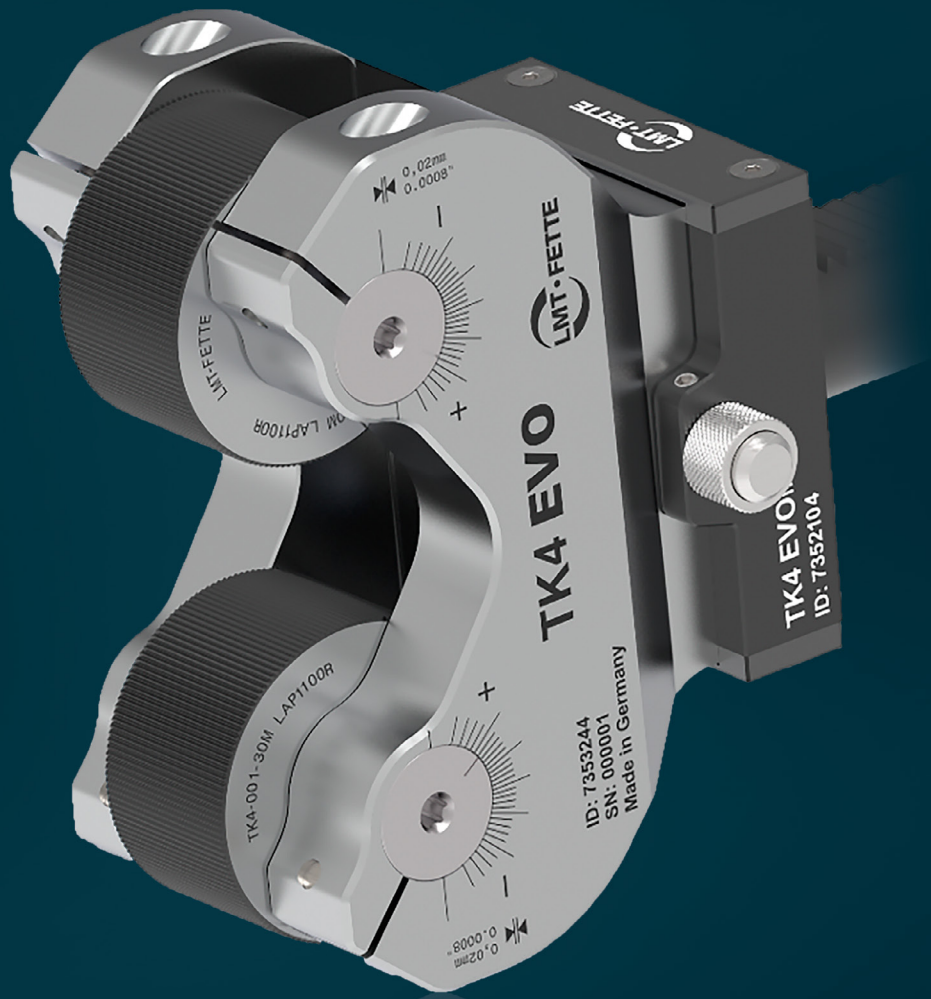
LMT • FETTE



EVOLINE

Tangential Knurling TK1–TK6 EVO

Operating Instruction

Notes

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1 General

1.1 Introduction

The *rolling system* has been constructed according to the state of the art in accordance with the recognized safety rulesand standards and manufactured in accordance with TÜV-CERT DIN ISO 9001 and VDA 6.4.

The operatings instructions apply solely to *rolling system* described in the operating instructions

Terms in italics are defined as a collective term at the appropriate place:
- In using the collective term the information relates to all single terms.
- In using the singular term the information relates solely to the single term.

NOTE

The collective term *rolling system* includes the single terms rolling head, all accessories, conumables, and spare parts.

The illustrations and information contained in these operating instructions are subject to technical changes that are necessary to improve the *rolling system*.

NOTE

Modifications or amendments to these operating instructions made at a later time can be found online under www.lmt-tools.de/dokumente-downloads.

The operating instructions are written with the intention to be read, understood and observed in all respects by those who are responsible for the use of the *rolling system*.

A safe and error-free use of the *rolling system* is only possible if the contents of the operating instructions are understood by the competent persons and observed in all respects.

NOTE

Work instructions are supplemented by position numbers.
Compare the information with the figure in Chapter 7.

Improper use of the *rolling system* can endanger people and cause property damage. No liability shall be assumed for any damage or malfunctions resulting from failure to observe these operating instructions.

NOTE

Note all warnings and safety instructions and the operating instructions for the machine.

Storage of the operating instructions

The entire operating instructions must be stored carefully and always kept with the *rolling system* as part of the product.

The operating instructions must be kept near the *rolling system* so that they are available to all persons working with the *rolling system* as required.

Warranty and technical support

We guarantee proper function of the delivered product with purchase.
We are not liable for damage in case of:
- Improper use of the *rolling system*.
- Use of non-original components.
- Use of accessories not authorized by us.
- Modifications undertaken without our authorization.
- Use of damaged components.

Modifications to the components are permitted only after written agreement with us.
We undertake modifications to the *rolling system* to adapt the *rolling system* to the requirements of the operator. We inform the operator of the modifications and impact on the use of the *rolling systems*. The operating instructions describe the use of a *rolling system* without modifications.

If you encounter any problems or have any questions, please contact our Service Hotline, which will be glad to help.

We offer training specially tailored to your needs for your staff at your site. We also hold regular seminars in the LMT Group Academy, our subsidiaries and representatives.

1.2 Operator's obligation of diligence

The operator of the *rolling system* must ensure that
- The intended use of the *rolling system* is ensured at all times.
- The *rolling system* is always in a perfect and functioning condition.
- Only qualified and authorized personnel assemble and operate the *rolling system* in accordance with these operating instructions.
- The qualified and authorized personnel are regularly informed about all these necessary rules of occupational safety and environmental protection.
- The qualified and authorized personnel are informed in detail about modifications made and their impact.
- There is sufficient necessary protective equipment for the qualified and authorized personnel that is in good condition and that such equipment is worn.
- The operating instructions are available in legible condition and in full at the installation site of the *rolling system*.

1.3 Contact

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21493 Schwarzenbek
Germany
Tel.: +49 4151 12 391
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teamrollen@lmt-tools.com

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Our homepage is:
www.lmt-tools.com

1.4 Copyright

The copyright of these operating instructions remains with LMT Fette Werkzeugtechnik GmbH & Co. KG.

These operating instructions include regulations and technical drawings, which may be neither duplicated in full or in part, distributed or utilized for the purpose of competition or communicated to others.

Disclosure to third parties is not permitted.

We do not allow copying ot the *rolling systems* or parts of the *rolling systems*.

2 Safety

2.1 Explanation of symbols and instructions

All safety instructions and warnings in the operating instruction are structured as follows:

Danger level/Signal word

Type and source of the danger
Measures to avoid danger

Hazard symbols

The operating instructions differentiate between three hazard symbols, which allow an initial allocation of hazards. The yellow triangle indicates a general risk to people, property, animals or the environment.

Danger level

General danger to people, property, animals or the environment from the *rolling system*.
Measure to avoid the danger

The red, octagonal hazard symbol with the signal word IMPORTANT indicates a potentially harmful situation for the *rolling system*. Observing the operational steps, guidelines and instructions avoids damage to or destruction of the *rolling system*.

IMPORTANT

A potentially harmful situation for the *rolling systems*.

Fellow all operational steps, guidelines and instructions in order to avoid damage or destruction to the *rolling system*.

The third hazard symbol with the signal word NOTE indicates important information and tips for the user.

NOTE

No direct danger

Important information and additional tips for the user on using the *rolling system*.

Danger levels/Signal word
In the case of the yellow triangle the danger level indicates the degree of danger. Three danger levels are used. Each word is chracterized by a color that illustrate the danger levels.

- **CAUTION**
  The danger level indicates a hazard with a low level of risk which, if not avoided, may result in slight or moderate injury.

- **WARNING**
  The danger level indicates a hazard with a medium level of risk which, if not avoided, may result in death or serious injury.

- **DANGER**
  The danger level indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.

Example:

DANGER
 General risk due to the use of the *rolling system* by unqualified or unauthorized personnel. Use of the *rolling system* only by qualified and authorized personnel.

2.2 Basic safety instructions

DANGER
 General danger when using the *rolling system*. Follow the operating instructions. These include ■ The basic safety instructions from the entire chapter 2 for the entire operating instructions, ■ The preceding instructions for a particular chapter and ■ The embedded instructions for a particular step. Follow all local health and safety and operational safety regulations.

Chapter 2, Safety, informs you about the basic safety instructions to ensure safe and trouble-free use of the *rolling system*.

- Please contact the operator in the event of any changes to the *rolling system*.
- Refrain from any methods of working which could compromise safety.
- Only ever perform work on the rolling system when the machine is at standstill and if necessary take the *rolling system* out of the machine room.
- Before starting work on the *rolling system*, secure the drives and additional devices of the machine against accidental activation.
- Make sure there is sufficient space in the machine and pay attention to the risk of injury originating from adjacent tools and machine parts.
- Before any commissioning, check that the screws on the *rolling system* are tightened.

WARNING

The *rolling system* is made of various materials (e.g. nickel), which can trigger an allergic reaction. General risk of injury from sharp edges.

Wear protective gloves and protective eyewear when using the *rolling systems*.

The weight of the *rolling system* may cause harm when it falls down.

General risk of injury during transportation/lifting of the *rolling system*.

- Ensure that the *rolling system* is protected of falling down or tipping over.
- Wear safety boot/hard-toed boot at all times.
- Use suitable hoisting devices.

2.3 Intended use

IMPORTANT

The *rolling system* may only be used for the intended use.

Make sure that the *rolling system* is free of chips at all times.

Never apply force when using the *rolling system*.

The *rolling system* must only be used as a tool on a processing machine for chip-free manufacture of profiles on the outside of rationally symmetrical work pieces.

