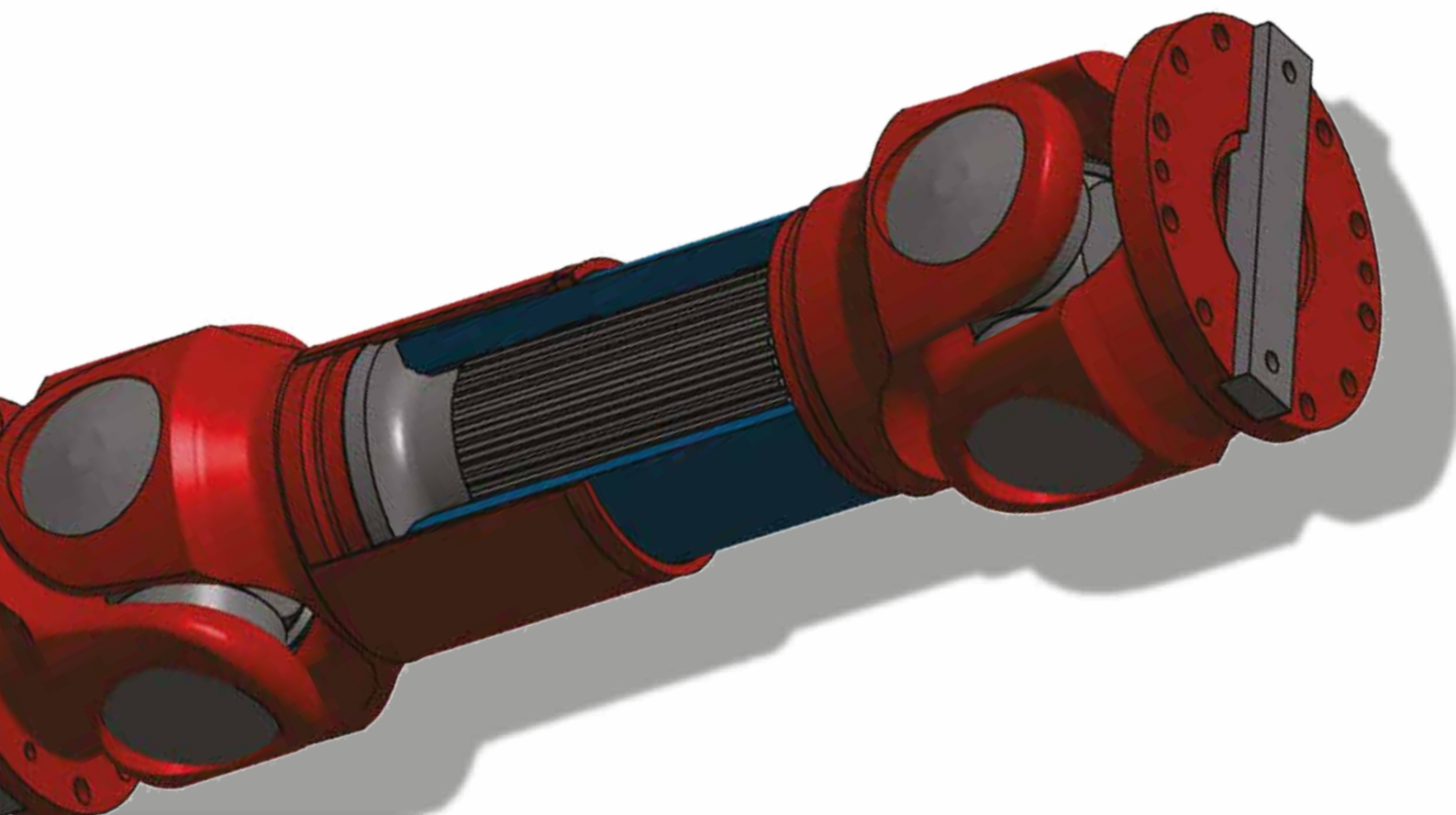


**Sicit®**



# **CARDANWORKS Manual**

**Operating, service & safety**



# CARDANWORKS Manual

## Operating, service & safety

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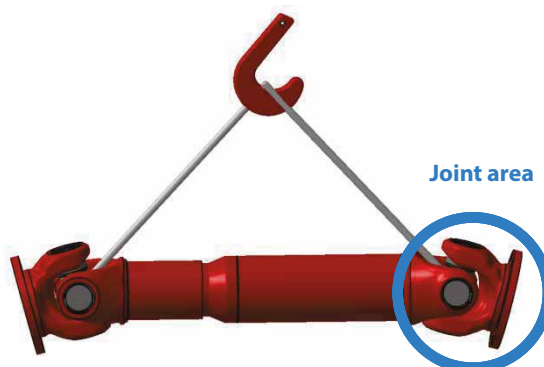
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## 1. Handling of the cardan shaft



*It must be assured all time that the cardan shaft is transported and stored safe in order to avoid any injuries to persons and the damage of the cardan shaft itself and its surrounding.*

The high quality state of the **CARDANWORKS** shafts resulting of a high precision manufacturing process should be maintained by a certain care during storage, transport and handling. Bumps and knocks must be avoided during transport and storage. Cardan shafts should be transported in a horizontal position like shown in the illustration. Strong nylon ropes or lifting belts can best be used to protect the edges. Care must be taken when using steel ropes to avoid damages. For vertical transport of the shaft additional precautions must be taken in order to prevent the splined parts from falling apart. The joint areas require special attention since the moving