# DLC-1, 2 AND 3 CABLE CONNECTING DEVICE COST REDUCTION BY DESIGN IMPROVEMENTS

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**Abstract:** DLC-1, 2 and 3 cable connecting devices are used in the winding installations, to safely fix the winding cable to the extraction vessel (cage), with a safety coefficient higher than 8. The paper shows new device design solutions, leading to simplification and standardization of solutions from technological point of view, without decreasing the safety coefficient, improving technical performances and their costs.
**Key words:** cable connecting device, design improvement

## Cable connecting device design and operation

Cable connecting devices are known to be very important from extraction point of view. They are subject to significant static and dynamic loads during the extraction process. Moreover, additional strains can come up in the form of transversal, longitudinal or torsion oscillations, due to incorrect mounting or excessive wear of the shaft guiding devices.

Connecting devices are classified function of design and function of the extraction cable used.

From the point of view of cable retaining manner, connecting devices fall into tightening devices and self-tightening devices.

Self-tightening devices can be carried out in several design variants, but for this paper we chose the ones with the cable wedged on one side. (Fig. 1)

DLC-1, DLC-2 and DLC-3 metal self-tightening cable connecting devices, of round section and one side wedging, are used to safely fix of winding installation cables of extraction vessels, with minimum 10 safety coefficient.

Design and operational characteristics of DLC-1, DLC-2 and DLC-3 devices shown in Fig. 2 are given in Table 1.

When ordering, it is required for the beneficiary to give the d cable diameter, the D bolt diameter and the $G_t$ width of the extraction vessel rod.

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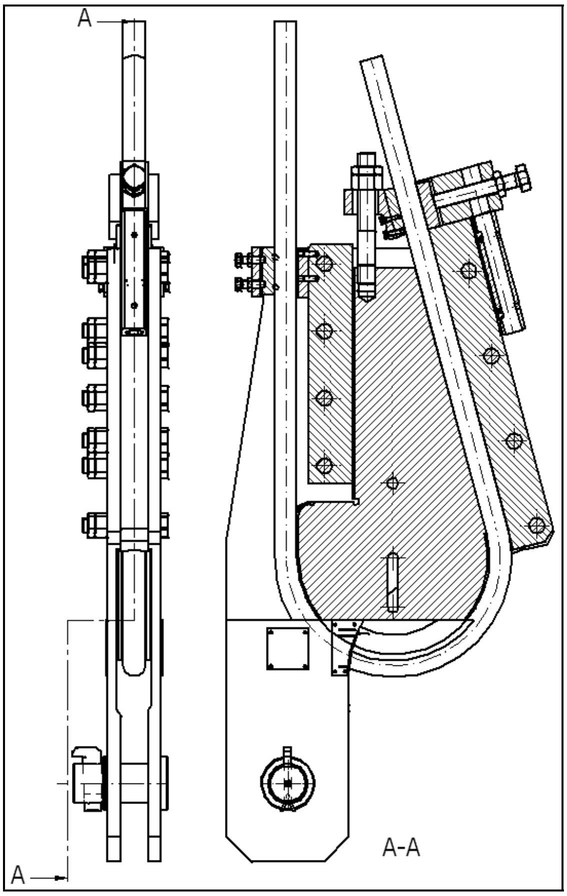


**Fig. 1** *Cable connecting device with one side self-tightening , the previous solution*

DLC-1, DLC-2 and DLC-3 type cable connecting devices are one side wedged core design variant. The extraction cable is wrapped around the, 9, feather shaped metal core.

The core can slide inside into a metal structure made up of left-right shields, 4-5 reference points and right-left jaws, 3 and 6 reference points, which are made rigid one against the other by means of special 7 screws and 8 adjustment pegs.

Adjustment peg are intended to provide execution and precise positioning of elements in the mechanical resistance structure in view of ensuring the wedging angle.

Right jaw, 9 reference point, is inwardly provided with a groove similar to the one on the core, which together provide the cable's wedging surface. The two cable fixing surfaces are lined with an anti-friction alloy based on lead and tin, providing cable protection against crushing.