NOTE

Note that the *rolling system* is customized to the requirements specified by the operator.

Please contact our Service Hotline if you wish to use the *rolling system* in any way other that the agreed use.

The scope of application for the *rolling system* is to carry out a *rolling process*.

The *rolling process* includes the following manufacturing processes:

- Knurling
- Smoothing and
- Cold forming of rotationally symmetrical workpieces, to produce other profiles.

} *rolling process*

NOTE

The collective term *rolling process* includes the production processes of knurling, smoothing and cold forming of rotationally symmetrical workpieces for manufacturing other profiles.

Smoothing is a surface compression.

Sizing by smoothing, to perform a tolerance constriction, is not possible.

IMPORTANT

Be sure to use a torque wrench for all work on the rolling head and observe the tightening torque for each bolt (see chapter 3.7).

NOTE

Use other than the intended use is only allowed after written agreement with us.

Any use other than the intended use is considered improper use. We shall not be liable for any damage resulting from improper use. The risk is borne by the operator.

Intended use includes the observance of these operating instructions.

Coolants and lubricants

Liquids that are also used during machining are suitable as coolants and lubricants:

- Emulsions in dilutions ranging from 1:10 to 1:20 (in some cases with high-pressure additives),
- Low viscosity cutting oils and
- Molybdenum (IV) sulfide.

NOTE

Observe the information and instructions provided by the manufacturer.

You can increase the service life of the rolls by using high-pressure additives, because high-pressure additives improve the sliding characteristics between the rolls and the workpiece.

Please contact our Service Hotline if you want to undertake dry processing with the *rolling system*.

IMPORTANT

Ensure that the cooling lubricant is free from chips or particles to prevent foreign bodies from being rolled into the thread and to prevent undue wear of the thread rolls and of the rolling head.

The rolling process is negatively affected by strong presence of swarf. Make sure that the rolling head is connected to the central lubrication/cooling system of the processing machine.

Install the rolling head into the processing machine in such a way as to ensure minimu exposure to chips directly. The chip guard included in the delivery should be used.

IMPORTANT

Only use coolants and lubricants for the *rolling system* that meet the above mentioned properties in ordert o avoid corrosion of the *rolling system*.

Observe the stated storage temperature and relative humiditiy in order to prevent corrosion on the *rolling system*.

Reasonably foreseeable misuse

Reasonably foreseeable misuse of the *rolling system* includes:

- Use of the *rolling system* by non-qualified or unauthorized personnel.
- Leaving tools in the *rolling system*.
- Over rolling the thread.
- Rolling outside of the permissible rolling speed.
- Rolling outside of the permissible operating range.
- Non-compliance with the operating instructions.

IMPORTANT

Avoid any reaonably foreseeable misuse of the *rolling system*.
We are not liable for damage resulting misuse.

2.4 Authorizied personnel and responsibilities

DANGER

General risk due to the use of the *rolling system* by unqualified or unauthorizied personnel.

Use of the *rolling system* only by qualified and authorizied personnel.

Authorizied personnel

- The *rolling system* may only be used by qualified and authorized personnel. These personnel must have received special instruction from the operator about possible hazards.
- The complete operating instructions must be read and understood by every person who deals with the use of the *rolling system*. We recommend the operator has this confirmed in writing.
- The qualification includes at least one mechanical technical training. In addition, we recommend staff training given by us at your site, training in our LMT Group Academy, our subsidiaries or our local repre-sentaitives.
- The operator is responsible for ensuring that work is undertaken by staff being trained only under the supervision of qualified and authorized personnel.
- The operator is responsible for ensuring that unauthorized persons have no access to the *rolling system* under any circumstances.

Responsibilities

- The operator must define all responsibilities for the use of the *rolling system* so that there are no ambiguities in terms of responsibility for safety aspects.
- The operator must clearly define the responsibilities of the personnel for each of the activities on the *rolling system*.

3 The *rolling system*

The *rolling system* forms the rquired profile in the workpiece with tangential feed direction. The rolling process is performed by chipless cold forming.

The moduls of the *rolling system*.

The *rolling system* consists of four components:

- Rolling head (1)
- Rolling head holder (2)
- Rolls (1 set = 2 pieces) (3)
- Setting gauge (4)

The four components of the *rolling system* TK EVO are shown in figure 1:

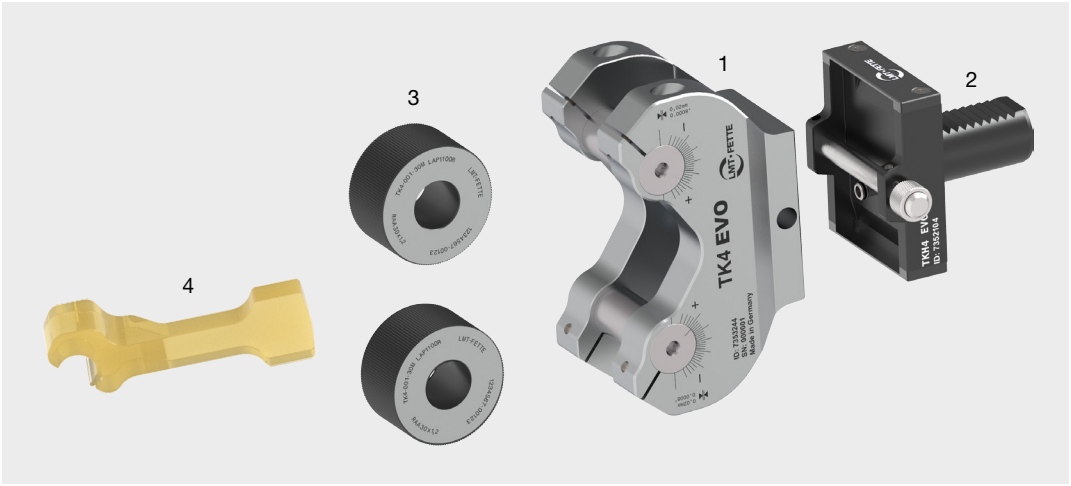
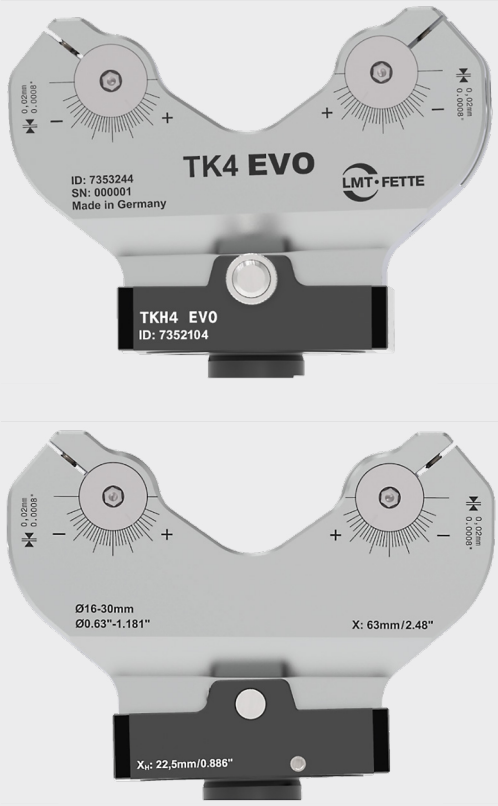


Figure 1: The four components of the *rolling system* TK EVO

The components of the *rolling system* are customized in order to fulfill the requirements of the specific application. Therefore each component is supplied separately.

Labeling of the *rolling system* (rolling head and holder)

The labeling of the *rolling system* is placed on the outer surfaces of the main bodies. (see Figure 2).



LMT Fette: Company

TK4: Rolling head description
TK Type
4 Size

00001: Serial-No.
7353244: ID-No.

TKH4: Holder description
TKH Holder Type
4 Holder Size

Ø 16–30: Working range
Ø 0.63“–1.181“

X: Distance measurement
Joint point: rolling head/holder till rolling center

X_H: Machine distance measurement
Machine contact surface till joint point: rolling head/holder

Figure 2: Labeling of the *rolling system*, rolling head and holder (Example: TK4 EVO)

3.1 Rolling Head

The rolling head is the centerpiece of a *rolling system*. The present version is available in six different sizes:

- TK1 EVO
- TK2 EVO
- TK3 EVO
- TK4 EVO
- TK5 EVO
- TK6 EVO

- Special designed rolling head are labeled in same manner, but are complemented by the letter „X“ and a consecutively number.

The rolling head stores the rolls and comes with a joint point in order to be assembled with a machine adaption respectively rolling head holder (see Figure 3).

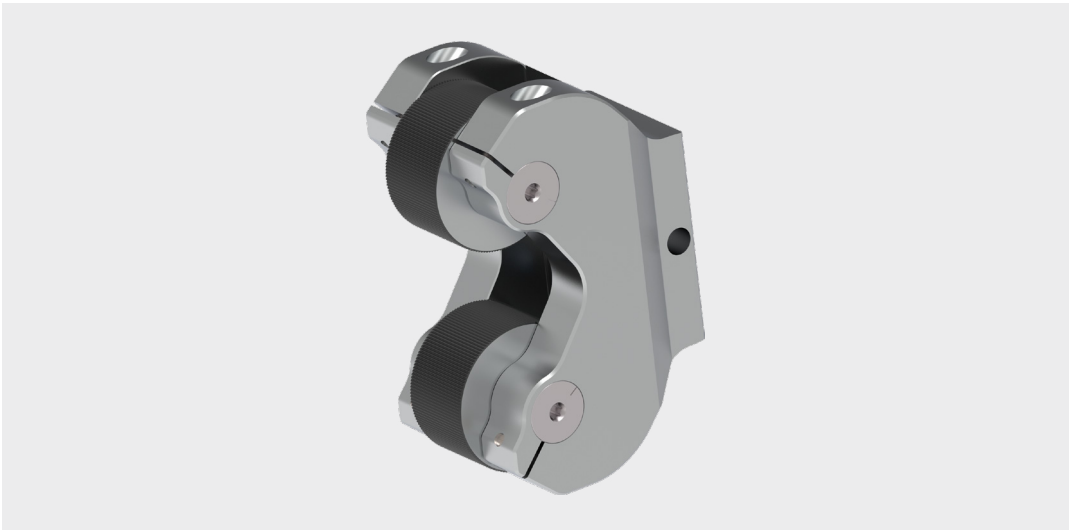


Figure 3: Example of rolling head type TK EVO

NOTE

Considering the used machine and the rolling head dimension we advise to choose the rolling head who will operate within the lower 2/3 of its working range.