parts may tilt and crush hands. We advise to store cardan shafts in a horizontal position using wooden shelves which avoid the tilting and rolling. It is also important in storage that there are no loads on flanges, joints and the cover tube area. The cardan shafts should be kept them in a dry place and if necessary protected with anti-corrosion oil.

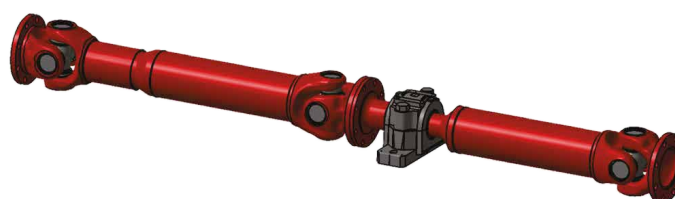


## 2. Installation of the cardan shaft

### Cardan shaft arrangements

The length of a single cardan shaft is limited by certain parameters like masses and critical bending speed or installation limitation. All installation exceeding the length limit must be realized using subdivided drive lines. For the following, most common arrangements the individual yoke positions and deflection angles must be adjusted with each other so that the degree of non-uniformity and the forces acting on the connection bearings are minimized. Special attention has to be placed on the design in order to compensate for length changes and fitting clearance, e.g. by usage of a suitable floating bearing.

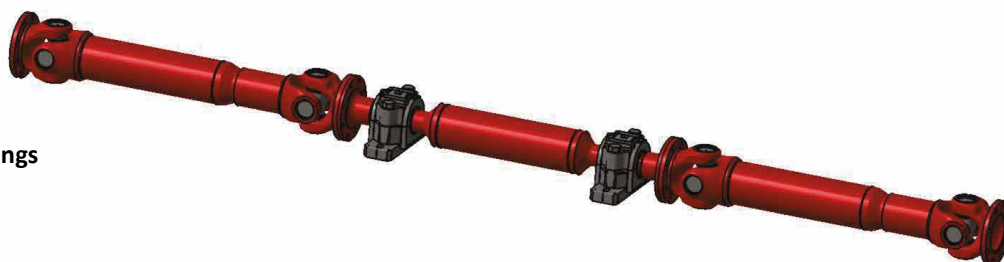
**Cardan shaft  
with one intermediate shaft,  
equipped with one center bearing**