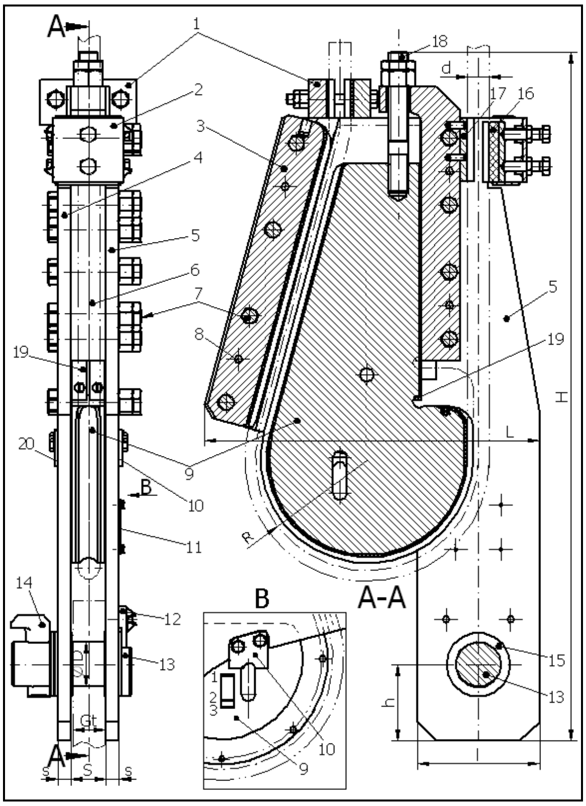


**Fig. 2** *Cable connecting device, with one side self tightening, the new solution*

The higher the suspended load, the more significant the friction force between the cable and the two surfaces. In the lower side, the shields are provided with holes for the main bolt, 13, reference point, which provides the connection with the extraction vessel. The principal bolt is mounted in the gland of 15, the main bolt gland, which allows the use of various bolt diameters, without processing the boreholes in the shields, the bolt's mounting diameter being obtained only by processing its inside.

Moreover, the gland has also the role to protect boreholes in the shields against becoming oval i the area where there might be direct contact with the main bolt.

The main bolt is fixed on the one hand with the help of a stopping plate, 12, which also hinders the bolt to be twisted, and on the opposite side by means of 14, an inclined wedge.

The boreholes centers in the shields, that is the centre of the main connecting bolt matches the cable axis, which is accomplished by adopting the right thickness of the 19 guiding rules, function of the cable diameter in the (d...d'), cable group, the rule's thickness variation is 2 mm.

In order to provide the cable's fixing capacity, in the device, as an additional possibility, the free end of the cable was fixed in a pair of 1, clamps, leaning on the upper part of the shields.

By guiding the cable on the lined centre, and fixing it between an elastic element 16, and a fixed guidance 17, the fatigue of the cable in the area of entering in the device is reduced, the number of broken wires of the cable in the respective area being less.

De-wedging of the core, which is releasing the cable from the device case, is made by detaching the clamps 1 from the cable and the nuts from the 18, dowel pin, and pushing the core downwards. The travel distance is limited by the right and left lugs, 10 and 20.

The 11, label is used to identify the cable connecting device.

**Table 1** *Characteristics of DLC-1, DLC-2 and DLC-3 cable connecting devices*

| Nr. crt. | Characteristic | | Unit | Value | | |
|---|---|---|---|---|---|---|
| | | | | DLC-1 | DLC-2 | DLC-3 |
| 1 | Maximum static load | | ton (kN) | 10,2 (102) | 17,5 (175) | 27 (270) |
| 2 | Cable diameter, d | | mm | 25; 26…30 31…35 | 36…40; 41…45 | 46…50; 51…55 |
| 3 | Cable wrapping radius , R | | mm | 173 | 220 | 270 |
| 4 | Cable fixing modality | | - | One-side self-tightening | | |
| 5 | Bolt diameter, D | | mm | 70; 80 | 80; 90 | 90; 100; 110 |
| 6 | Space btw. shields, S | | mm | 55 | 60 | 70 |
| 7 | Shield dimension (in bolt area) | height, h | mm | 120 | 160 | 200 |
| | | width, l | mm | 190 | 250 | 300 |
| | | thickness, s | mm | 20 | 28 | 35 |
| 8 | Clearance gauge dimensions | height, H | mm | 1141 | 1445 | 1775 |
| | | width, L | mm | 520 | 670 | 820 |
| | | thickness, G | mm | 202 | 233 | 262 |
| 9 | Weight without cable pulling device and cable grips | | kg | 181 | 376 | 649 |
| 10 | Space btw. cable axis and B, pulling device screw axis | | mm | 110 | 141 | 166 |

The cable pulling device, Fig. 3, is only used to connect the cable in the unit, to pull the cable end through the unit. This should not be ordered for each device, given that they are interchangeable and can only be used in the mounting of the device. To mount the winding cable to the connecting devices, for each typo-dimension, cable pulling devices are required.