3.2 Rolling Head Holder

Please note that due to the different versions of processing machines specifically adapted rolling head holder are available.

For information about suitable rolling head holders for your processing machine, please contact our Customer Service (see chapter 1.3). Our employees have extensive experience in installing our *rolling systems* and will be pleased to help you define the right rolling head holder for your processing machine.

We recommend using the rolling head holder with a chip guard (see Figure 4, No. 13) to protect the area between the rolling head and the rolling head holder.

The following rolling head holder types are suitable:

- VDI according to DIN 69880 (Example in Figure 4)
- Roundshank

Cross slide holder or similar on request.

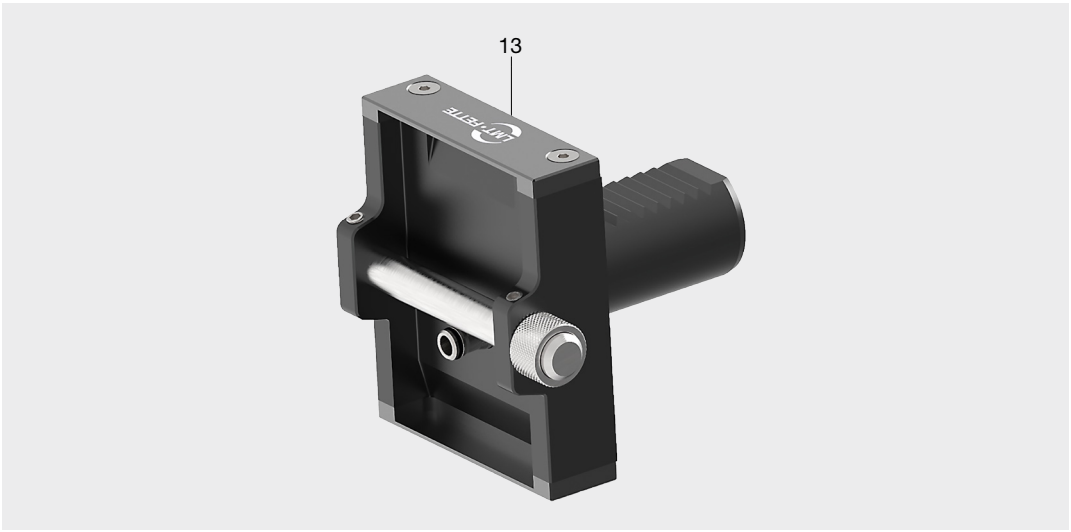


Figure 4: Example of a rolling head holder according to DIN 69880

3.3 Rolls

IMPORTANT

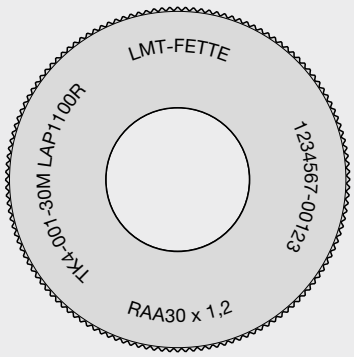
Use rolls only in the sets delivered by us. Do not combine rolls from different sets.

Check that the roll set number (serial number) is the same.

Labeling of the rolls

- Profile description
- Rolling head type
- Code number
- Roll width
- Roll version
- LMT material code (roll material)
- Company
- ID number
- Serial number

Depending on the roll size, the rolls are labeled either on one or more sides.
Figure 5 shows an example of the labeling of the rolls.



RAA:	Profile definition
30x1,2:	Profile diameter and pitch
TK4:	Rolling head
001:	Code number
30:	Roll width
M:	Roll version
LAP1100R:	LMT Code (roll material)
1234567:	ID number
00123:	Serial number
LMT Fette:	Company

Figure 5: Labeling of the rolls

Roll versions

Depending on the application, the rolls are available in different versions (see table 1).

> **NOTE**
> The standard version is full roll width.

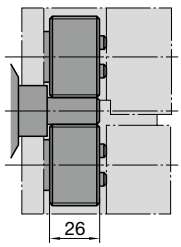
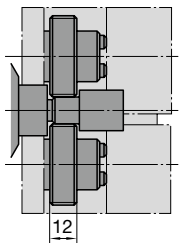
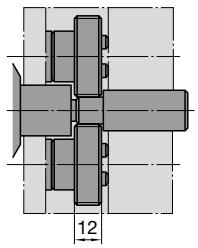
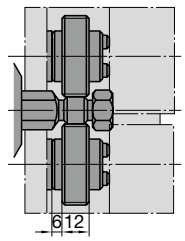
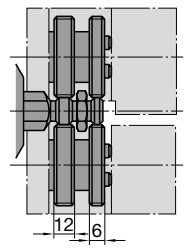
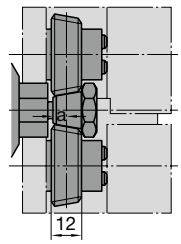
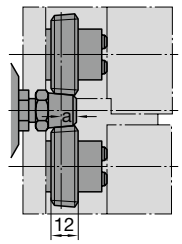
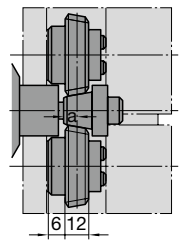
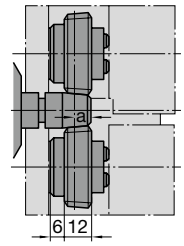
Roll version				
full roll width	**A**	**B**	**M**	**AB**
				
code number (example)				
TK4-33-26	TK4-33-12A	TK4-33-12B	TK4-33-12M6	TK4-33-12A-6B
A	**AV**	**M**	**MV**	
				
code number (example)				
TK4-77-12A	TK4-77-12AV	TK4-77-12M6	TK4-77-12MV6	

Table 1: Roll version

Tool life

The tool life of the rolls is influenced by the following factors:

- Material properties (particularly tensile strength and elongation at fracture)
- Hardness increase behavior of the material under cold forming
- Degree of roll out of the profile
- Execution of chamfers during workpiece preperation
- Correct adjustment of the tool
- Rolling speed and operating feed
- Sufficient supply of clean coolant
- Avoidance of chips on workpieces and rolls prior ro the rolling process
- Profile roll start and run-out

Review your application and discuss it with our personnel (chapter 1.3). They will be pleased to give you useful advice with regard to the ideal design of your roll. When the rolls are worn, they must be replaced with new ones.

3.4 Setting gauge

The setting gauge is customized and hast he following tasks:

- Preadjustment of the axle distance in the rolling head
- Adjustment of the cross stroke in the processing machine

Depending on the size of the setting gauge it is inscribed by the following information:

- Company
- Profile description
- Code number (rolling head type and roll code number)
- Roll width
- Setting values *F* und A_v
- ID number