**Cardan shaft with two intermediate shafts, each equipped with one center bearing**



**Cardan shafts with intermediate tube shaft, equipped with two center bearings**



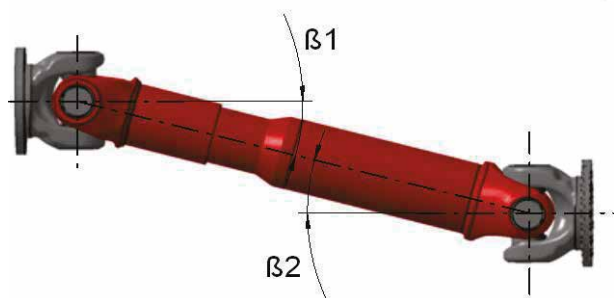
**⚠** Many cardan shafts are operated in severe environment. It is important that the length compensation of the cardan shaft is protected to the greatest possible extend from pollution, humidity and heat. The illustration shows an installation with water flowing away from the spline seal.



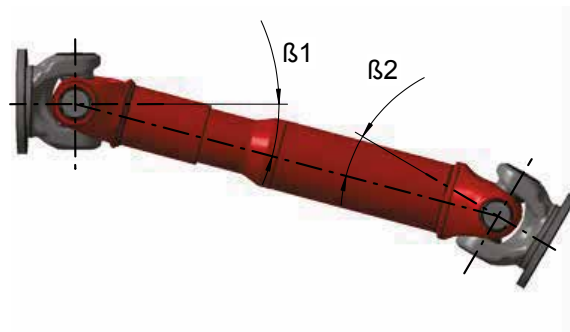
## Kinematics of the cardan joint

In the theory of mechanics the single cardan joint is described as a spherical drive unit with a non-uniform transmission. By the combination or connection of two or more joints to a cardan shaft or a driveline a synchronous or homokinematic operation can be achieved. The most common arrangements are the Z- and W- or M- deflection. It is an essential requirement for a uniform output speed condition that the deflection angles of joint 1 and joint 2 are equal and that the yokes are in the same plane.

### Z-deflection



### W- or M- deflection



$$\beta_{v1} = \beta_{v2} \quad \text{as well as} \quad \beta_{h1} = \beta_{h2}$$

Deflection in two planes, a three-dimensional deflection, means that the deflection is both horizontal and vertical. Uniformity is ensured if the deflection of both joints is either Z/Z or W/W and the angles are equal. The resulting, three-dimensional deflection angle can be calculated for the two joints taking the two components, the horizontal deflection angle  $\beta_h$  and the vertical deflection angle  $\beta_v$ .

$$\beta_{12} = \arctan \sqrt{\tan^2 \beta_{h12} + \tan^2 \beta_{v12}}$$

If the requirements mentioned before are not fulfilled and the arrangement of the shaft is a combination of W- and Z-deflection the inner yokes must be positioned offset. The angular difference between the inner yokes to each other, the phasing, can be calculated and will compensate the uniformity to an acceptable value.

### Degree of non-uniformity

The conditions and requirements for a uniform output speed cannot always be fulfilled in practise but must be considered in order to ensure a sound cardan shaft application and operation. For analysis and comparison of an eventual non-uniformity, the coefficient of cyclic variation **U**, the so called degree of non-uniformity can be calculated for each single joint.

$$U_n = \tan \beta_n \cdot \sin \beta_n \quad \text{no. of joints: } 1, 2, 3, \dots, n$$

The total non-uniformity **U** of the cardan shaft consisting of two or more joints or a complex drive line is determined as following, considering that the joints with the same position of the yokes have the same operator:

$$\sum U = U_1 \pm U_2 \pm U_3 \dots \pm U_n$$

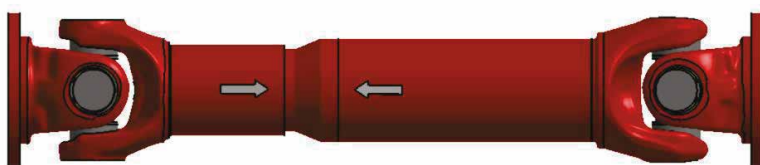
The permissible limits are as following:

$$\text{Limit for speed below 500 rpm} \quad U \leq 0,0027 \text{ } (\sim 3^\circ)$$

$$\text{Limit for higher speed} \quad U \leq 0,0007 \text{ } (\sim 1,5^\circ)$$

The VDI-recommendation 2722 will give more detailed and advanced insight into the kinematics of the cardan shaft.