The main component parts of the cable pulling devices are shown in Fig. 3.

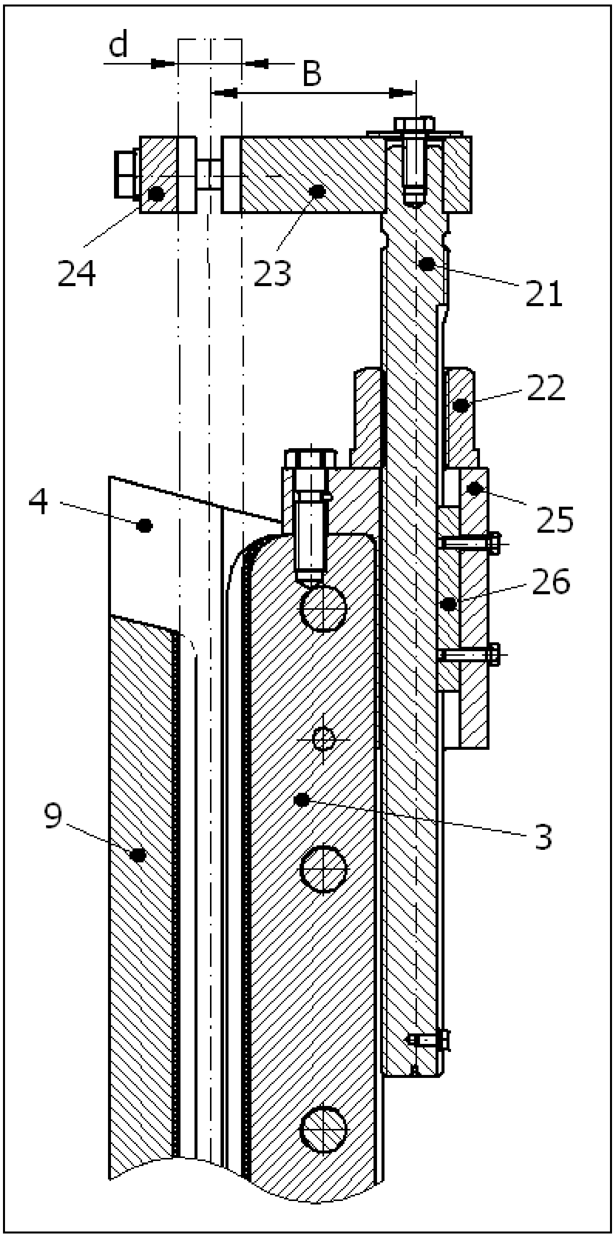


**Fig. 3** *Cable end pulling device*

The cable pulling device is made up of a threaded axis, provided with a square thread Pt 36x6, on which the nut 22 moves. By a parallel wedge, 26, the threaded axis slides in support 25, which in its turn is fixed to the cable connecting device, to the right jaw, 3 by means of M16 fixing screw, 27 reference point.

The extraction cable, which will be pulled, is fixed in the 23, fixed collar and 24, clamp.

The fixing groove of the cable is function of its diameter, per diameter groups.

By manual actuation of the 22, nut, the relative movement of the entire mechanism is ensured, that is pulling the free end of the cable of the winding installation.

Checking the idle operation, in both senses, of the free cable end pulling mechanism, is done by manual actuation of the lever of a fixed wrench over the coupling nut, with less than 50 N actuation force.

The cable connecting devices should provide interchangeability of component elements, to avoid cable wear and slipping of the cable. To this end, the surfaces of the fixed jaws and metal core, touching the metal cable, are covered with a 3,5 – 4 mm thick Y-Sn10/STAS 202-86 antifriction alloy layer. Similarly, the main bolt and its glands in the shields should not show plastic deformation in the contact area, as a result of operation.

The main elements (right shield, left shield, main bolt, metal core, fixed jaws) should be sized in such a way as to have a higher safety coefficient than 10 at maximum load.

The scaling of the cable connecting device, in view of warning against cable crushing, is done by carving 1,2 and 3 marks (Fig. 1, from B) on the core on the lower edge of the lug, on both sides, in the following way:

- for division 1, a minimum diameter gauge of the cable range for which the device was made(25; 26; 31 mm for DLC-1, 36; 41 mm for DLC-2 and 46; 51 mm for DLC-3), is inserted in the groove made between the core and the right jaw, and the core is tightened until the gauge is blocked. Division 1 shows the correct operation of the device;
- for division 2, a 3 mm thick plate is inserted between the core sides and the right jaw and the core is tightened until blocking. Division 2 shows the limit for the use of the devices;
- for division 3, a contact is made between the core and the right jaw, tightening the core by means of the dowel pin's nut. Division 3 shows the complete crushing of the cable and the device's self-blocking..