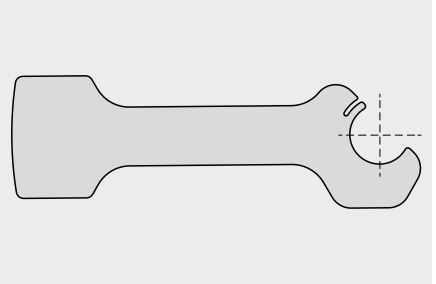


Figure 6: Setting gauge

3.5 Dimensions of the *rolling system*

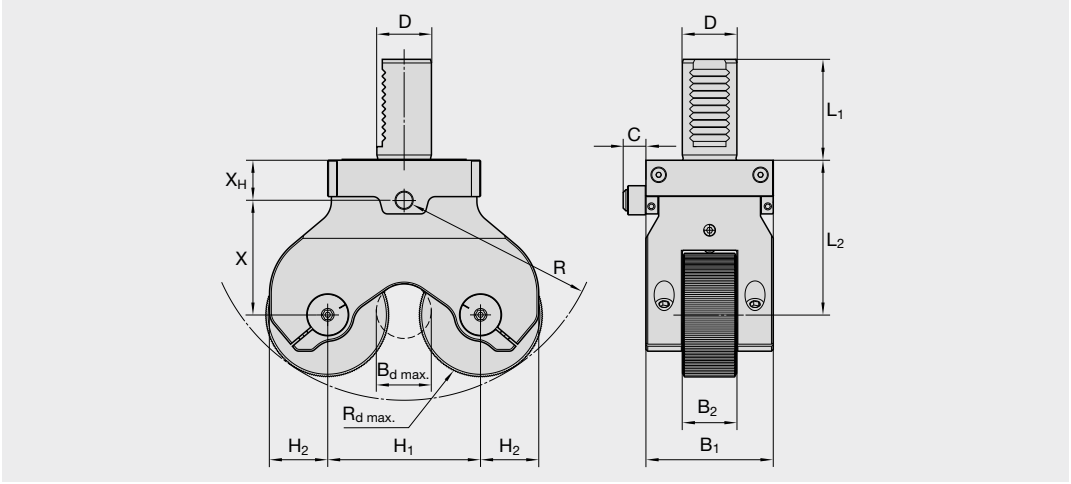


Figure 7: Dimension of the *rolling system*

Rolling head-type	TK1 EVO	TK2 EVO	TK3 EVO	TK4 EVO	TK5 EVO	TK6 EVO
Ident number	**7368881**	**7368882**	**7368883**	**7368884**	**7368885**	**7368886**
Construction dimensions	**[mm | Inch]**					
B_1	42 | 1.654	48 | 1.889	64 | 2.520	70 | 2.756	70 | 2.756	70 | 2.756
B_2	14 | 0.551	20 | 0.787	25 | 0.984	30 | 1.181	30 | 1.181	30 | 1.181
L_1	48 | 1.889	48 | 1.889	48 | 1.889	48 | 1.889	48 | 1.889	48 | 1.889
L_2	59 | 2.323	63.5 | 2.500	79 | 3.110	87 | 3.425	87 | 3.425	110.5 | 4.350
C	10 | 0.394	10 | 0.394	10 | 0.394	10 | 0.394	10 | 0.394	10 | 0.394
X_H	19 | 0.748	19 | 0.748	21 | 0.827	22.5 | 0.886	22.5 | 0.886	23 | 0.906
X	39 | 1.535	46.5 | 1.831	58 | 2.283	63 | 2.480	77 | 3.031	90 | 3.543
H_1	38 | 1.520	52 | 2.047	68 | 2.677	84 | 3.307	104 | 4.094	126 | 4.961
H_2	23.5 | 0.959	20 | 0.787	26 | 1.024	32 | 1.260	35 | 1.378	35 | 1.378
R	60 | 2.362	74 | 2.913	95 | 3.740	110 | 4.331	132 | 5.197	150 | 5.906
$R_{dmax.}$	35 | 1.378	43 | 1.693	57 | 2.244	69 | 2.717	79 | 3.110	82 | 3.228
$B_{dmax.}$	20 | 0.787	24 | 0.945	32 | 1.259	42 | 1.654	60 | 2.362	82 | 3.228
D	20; 30; 40; 50 0.787; 1.181; 1.575; 1.968		30; 40; 50; 60 | 1.181; 1.575; 1.968; 2.362			
m-Rs	2 kg | 4.4 lb	3 kg | 6.6 lb	5 kg | 11 lb	7 kg | 15.4 lb	8.5 kg | 18.7 lb	11 kg | 24.2 lb

Table 2: Dimensions of the rolling head TK EVO

3.6 Working ranges and rollable materials

Working ranges for knurls, form beads and burnishing				
Knurling head	**Major-Ø**	**Pitch**	**max. profile depth**	**max. profile width**
	[mm | Inch]			
TK1 EVO	4 – 16 | 0.157 – 0.630	0.5 – 2 | 0.02 – 0.079	2 | 0.079	14 | 0.551
TK2 EVO	8 – 22 | 0.315 – 0.866	0.5 – 2 | 0.02 – 0.079	2 | 0.079	20 | 0.787
TK3 EVO	12 – 30 | 0.472 – 1.181	0.5 – 2 | 0.02 – 0.079	3 | 0.118	25 | 0.984
TK4 EVO	16 – 38 | 0.630 – 1.496	0.5 – 2 | 0.02 – 0.079	3 | 0.118	30 | 1.181
TK5 EVO	26 – 58 | 1.024 – 2.283	0.5 – 2 | 0.02 – 0.079	3 | 0.118	30 | 1.181
TK6 EVO	45 – 80 | 1.772 – 3.149	0.5 – 2 | 0.02 – 0.079	3 | 0.118	30 | 1.181

Table 3: Working ranges of *rolling system* TK EVO

Rollable materials

A large number of characteristics and properties influence the rollability of materials and the resulting profile quality.

In order to reduce the complexity the chosen properties:

- Elongation and
- Tensile strength

enable an evaluation of the rollability of materials suitable for everyday use.

IMPORTANT

The following property values aren't hard limits, rather empirical values who define the feasible.

Metallic materials with the following properties can be rolled with a *rolling system* TK EVO:
- Elongation $\sigma_B \geq 7\%$ und
- Tensile strenght $\sigma_Z \leq 1000$ MPa

Please contact our Service Hotline if you wish to perform rolling processes outside of these limits or very near them.

3.7 Tightening torques

IMPORTANT

Observe the tightening torques.

Dimensions	Tightening torque
M3	1.28 Nm
M4	2.97 Nm
M5	3.03 Nm
M6	10.25 Nm
M8	24.93 Nm
M10	49 Nm
M12	86 Nm

Table 4: Tightening torque

3.8 Condition upon delivery

We deliver your *rolling system* in the following condition separately:

- The rolling head with tools (without set of rolls)
- The rolling head holder
- The set of rolls
- The setting gauge

NOTE

Please note that the delivered components are matched to the size of the *rolling system*. Only use the supplied components for the delivered *rolling system*.

The condition upon delivery is the proper storage condition.

CAUTION

The components of the *rolling system* are sprayed with a commercially available creeping oil to protect them against corrosion. Touching the oily surface of the components may result in skin irritations. Avoid skin contact, especially in case of allergies or open skin lesions.

Do not touch the oiled surface if you have an open lesion. Do not touch the oiled surface if you are worried about an allergic reaction. Call the service hotline to find out the contents of the creeping oil and check your tolerability.

4 Installation

IMPORTANT

Please contact our Service Hotline in the event of initial insallation of the *rolling system*.

We will gladly advise you on:

- Inserting the rolls into the *rolling system*,
- Functional testing of the *rolling system*,
- Inserting the rolling head into the rolling head holder, and
- Installing the *rolling system* into the processing machine.

WARNING

General risk of injury from sharp edges.
The *rolling system* is made of various materials (e.g. nickel), which can trigger an allergic reaction.

Wear protective gloves and protective eyewear when using the *rolling systems*.

The weight of the *rolling system* may cause harm when it falls down.
General risk of injury during transportation/lifting of the *rolling system*.

- Ensure that the *rolling system* is protected of falling down or tipping over.
- Wear safety boot/hard-toed boot at all times.
- Use suitable hoisting devices.

4.1 Machine requirements

Collision check

WARNING

General risk of collision.

Don't equipe the machine with a *rolling system* without a collision check.

Please contact our Service Hotline in the event of initial equipment or change of a *rolling system* on your machine. We will be happy to guide you through.

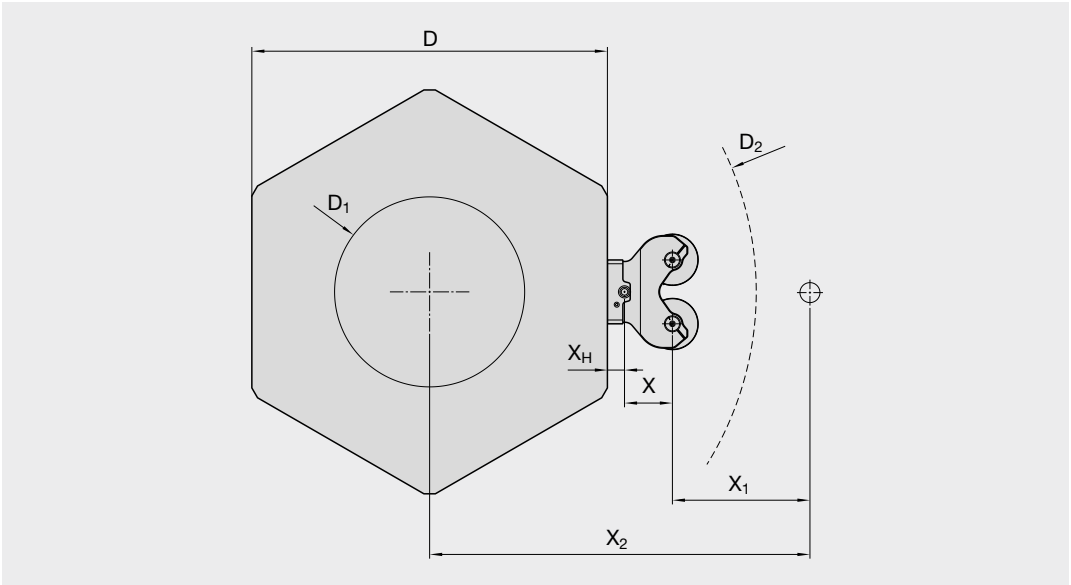


Figure 8: Sketched illustration of a *rolling system* on a turret

NOTE

D: Turret outside dimenions
D_1: Inner turret dimenions
D_2: Max. swing circle-Ø
X_2: Turret center to workpiece center
X_1: Travel
X_H: Machine contact surface till joint point: rolling head/holder
X: Joint point: rolling head/holder till rolling center (workpiece center)

For a collision-free use of the *rolling system* dimensions must lay be within the max. swing circle-Ø.

See chapter 3.4 for *rolling system* dimensions.

4.2 Inserting the rolls into the *rolling system*

1. Loosen the clamping screws (3) and remove the roll axis (2).

IMPORTANT

In order to ensure a good friction coefficient between roll (8) and roll axis (2), be sure to lubricate sufficiently the roll bore and the roll axis in the region in the region of the roll and the pinion using molybdenum sulfide grease. (e.g. Molykote).

2. Lubricate sufficiently the bore of the roll with molybdenum sulfide grease.
3. Place the rolls into the main body (in arbitrary order) with matching boreholes.
4. Push the roll axis (2) with the small-Ø ahead in to the main body's bigger borehole until it is flush.
   4.1 The marking line on the roll axis front side should point to the "+" side of the scale.
5. Fix the roll axis in position with the clamping screw (3).