**⚠** *Cardan shafts are marked with arrows to show the fitting position of the length compensation prior to the balancing. In this position the inner yokes are in the same plane. It is permitted to separate the cardan shafts, to mix them up or to re-fit them in wrong position. This, as well as the removal of the balancing weights, would cause the loss of balance quality and lead to a premature breakdown of the shaft and its connected devices.*



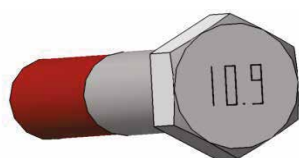
**⚠** It is not an appropriate method to create uniform motion at the output by the off-set of a cardan shaft at the length compensation. A wrong positioning may even increase the non-uniformity and lead to the early destruction of the splines and the universal joint bearings.

## Assembly of the cardan shaft with the mating units

In general the cardan shafts are connected to the mating units by companion flanges. The companion flanges must have a minimum tensile strength of  $750 \text{ N/mm}^2$ . The standard flange connection transfers the torque by friction of the flange faces areas which are pressed in contact and partly by the shear stress of the bolt cross section.

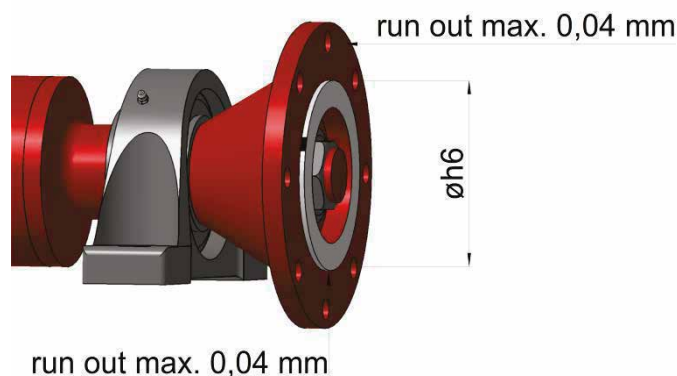
**⚠** The friction fit of the companion flange connection may only allow the transmission of a torque below the capacity of the cardan shaft. In order to utilize the full torque capacity it may be advisable to install additional elements such as dowel pins, split sleeves or flange face keys. Hirth serrated flanges offer a compact, high torque capacity alternative with self centring form fit.

Hexagon bolts with short thread similar to DIN 931 of quality grade 10.9 and self locking nuts similar to DIN 980/934-10 should be used. It has to be assured that the surfaces of the joint- and companion flanges are cleaned accurately of grease and dirt and that the contact areas are free of any defects. The bolt and nuts set should be evenly tightened crosswise according to the bolting torque  $M_a$  in the chart, most suitable using a torque wrench. These values apply for a coefficient of friction  $\mu = 0,12$  and for a 90 per cent (80% Hirth-serration) utilisation of the bolt yield point value and for slightly oiled bolts. Do not use  $\text{MoS}_2$  or any grease on the bolt sets. The flange bolts have to be checked at regular intervals and should be retightened with the prescribed torque.