**Design and technology improvement of devices**

The shields are basic elements of the cable connecting devices, playing both a part in the structure, being a support for the assembling of the other reference points, and in the resistance, transmitting the cable traction force from the cable to the bolt.

Fig. 4 shows the two design solutions, the original one, Fig. 4a, and the improved one, Fig. 4b.

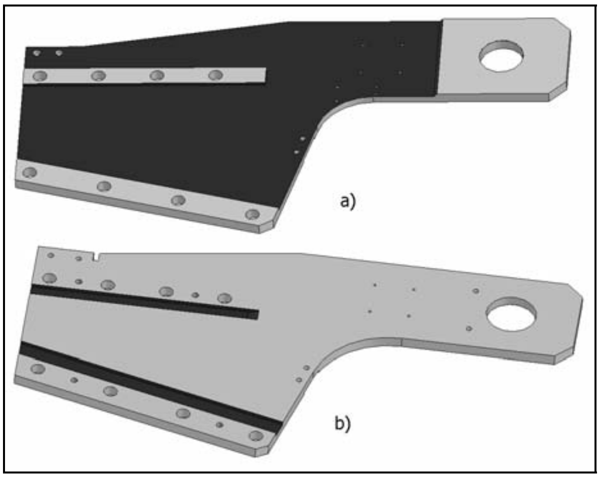


**Fig. 4** *Shield design variants*

In the initial variant, the inside shield surface was milled, to gain the two support thresholds for the jaws, the shields' assembling holes having H7 tolerance, using screws for centring.

For the new variant, for which the execution documentation was drawn up, these disadvantages were eliminated, thus having:

- more than six times reduction of energy, tools and manoeuvre consumption, for 2148,17 cm3 initial value of the volume to be cut, and 357,47 cm3 or the improved variant, for DLC-1;
- a 42% increase of cross section of the shield plate from 190x14 mm to 190x20 mm, DLC -1;
- centring holes on the screw body, both on jaws and on shields were removed, being replaced by pass-through holes, and centring is done by means of two pins; this led to the use of standardized screws and pins, that is reduction of shield and jaw processing manoeuvre and cost;
- the contact area between the inclined jaw and the shield increased by 5% to reduce contact pressure;
- the connection radius between the plate and the body of the shield increased, from 100 to 150 mm, to reduce the tension concentrator, for DLC-1.

The shield weight increases by 9,2 kg, and the pulling device of the cable end by 11,4 kg, respectively, but this disadvantage is partially eliminated by its demountable structure. The device weight increase is actually less than 5%.

The groove of the metal core and jaws, used to tighten the cable, is covered by a 3-4 mm layer from Y-Sn10/STAS 202-86 anti-friction material, applied by casting. This layer of material has the role to protect the cable wire from crushing.

To prevent the applied layer from exfoliation, in the initial variant, Fig. 5a, 8 mm diameter and 15 mm deep holes were made, with 30º inclination, all along the length of the groove controlled.

This is a difficult, high manoeuvre technology, and their degree of filling with molten material cannot be controlled.

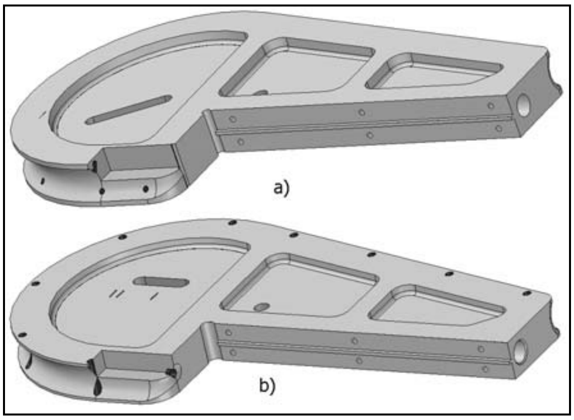


**Fig. 5** *Metal core design variants*

In the improved variant of the cable connecting device, these disadvantages were eliminated, by penetration holes for the cable in the groove, Fig. 5b.

This is easily done before the milling of the cable groove, and allows the filling degree with molten metal to be controlled.

Figure 6a shows the design of the inclined wedge grip, which did not have protection layer against cable crash. The additional blocking of the cable end is made with a screw and two clamps, one fixed, the other mobile; this solution may lead to a cable shear strain in the respective area.