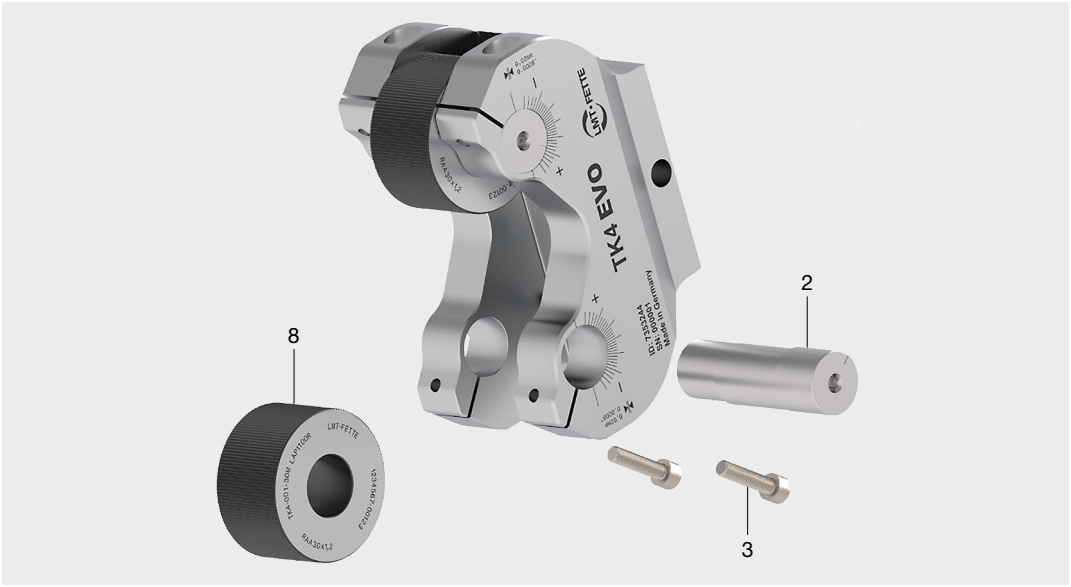


Figure 9: Inserting the rolls into the *rolling system*

Checking the rolls

Move or rather rotate the rolls in order to check a smooth-running.

Figure 10: Checking the rolls

IMPORTANT

Contact our Service Hotline if you can't move the rolls.

CAUTION

General risk of component breakage.

Don't do a roll process if you can't move the rolls.

4.3 Adjusting the axle distance to workpiece dimension

The eccentric roll axis (2) are used to adjust the axle distance to workpiece dimension.

1. Loosen the clamping screw (3).
2. Place the setting gauge (9) between the rolls (8) and adjust the roll axis (2) in the manner that the rolls touch the reference plane on the setting gauge slightly (see figure 7). We advice to adjust both roll axis evenly so that both marking lines are on the same scale position on each arm of the main body (1).
3. Fix the roll axis in position with the clamping screw (3)

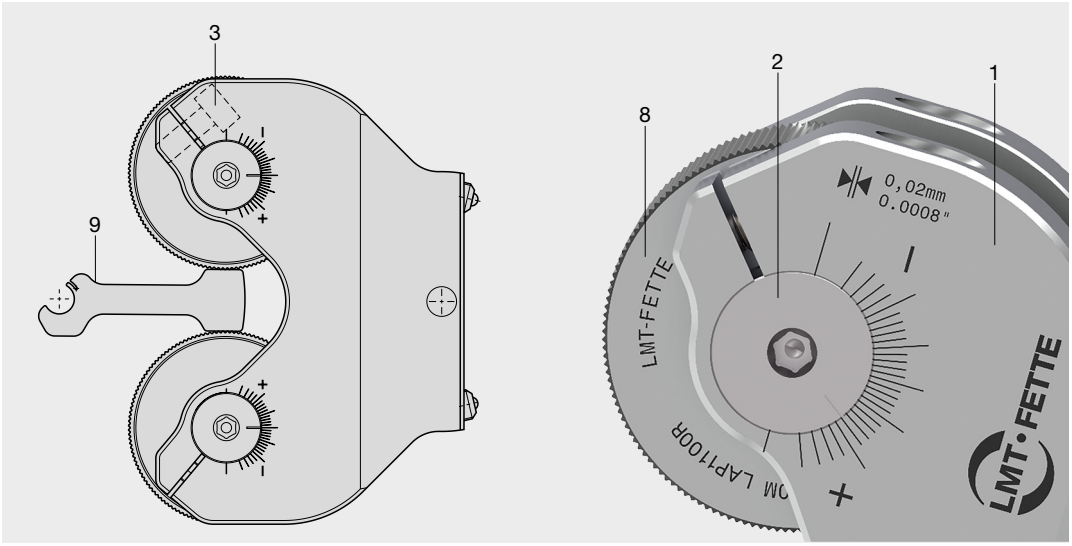


Figure 11: Adjusting the axle distance to workpiece dimension

IMPORTANT

Don't perform a second rolling process on a once rolled profile.

Following our installation instructions you will produce a non-completely formed profile tooth.
If the core/middle diameter is too large or the external diameter too small, make the following adjustments:

1. Decrease the axle distance. This makes the rolling head narrower and the core diameter smaller.
2. As a result of reducing the axle distance, more material is pressed into the tooth crest. This automatically increases the external diameter of the thread.

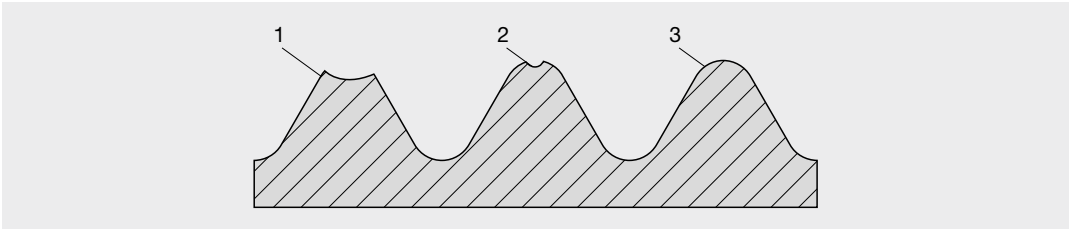


Figure 12: Degree of forming at the profile tooth

Closely inspect the rolled profile. Figure 12 shows the possible degrees of forming of a profile tooth:

- Tooth 1 represents a profile tooth that is **not completely formed**. This degree of forming normally yields a stable profile. In most applications this degree of forming I aimed for.
- Tooth 2 represents a thread tooth that is **completely formed**. This degree of forming is used to meet the highest requirements in optics and tightness.
- Tooth 3 represents a profile tooth that is **overformed**.

NOTE

After rolling, the workpiece external diameter d must not have a burnished finish and must not be overformed in the profile crests. This leads to increased roll wear.

4.4 Inserting the rolling head into the rolling head holder

The rolling head is delivered with springe plungers (7) which are set at our factory (don't move them).
You can insert and mount the rolling head without any additional tools.

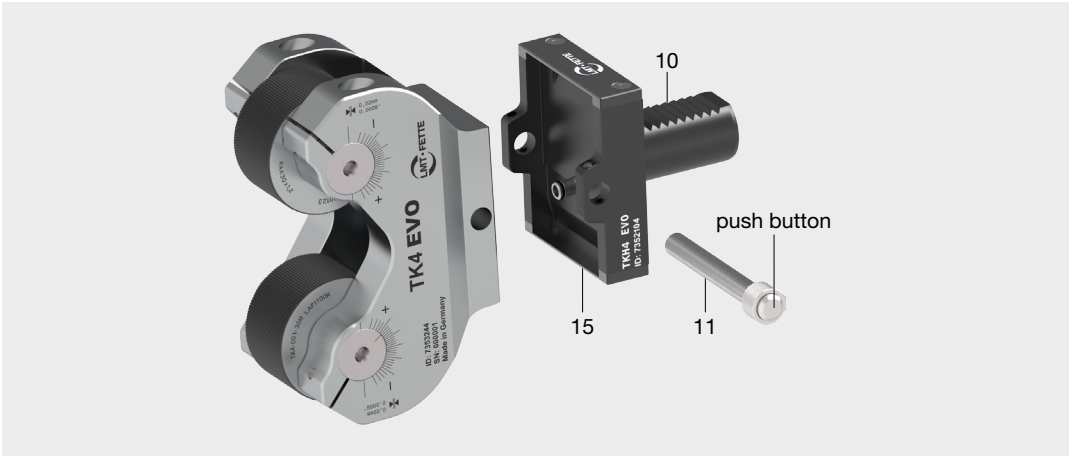


Figure 13: Inserting the rolling head into the holder

1. Push the button on the shaft (11) and pull the shaft (11) out of the holder (10).
2. Insert the rolling head into the holder in the manner that the coolant pipe (15) matches the determined borehole in the rolling head.

NOTE

We recommend to grease the o-ring (mounted on the coolant pipe (15) with customary silicone grease.

3. Push the putton on the shaft (11), plug the shaft fully into the holder (10) and let go of the push button. Make sure that the quick-release balls of the shaft snap into the locking boreholes. You may have to rotate the shaft in the mounted position until the quick-release balls engage.

IMPORTANT

The push button jumps slightly upwards when the quick-release balls engage successfully. Check if the shaft (11) is secured in position by attempting to pull the shaft out of the holder.

4. Hold the holder tight and check the pendular play of the rolling head in the holder, by moving the rolling head as shown in figure 14.

Figure 14: Checking the pendular play of the rolling head in the holder

4.5 Installing the *rolling system* in the processing machine

WARNING

General risk of injury from sharp edges.
The *rolling system* is made of various materials (e.g. nickel), which can trigger an allergic reaction.

Wear protective gloves and protective eyewear when using the rolling systems.

The weight of the *rolling* system may cause harm when it falls down.
General risk of injury during transportation/lifting of the *rolling system*.

- Ensure that the *rolling system* is protected of falling down or tipping over.
- Wear safety boot/hard-toed boot at all times.
- Use suitable hoisting devices.

1. Check if you need suitable hoisting device.
2. Insert the *rolling system* in the processing machine.
3. Fix and secure the mounting position of the *rolling system*.

Shank according to DIN 69880
Using a rolling head holder with a shank according to DIN 69880 on a turret, the correct alignment within the machine is via DIN 69880 ensured.

Roundshank
In the case of using a round shank the entire *rolling system* is turned is positon and then clamped. For centering, the *rolling systems* is moved against the initial diameter on the workpiece. The *rolling system* is turned until both rolls touch the initial diameter simultaneously.

5 Operation

IMPORTANT

First follow the instruction in chapter 4, installation.
Please contact our Service Hotline in the event of initial commissioning of the *rolling system*.

We will gladly advice on:
- Preparing the workpiece,
- Defining the process variables and
- Fine-adjusting the *rolling system*.