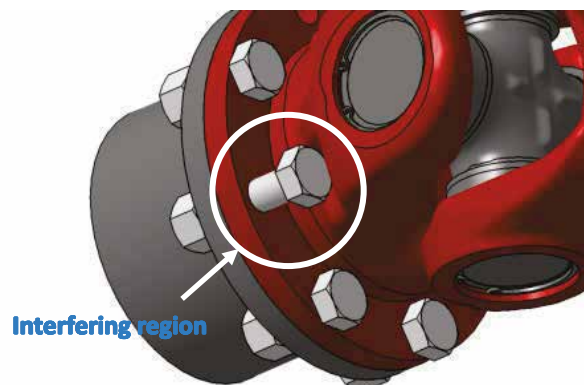
Threat	Wrench size [mm]	Bolting torque $M_a$ [Nm]
M 5	8	8,5
M 6	10	14
M 8	13	35
M 10	17	69
M 12	19	120
M 14	22	190
M 16	24	295
M 18	27	405
M 20	30	580
M 22	32	780
M 24	36	1000
M 27	41	1500
M 30	46	2000
M 36	55	3500

**⚠** The running quality and precise balancing of the cardan shaft can be maintained by using mating components with appropriate accuracy. In case of an application with a speed up to 3000 rpm we recommend the centring tolerance h7 and a axial and radial runout of 0.08 mm. Above that speed the tolerance should be reduced to h6 and the radial and axial deviation should not exceed 0.04 mm in order to ensure precise operation.





**⚠** The bolts for the flange connection cannot always be inserted from the joint side or the companion flange side. Stud bolts or slotted flanges may be the right solution.



### 3. Maintenance of the cardan shaft

Cardan shafts are used in a great variety of application under very different conditions. It is essential for a safe operation to inspect and to carry out maintenance work at regular intervals, ideally coordinated with the maintenance work on the other equipment, at least once a year. The greasing of the moving parts removes used lubricants, eventual pollution and abrasion and replenishes the lubricant.







We recommend the following inspection and lubricating intervals in the interest of the full utilization of the desired service life. Unfavourable operating conditions like humidity, dirt or heat may necessitate shorter intervals.

**CARDANWORKS** shafts are supplied ready lubricated with a lithium complex grease of the following specification: KP2N-20 / DIN 51502 acc. to DIN 51818 and are constructed for an environmental temperature range of -30°C to +80°C. For any application at higher or a lower temperatures special versions may be available on request.







Length compensations equipped with Rilsan® coating or TOPSPLINECOAT are lube for life and need no re-lubrication, if not stated otherwise. Splines in steel/steel-execution should be re-lubricated in coordination with the universal joint maintenance intervals.

Cardan shaft application	Maintenance intervals
Stationary industrial applications	1 month of service
Travelling cranes	500 hours of service
Railway vehicles	3000 hours or 6 month of service
Marine drives	1500 hours or 6 month of service
Commercial vehicles	
- construction site and off-road	250 hours or 10000 km of service
- road / off-road application	12 month or 30000 km of service
- road application	12 month or 50000 km of service

**Lubrication instruction:**

-  *Re-lubricate cardan shafts after each cleaning and also before putting into service if they have been stored for more than 6 month.*
-  *Do not mix with greases which are not lithium complex greases-based on mineral oil basis or have MoS<sub>2</sub> or other solid lubricant additives.*
-  *Do not clean lube for life cardan shafts using pressurized water or a steam jet or use aggressive chemical detergents.*
-  *Clean the grease nipples prior to the lubrication.*
-  *The maximum permissible lubricating pressure is 15 bar and any hard strokes or pressure shocks must be avoided to prevent damaging of the seals.*
-  *Re-lubricating should be done at shortest compressed length of the shaft and until the grease leaks from the universal joint bearing seals.*

**The following inspections should be carried out. In case of the detection of any abnormality a thoroughly overhaul is necessary.**

-  *Control the flange bolts and retighten them if necessary.*
-  *Check for any lost balancing weights.*
-  *Inspect of the joints and length compensation for tangible backlash by lifting and moving.*
-  *Observe any unusual noise or vibration.*
-  *Visible dents and injuries may be an indication for a worse mechanical damage.*
-  *Check for loose or lost grease nipples and pressure relief valves.*

## 4. Repair and overhaul of the cardan shaft

A cardan shaft, like any other technical component, has a restricted life span. Even the usage of parts with superior quality, perfect selection and design for the application, load and operating conditions and an ideal care and maintenance cannot totally prevent finally a breakdown. The more important is the regular inspection and monitoring.