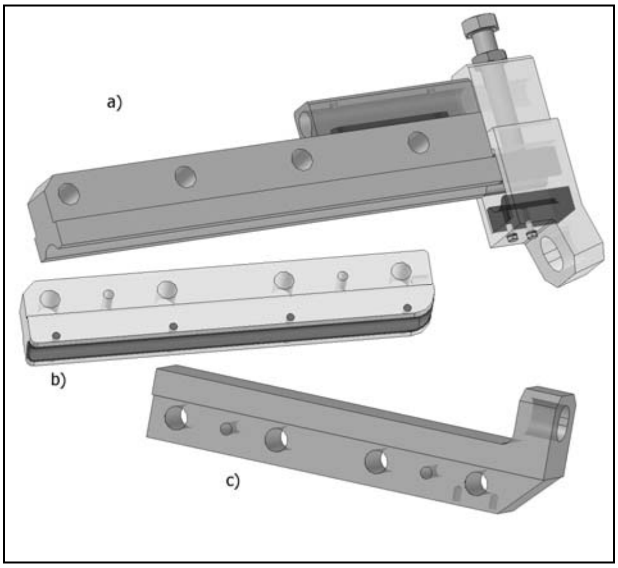


**Fig. 6** *Wedge grip design variants*

Similarly, additional blocking of the cable end can be done only after cable end pulling device is demounted.

The metal core tightening lever arm between the wedge grips was reduced and transferred to the vertical wedge grip, to improve the device's working manner.

Fig. 6b shows the new solution for the inclined wedge grip, simpler and easier to be developed, and Fig. 6c show the new solution for the vertical wedge grip.

An essential improvement brought about to the cable connecting devices to the vessels of the winding installation, is the separate structure of the cable end pulling device, Fig. 7, in view of tightening the cable in the unit. In the previous cable connecting devices, this device was included in the device structure.

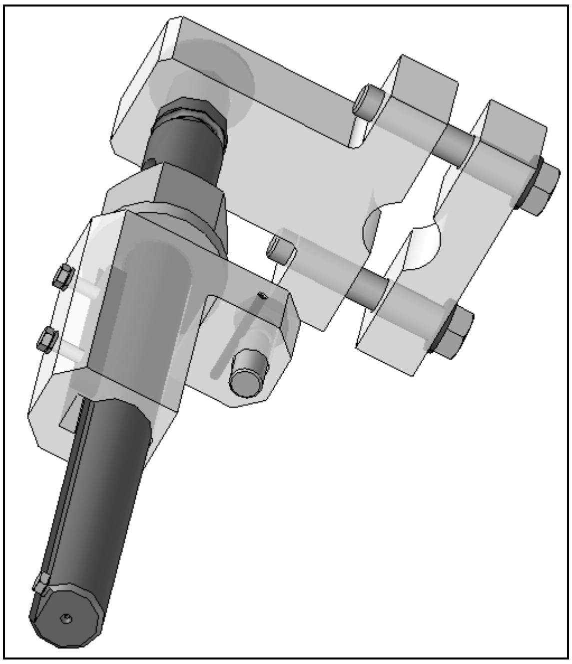

**Fig. 7** *Device to pull the cable end*

In the previous cable connecting devices, this device was included in the design of the device on the inclined wedge grip (Fig. 6).

In the new ones, it is a separate design, and the same cable end pulling device can be used for all DLC devices, only by changing the cable fastening jaws.

**Conclusions**

When a new documentation is drawn up, for the execution of the DLC-1, 2 and 3 cable connecting devices, the following improvements were established:

- cutting down the shields' processing surface;
- using standardized screws and two centring pins to position the jaw against the shields, removing the holes and special screws with centring bodies;
- using a device for independent pulling of the cable end, apart from the device structure;
- anti-friction alloy protection lining, all along the metal core groove, and simplification of it fixing solution on the cable groove;
- support arm for core wedging was taken from the inclined jaw and was attached to the vertical jaw, thus the design solution was simplified, the arm length and the load momentum of the jaw were reduced;
- glands were mounted in the bolt holes, resulting in rapid adaptation of the device to the extraction vessel rod, and in the increase of the duration of use of the device by replacing the oval shaped hole gland by the bolt;
- improvement of the bolt fixing solution against the shields, by double fixing, at both ends;

All these improvement resulted in manoeuvre and manufacturing cost reduction and improvement of technical characteristics of the cable connecting devices.

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