WARNING

General risk of injury from sharp edges.
The *rolling system* is made of various materials (e.g. nickel), which can trigger an allergic reaction.

Wear protective gloves and protective eyewear when using the *rolling systems*.

The weight of the *rolling system* may cause harm when it falls down.

General risk of injury during transportation/lifting of the *rolling system*.

- Ensure that the *rolling system* is protected of falling down or tipping over.
- Wear safety boot/hard-toed boot at all times.
- Use suitable hoisting devices.

5.1 Preparing the workpiece

Blank diameter

- For standard knurling use following formula:

NOTE

$d_V \approx d - h_Z$
d_V: Blank diameter [mm]
d: Nominal diameter [mm]
h_Z: Tooth depth according to DIN 82 [mm] – see table 6

The resulting blank diameter must be complied with a tolerance of –0.02 mm.

Chamfer

- The chamfer angle should be γ = 10°–30°.
- The interior diameter d_1 must be smaller than the core diameter.

NOTE

$d_1 \leq d_3 - 0.1$ mm
d_1: Interior diameter [mm]
d_3: Core diameter [mm]

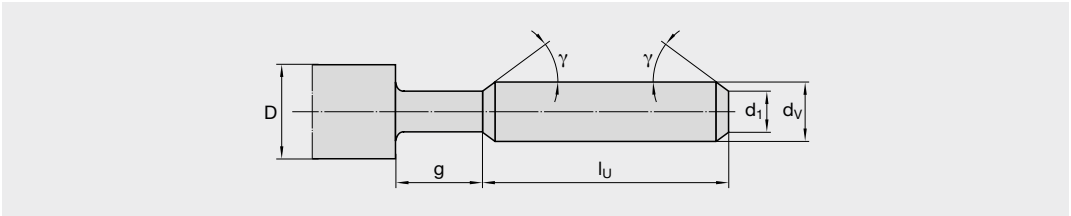


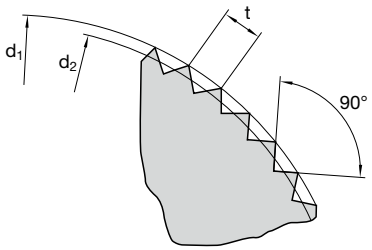
Figure 15: Preparing the workpiece incl. undercut

NOTE

g: Undercut (profile outlet) [mm]
γ: Chamfer angle [°]
D: Shoulder diameter [mm]
d_1: Interior diameter [mm]
d_V: Blank diameter [mm]
l_U: Profile length

Knurls according to DIN 82 (see table 5) can be manfucatured with *rolling system* type TK EVO.

Knurl



d_1 = Nominal diameter
d_2 = Pre-diameter
t = Pitch

Standard pitch *t*:
0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.6 mm

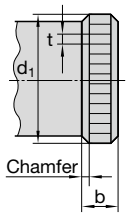
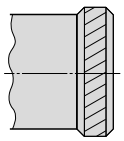
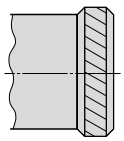
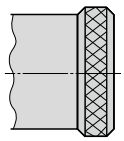
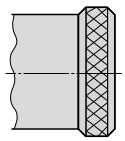
Form	RAA	RBL	RBR	RGE	RGV
Nomination	Knurls with axially parallel grooves	Left-hand knurl	Right-hand knurl	Left-hand/ right-hand knurls, points raised	Left-hand/ right-hand knurls, points intended
Illustration					
***d*2**	d_1 – 0.5 t			d_1 – 0.67 t	d_1 – 0.33 t

Table 5: Knurl profiles according to DIN 82

In the following table are the commonly used pitch and tooth heights with the pressure angle 90° shown.

Pitch t in mm	Tooth height in mm
0.5	0.23
0.6	0.25
0.8	0.37
1.0	0.47
1.2	0.50
1.5	0.64
1.6	0.75
2.0	0.95

Table 6: Tooth height depending on the pitch

5.2 Rolling process and feed

Tangential-Knurling *rolling systems* are designed to be operated on CNC lathe and multi spindle machines by using the plunge cutting method. Therefore the profile lengths is limited to the roll widths. In general the tangential rolling process consist the following process steps:

approach fast feed → work cycle slow feed → return fast speed

Each step is shown in figure 16. Make sure that the fast feed approach is finished before the beginning of the work cycle. The working feed is the theoretical travel “AV” of the *rolling system* from the moment of initial contact of the rolls on the workpiece diameter all the way up to the end position of the work cycle. The working feed (AV) is shown in the table below. The precise “Av” value of an specific application is written on the setting gauge. The actual working feed should be completed within W = 20 workpiece rotations.

Working feed depending on the pitch (AV)								
Rolling head	Knurling pitch t in mm							
	0.5	0.6	0.8	1.0	1.2	1.5	1.6	2.0
TK1	6.327	6.404	6.850	7.202	7.304	7.766	8.112	8.710
TK2	6.327	6.404	6.850	7.202	7.304	7.766	8.112	8.710
TK3	7.525	7.617	8.144	8.559	8.680	9.226	9.634	10.338
TK4	8.361	8.462	9.046	9.507	9.641	10.245	10.696	11.475
TK5	9.478	9.592	10.253	10.773	10.925	11.607	12.117	12.995
TK6	10.236	10.359	11.072	11.633	11.796	12.531	13.081	14.028

Table 7: Knurling pitch and working feed (AV)

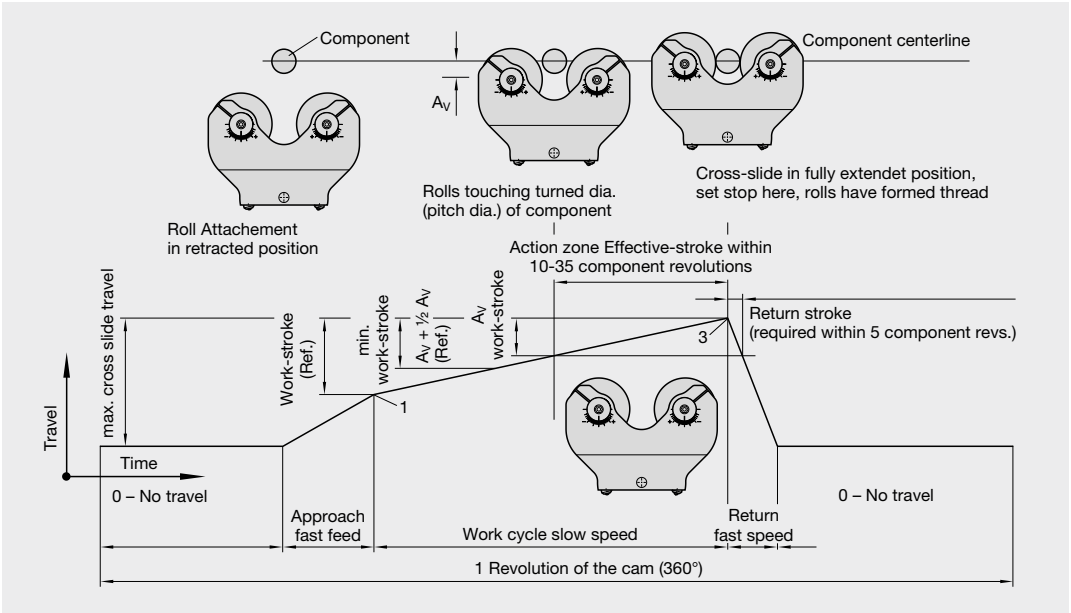


Figure 16: The tangential rolling process

Operating feed

Calculate the operating feed f and the feed rate f_v as follows:

CAM controlled machines:

$$f = \frac{A_V}{n_w}\ [\text{mm/rev.}]$$

non-CAM-controlled machines:

$$f_v = \frac{A_V \cdot n}{n_w}\ [\text{mm/rev.}]$$

NOTE

f: Operating feed [mm/U]
f_v: Feed rate [mm/min]
n: Machine speed [min^{-1}]
n_w: Workpiece revolutions
A_V: Working stroke [mm]

NOTE

RAA type knurls require faster operation feed than usual knurls.
We recommend for RAA type knurls:

- Operation feed: 1.0 – 1.5 mm/revolution and
- Workpiece revolution: W = 10 – 15.

5.3 Travels – set up the *rolling system* depending on the workpiece

To determine the tooling length you can use a formula or use the setting gauge to set up the *rolling system*.

Calculating the tooling length

The tool length is calculated using the following formula:
$l_w = X_H + X$

NOTE

The measures X_H and X are labeled on the rolling head and the holder.

l_w: Tool length [mm]
X_H: Machine conctact surface till joint point: rolling head/holder
X: Joint point: rolling head/hilder till rolling center (workpiece center)

IMPORTANT

Note that the tool length l_w is merely the theoretical tool length.
Inspect the travel paths for problematic geometries by running them slowly without workpiece.