Only a few technical components are so much pre-destinated for remanufacturing and overhaul like a cardan shaft. A preventive renewal of components and the re-establishment of the initial delivery status is a very economical option to prolong the service life of the cardan shaft and to optimize the total cost of ownership.

For the reason of safety and quality a cardan shaft should only be repaired in a specialized workshop equipped with the suitable machines, tools and the necessary know-how and expertise, using the corresponding quality spare parts.

In case that it is not reasonable for economic and lead time to execute a necessary repair by a **CARDANWORKS** manufacturing & service workshop, we are of service to organize a professional and qualified overhaul in the customers region.

The repair of the cardan shaft at the user's workshop should only be made in emergency cases and only for such shafts where the operating speed is below 300 rpm. In any cases the speed of cardan shaft exceeds 300 rpm the shaft must be re-balanced.



## 5. Safety instructions

The following instructions must be observed carefully in order to protect against injuries or danger to life of persons and to prevent any damage of the cardan shaft as well as the peripheral equipment in the environment. We do not accept any responsibility for the misapplication and eventual violation of the operation, service and safety instructions.



### **Serious hazard caused by accidental moving and tilting of universal joints!**

- *Don't touch or access the cardan joints by hand. This may crush limbs.*
- *The cardan joints must be disabled to tilt over, e. g. fastened with wedges or other appropriate elements.*
- *Secure cardan shafts while lifting, transporting, and placing down to prevent from any accidental moving and tilting over.*



### **Serious hazard caused by separated shaft parts falling down!**

- *Cardan shafts with length compensation must be retained against separation into its two parts, e. g. by clamping or using a safety-cord.*
- *Take precautions against trespassing the hazardous area under the lifted cardan shaft.*



### **Serious hazard caused by a swinging or dropping cardan shaft!**

- *Don't use inadequate hoisting equipment without sufficient design, testing, and regular inspection.*
- *Take precautions against trespassing the hazardous area beneath the lifted cardan shaft.*
- *Make sure that appropriate personal protective equipment, i.e. safety shoes and helmets, is used.*
- *Take care of proper attachment of the lifting ropes at the cardan shafts.*
- *Secure the cardan shaft against dropping before dismantling it from the companion flanges.*



### **Serious hazard caused by a cardan shaft in operation!**

- *Whenever people or equipment might be in danger by the operation of a cardan shaft, relevant safeguarding equipment like solid safety fences or catch brackets must be installed.*
- *Only remove or deactivate the safeguarding equipment when the cardan shaft has come to a standstill.*
- *Protect against any accidental system start-up.*
- *Enable only authorized personnel to handle the cardan shaft. Keep casual persons away by fences and barriers.*



### **Serious hazard caused by a cardan shaft rolling away!**

- *Place and store the cardan shaft only on an appropriate and designated ground floor.*
- *Take care for suitable supporting equipment like frames or racks.*
- *Use chocks or blocks to prevent cardan shafts from rolling away.*



### **Serious hazard caused by inadequate use and operation!**

- *Only employ adequate and technical accurate cardan shaft and component for the dedicated application.*
- *The mating elements of the cardan shaft must be suitable designed and of adequate precision.*
- *The operating data of the cardan shaft, as it has been the basis for the layout of the shaft, must never be exceeded.*
- *Do not alter the delivery state of the cardan shaft, this would void any warranty.*
- *The adherence of the handling, installation and maintenance instructions is absolutely necessary.*
- *Follow the DIN EN ISO 12100 or equivalent local standards and regulations.*
- *Qualified personnel and workmanship is required for the assembly, installation and maintenance of cardan shafts.*