorbs the tensile forces and transfers them via the mounting brackets into the support structure. So the chain (here round and hanging) is not hanging with its entire weight on the suspension points during every movement.

- Above a certain length, energy chains need a guide trough.
- Above a certain travel, energy chains (incl. cables and guide troughs) are more expensive than comparable installations with busbars.
- Energy chains need more installation space than busbars.

Figure 4: igus® offshore chain with similar design as the e-loop
(Source: igus® GmbH)

High resistance to mechanical loads

The e-loop is suitable for three-dimensional movements and can absorb high forces from all directions. This (as well as the effective strain relief) is necessary because the cable packages can reach considerable weights of 20 to 30kg/m. Very powerful drives are required to propel the drill, and these in turn require motor cables with a cross section of typically 400mm² per single core. The chain must withstand corresponding loads in the three-dimensional movement. The "hybrid construction", i.e. the combination of the polymer energy chain with the high-tensile rope as the "soul" of the whole, meets these requirements. And with 500mm² it also achieves a small bend radius. This saves space.

- Single core cables with cross sections of 400mm² are guided safely.
- Thanks to the "hybrid design", the three-dimensionally moving energy chain is highly resilient.

Figure 5: Structure of the e-loop, half-shells with shock-resistant PU attachment
(Source: igus® GmbH)

One system for all cables

In contrast to the service loops, a single e-loop system can accommodate all the cables that are routed to the top drive: motor cables, signal cables and, if necessary, the hydraulic medium. This prevents the service loops from becoming entangled with each other, for example in strong winds. The division into two chambers creates the conditions for a wear-free movement of the various cables.

- A protected cable system is less susceptible to wear than two or three moulded cables that can move against each other.
- The separation of the e-loop into two chambers protects the individual cables.

Easy maintenance, assembly and disassembly

Several secured screw connections are used between the elements of the energy supply, which prevent components from falling down and increasing operational reliability. The screwed mounting brackets also facilitate the assembly and disassembly of the e-loop.

- The e-loop is easy to install.
- If necessary, individual cables can be replaced with little time and effort.

Reliable cable protection

e-loop consists of individual chain links, which have a shock-resistant outer body attachment (protector) made of PU foam and cable-friendly inner parts made of igumid high-performance polymer (picture 5).
The igus® material is corrosion-free and chemical-resistant. The movable connections of the chain links are also designed for long service life under extreme conditions.

The rope at the centre of the e-loop is produced from a synthetic plastic fibre and is therefore shatterproof, weather-resistant, flexible and corrosion-free. The individual chain links are clamped onto the pull rope, which is pre-tensioned to the working load.

- Protected from the outside and inside: this is one of the reasons why the e-loop and the cables achieve a long service life.

Figure 6: Chain link of an e-loop with two-chamber design and PU outer body
(Source: igus® GmbH)

"Tried and tested". Crash test for energy chain

As is typical with all igus® products; comprehensive tests are carried out in the development phase, which take place in our own test centre. For example, a fully harnessed e-loop with cable filling for a 500-tonne top drive was subjected to endurance testing in the open air, which was exposed to all environmental elements as well as additional simulation of wind and vibrations. The chain has now completed 40,000 double strokes. The result: the e-loop was able to operate without weather having an effect on its functionality. Even lateral shocks, impacts and constant vibrations do not impair the function of the energy chain and cables.
A break test was also revealing. In this case, an e-loop was dropped against a strong box from a height of 10m and hit it with full force. The chain system also survived this test without any problems (Figure 7).

- Endurance test with 40,000 double strokes under tough practical conditions without failures
- The system has also successfully passed a pendulum break test against a steel cabinet.

Figure 7: The e-loop survived the breaking test with a strongbox without any problems.
(Source: igus® GmbH)

Cables developed for mobile applications

For this application, i.e. the energy supply of top drives, igus® has expanded the range of chainflex motor cables with larger cross sections. The entire chainflex range has been developed from the ground up for use in moving applications - and the user benefits (when properly designed) from dependable operation of the cables for at least 36 months. This is the duration of the guarantee that igus® gives on all chainflex cables and also on the energy chain.

- Suitable chainflex (motor) cables with 36-month guarantee are available.
- The guarantee also applies to the energy chains.

Application. Not only in deep drilling rigs

The e-loop is available in different versions and two outer diameters (220mm and 300mm). One of the first users, is a company in the oil and gas industry that operates various vertical drilling rigs and uses the e-loop as an energy supply system on the top drive of a deep drilling rig (land rig). The chain with a travel of 34m moves at a maximum speed of 2.2m/s and carries a fill weight of 19kg/m. It has proven its worth in practical use (Figure 8).

In addition to vertical drilling technology, igus® also targets other demanding areas of application with the e-loop. The corrosion-free system is suitable for hanging applications in the offshore industry, for construction machinery and shore power or wind turbines. For these applications, the chain links of the e-loop can be equipped with rollers (for easy movement on the floor) or handles (for easier handling in combination with rollers).

- The system has successfully completed the initial practical tests.
- In addition to vertical drilling technology, there are also other possible applications, e.g. in the offshore industry, construction machinery and shore power and wind turbines.

Figure 8: The first e-loop systems are already in operation on land drilling rigs. (Source: igus® GmbH)

Contact

If your require further information, the experts in the energy chain systems department will be happy to help you.

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