Creating the travel paths using the calculated tooling lengths

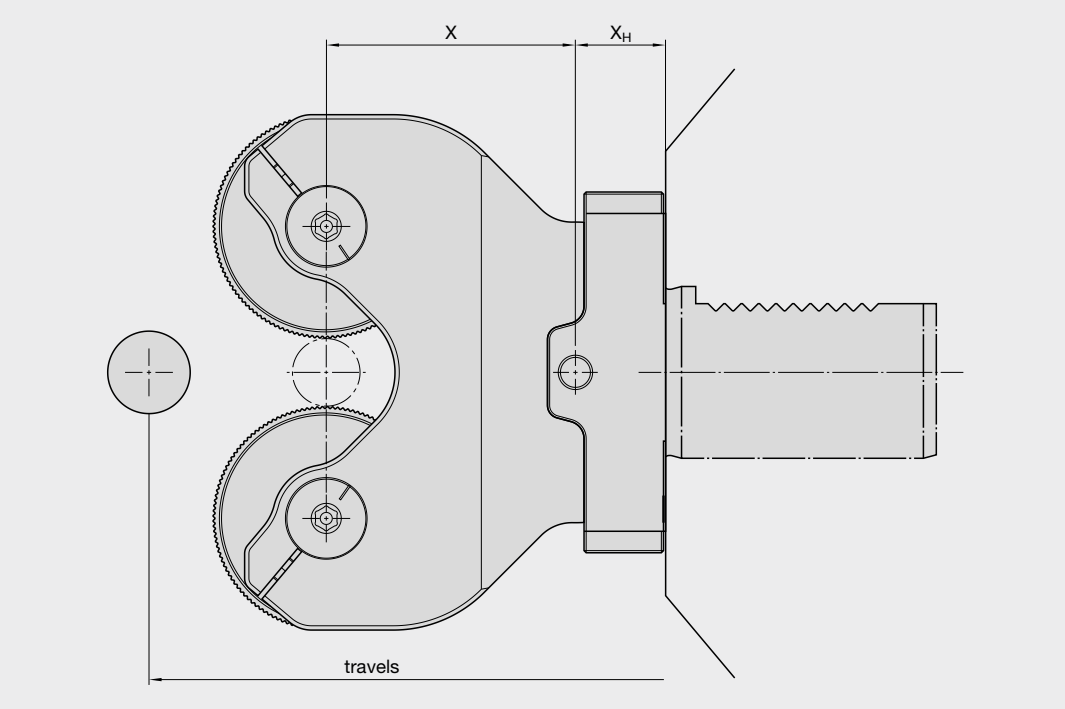


Figure 17: Creating the travel paths via calculated tooling lengths

Creating the travel paths using the setting gauge

1. Install the rolling head holder into the processing machine.
2. Clip the setting gauge on the shaft (11).
3. Move the rolling head hoolder with the setting gauge towards the workpiece until the leading edge of the setting gauge touches the blank diameter d_A of the workpiece, This position is equivalent to the end point of the travel path. The rolling head must not be moved farther towards the workpiece. Particularly in cam-controlled machines, a fixed stop must be set here.

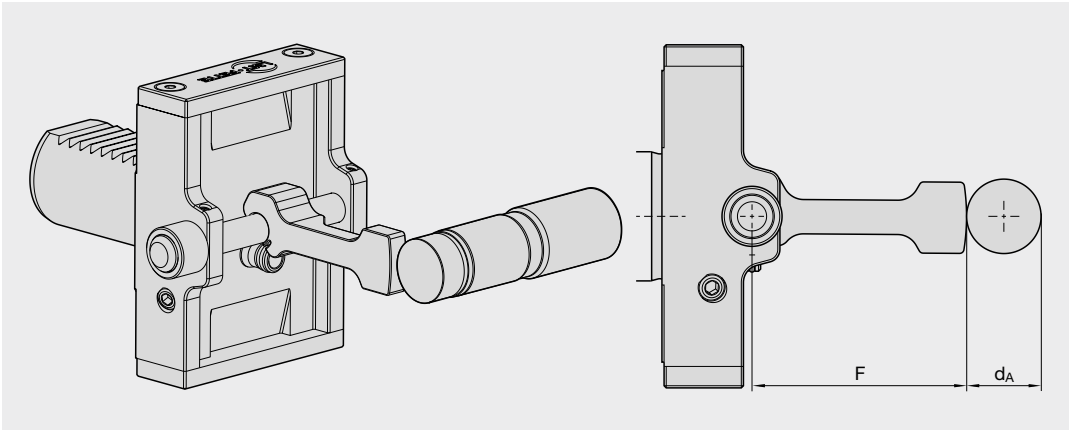


Figure 18: Creating the travel paths using the setting gauge

5.4 Rolling speed and machine speed

Rolling speed

NOTE

Determine the rolling speed depending on the material using the table 8.

Tensile strength (yield) and elongation at fracture of the material:

For materials with high tensile strength, operate at 20 – 30 m/min. Bear in mind that the rolling speed depends on the tensile strength. Choose low rolling speeds for high tensile strength, and for low tensile strength choose high rolling speeds.

Machine speed

NOTE

The machine speed is calculated as follows:

$$n = \frac{1000 \cdot v}{d_A \cdot \pi} \qquad n = \frac{1000 \cdot v}{d_A \cdot \pi} \ [\text{min}^{-1}]$$

n: Machine speed [min^{-1}]
v: Rolling speed [m/min]
d_A: Blank diameter [mm]

	Steel grade	Tensile strength N/mm²	Abbreviation	Material number	Rollability	Rolling speed	
						m/min	ft/min
Ferrous metals	General structual steels	500	S235JRC	1.0120	☺	40–80	130–265
		500– 600	S550GD	1.0531	☺	30–60	100–200
		750– 900	C50	1.0540	☺	20–50	65–165
		630– 850	C45E	1.1191	☺	20–50	65–165
	Case hardening steels	590– 780	C15E	1.1141	☺	40–70	130–230
		780–1080	16MnCr5	1.7131	😐	30–50	100–165
	Nitriding steels	780	34CrAl6	1.8504	😐	20–50	65–165
		900–1300	31CrMoV9	1.8519	😐	20–40	65–130
	Free cutting steels	350– 530	10S10	1.0711	☺	30–60	100–200
		360– 760	11SMnPb30	1.0718	☺	30–60	100–200
		590– 830	35S20	1.0726	☺	30–60	100–200
	Heat tratable steels	630– 780	C35	1.0501	☺	40–70	130–230
		850–1000	C60E	1.1221	😐	30–60	100–200
		1100–1300	42CrMo4	1.7225	😐	20–50	65–165
		1250–1450	30CrMoV9	1.7707	☹	20–40	65–130
		1200–1400	34CrNiMo6	1.6582	☹	20–40	65–130
		1100–1300	51CrV4	1.8159	☹	20–40	65–130
	Tool steels	800– 850	X210Cr12	1.2080	😐	30–50	100–165
		800–1000	X130W5	1.2453	😐	20–40	65–130
		760– 810	115CrV3	1.2210	😐	30–50	100–165
	High speed steels	920	HS6-5-2C	1.3343	☹	20–40	65–130
		880	HS6-5-2-5	1.3243	☹	20–40	65–130
	Stainless steels	650– 730	X12Cr13	1.4006	😐	30–50	100–165
		800– 950	X17CrNi16-2	1.4057	😐	30–50	100–165
		650– 850	X14CrMoS17	1.4104	😐	30–50	100–165
		500– 700	X5CrNi18-10	1.4301	☺	35–55	115–175
		500– 750	X8CrNiS18-9	1.4305	☺	35–55	115–175
		500– 700	X5CrNiMo17-12-2	1.4401	😐	30–50	100–165
		500– 700	X6CrNiMoTi17-12-2	1.4571	😐	30–50	100–165
	Cast steels	380– 530	GE200	1.0420	☺	40–60	130–200
		540	G36Mn5	1.1176	☺	40–60	130–200
		1000–1200	G50CrMo4	1.7232	😐	30–50	100–165
	Malleable cast iron	450	EN-GJMB-450-06	EN-JM 1140	😐	30–60	100–200
		650	EN-GJMB-650-02	EN-JM 1180	😐	30–60	100–200
	Cast iron	400	EN-GJS-400-15	EN-JS 1030	☺	30–60	100–200
		500	EN-GJS-500-7	EN-JS 1050	😐	30–50	100–165
		600	EN-GJS-600-3	EN-JS 1060	😐	30–50	100–165
	High temperature materials	≥ 970	NiCo20Cr20CoMoTi (Nimonic 263)	2.4650	😐	30–50	100–165
		700– 950	NiMo16Cr15W (Hastelloy C276)	2.4819	😐	20–40	65–130
	Nickel alloys	580– 800	NiCr15Fe (Inconell 600)	2.4816	☹	20–40	65–130
Non-ferrous metals	Copper	240–300	E-Cu	CW004A	☺	40–80	130–265
	Copper alloys (Brass)	310	CuZn37	CW508L (R310)	☺	40–80	130–265
		410	CuZn38Pb2	CW608N (R410)	😐	40–70	130–230
		360	CuZn38Pb2	CW608N (R360)	☺	40–70	130–230
		430	CuZn39Pb3	CW614N (R430)	😐	40–70	130–230
	Aluminum alloys	150– 240	AlMg2	EN AW-5251	☺	40–70	130–230
		160– 310	AlSi1MgMn	EN AW-6082	😐	40–70	130–230
		220– 350	AlZn4,5Mg1	EN AW-7020	☹	30–50	100–165
		220– 440	AlCu4Mg1	EN AW-2024	😐	30–50	100–165
		275– 540	AlZn5,5MgCu	EN AW-7075	😐	30–50	100–165
	Titanium alloys	390– 540	Ti2	3.7035	☺	30–60	100–200
		540– 650	TiCu2	3.7124	☺	30–60	100–200
		750– 950	TiAl5Sn2,5	3.7115	😐	30–60	100–200
		1030–1100	Ti6Al4V	3.7164.7	😐	20–40	65–130

Table 8: Rolling speed

5.5 Tangential force, driving power, torque and rolling time

Tangential force

The rolling head works with plung cutting mehtod. The two rolls move laterally over the workpiece. The roll profile penetrates tangentially into the workpiece, creating the desired shape. The processing machine generates the tangential force F_T. The rolling head absorts the radial force F_R.

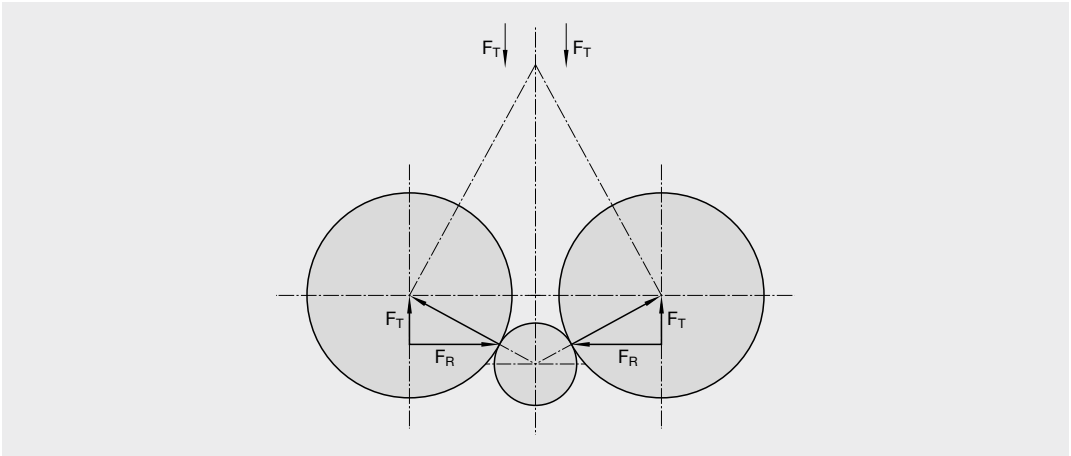


Figure 19: Forces occurring during the tangential rolling process

In the case of hydraulically or electrically driven slides check the maximum tangential force. Calculate the tangential force F_T as follows:

$$F_T = \frac{2340 \cdot L \cdot K_{WT}}{n_w} (0.06 \cdot d^{0,82} + 0.46 \cdot P - 0.1 \cdot Z + 1) \text{ [N]}$$

NOTE

F_T: Tangential force [N]
F_R: Radial force [N]
L: Profile lengths [mm]
K_{WT}: Material constant
n_w: Workpiece revolutions
d: External diameter [mm]
P: Pitch (profile depths) [mm]
Z: $\frac{\text{Roll-Ø}}{\text{Workpiece-Ø}}$

The material constant K_{WT} is derived from the following table:

Tensile strength R_M of the workpiece [N/mm²]	K_{WT}
0 – 500	1
500 – 700	1.2
700 – 900	1.3
> 900	1.4
Copper	1.1
Brass	0.9

Table 9: Material constant K_{WT}

NOTE

Increase the number of workpiece revolutions in ordert o get a lower tangential force.

Calculate the driving power and torque as follows:

Driving power
$N = 0.105 \cdot 10^{-5} \cdot n \cdot F_T$ [kW]

Torque
$M = 0.01 \cdot F_T$ [Nm]

NOTE

n: Machine speed [min^{-1}]
F_T: Tangential force [N]
N: Driving power [KW]
M: Torque [Nm]

6 Disassembly after operation

IMPORTANT

Please conctact our Service Hotline in the event of dismounting:

- Removing the *rolling system* from the processing machine.
- Dismounting the rolling head.
- Dismounting the rolling head holder.
- Dismounting the thread rolls.

Check all modules of the *rolling system* for wear and damage.
Please contact the operator if you notice wear or wear on a component of the *rolling system*.

CAUTION

Risk of injuries the hands!

During decommissioning, dismounting or disposal activities there is a risk of sustaining injuries caused by rough, sharp surfaces of transport crates, boxes, pallets or packaging aides.

Wear safety gloves to avoid injuries by cutting.

WARNING

General risk of injury from sharp edges.

The *rolling system* is made of various materials (e.g. nickel), which can trigger an allergic reaction.

Wear protective gloves and protective eyewear when using the *rolling systems*.

The weight of the *rolling system* may cause harm when it falls down.
General risk of injury during transportation/lifting of the *rolling system*.

- Ensure that the *rolling system* is protected of falling down or tipping over.
- Wear safety boot/hard-toed boot at all times.
- Use suitable hoisting devices.

6.1 Removing the *rolling system* from the processing machine

WARNUNG

Risk of burns from the hot surface of the *rolling system*.

Only remove the *rolling system* after the *rolling system* has cooled down.

Risk of cuts due to chips adhering to the *rolling system*.

Remove any chips adhering to the system from the *rolling system* before removing the rolling system form the processing machine.

1. Check if you need suitable hoisting device.

   - We advise to use suitable hoisting device when lifting the *rolling system* from a weight of 5 kg | 11 lb.

NOTE

Suitable hoisting devices are for example:

- A sling
- Hoisting Chain
- Lift cable.

Please contact your occupational safety specialist before transportating the *rolling system*.

2. Make sure that the *rolling system* or components do not fall down.
3. Unclamp the *rolling system* in the processing machine.
4. Remove the *rolling system*.

6.2 Removing the rolls

1. Loosen the clamping screw (3) and remove the roll axis (2).
2. Hold the rollers (8) with your hand to secure them.
3. Remove the rolls.

NOTE

Use only rolls with the same roll set number (profile dimension, rolling head type, roll code number, roll width and roll version).
Be sure to lubricate the roll bores and and the roll axis with molybdenumsulfide grease (e. g. Molykote).

After changing the rolls, check the rolled profile. If the external diameter is not correct, compensate this by making changes to the rolling head settings.

6.3 Removing the rolling head holder

1. Push the button on the shaft (11) and pull the shaft (11) out of the holder.
2. Remove the rolling head.
3. Reinsert the shaft (11) into the rolling head holder.

7 Wear parts, parts list

Wear parts

NOTE

Wear parts are

- Roll set (6)
- Roll axis (2)

Please contact the operator if you notice wear or wear on a component of the *rolling system*.

Parts list

NOTE

When ordering spare parts be sure to state the ID number.

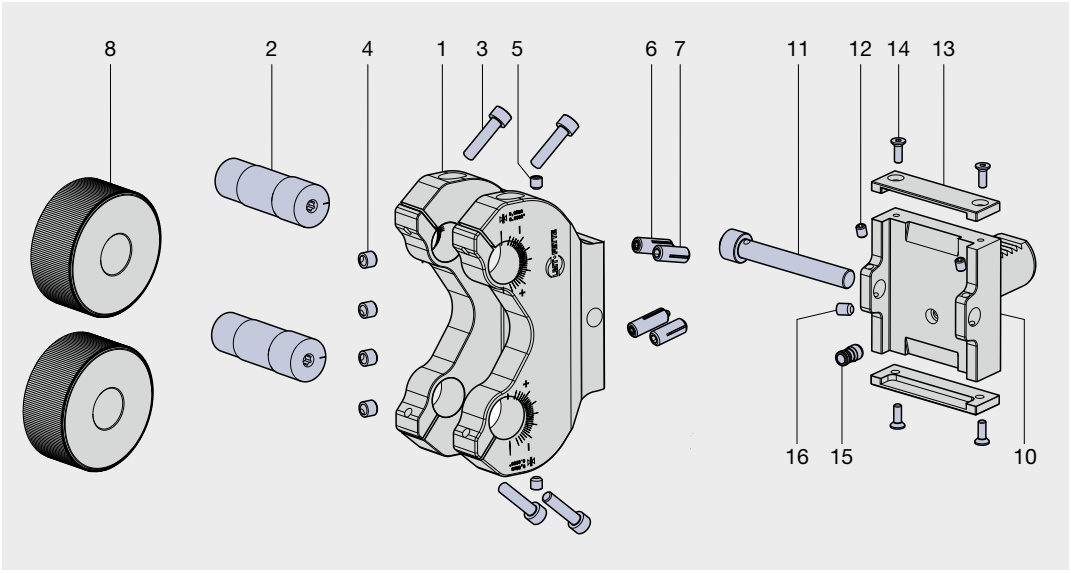


Figure 20: Exploded view TK1 – TK6 EVO

The following ID numbers are used in the standard TK EVO *rolling systems*.

Rolling Head			TK1 EVO	TK2 EVO	TK3 EVO	TK4 EVO	TK5 EVO	TK6 EVO
Part No.	Qty.	Designation	Ident No.					
			7368881	7368882	7368883	7368884	7368885	7368886
1	1	Body	7351126	7351138	7351139	7351123	7351140	7351142
2	2	Roll axis	7351151	7351152	7351150	7351143	7351143	7351143
3	4	Clamping screw roll axis	7370076	2900634	2142021	2142022	2142023	2142023
4	4	Nozzle	7045437	7210132	7210132	7210132	7210132	7210132
5	2	Coolant channel plug screw	7337739	2142073	2142073	2142073	2142073	2142073
6	2	Spring plunger	7294245	7294245	7366490	7366490	7366490	7366490
7	2	Pendeulum stop		7367319	7366491	7366491	7366491	7366491
8	2	Roll	individual					
9	2	Setting gauge	individual					
10	1	Body holder	individual					
11	1	Shaft	7294197	7294257	7294397	7294497	7294497	7294497
12	2	Screw pin	2142056	2142056	2142061	2142067	2142067	2142067
13	2	Chip guard	individual					
14	4	Clamping screw chip guard	2142991	2143245	2143246	2143246	2143246	2143246
15	1	Coolant connection pipe	7351144	7351144	7351144	7351144	7351144	7351144
16	1	Plug screw for holder	7337739	2142074	2142073	2142074	2142074	2142074

Table 10: Components of the *rolling system* TK1 – TK6 EVO

8 Maintenance

Maintenance

Daily:
Check all components of the *rolling system* for wear and damage.

Weekly:
1. Follow the instructions in chapter 6.
2. Follow the instructions in chapter 4.

Maintenance when replacing the roll set

1. Follow instructions in chapter 6.
2. Follow instructions in chapter 4.

Maintenance intervals

Be sure do adhere to the maintenance intervals listed in table 11. If the *rolling system* is used under more difficult conditions, the cleaning and maintenance intervals must be shorter.

Interval	Activity	Desricption
Weekly (preferable daily)	Machine operator	Check the rolls for wear or toher damages. Clean the rolls from chips.
Weekly	Machine setter	Lubricate the rolls and the roll axis with molybdenumsulfide (e. g. Molykote).

Table 11: Cleaning and maintenance intervals

9 Storage

NOTE

The storage state is the condition upon delivery.

1. Follow the instruction in Chapter 6.
2. Conserve the *rolling system*.
3. Store the *rolling system*.

Storage temperature: –10 °C maximal +30 °C
Relative humidity: < 60 %

10 Disposal

NOTE

Dispose the *rolling system* with harmful coatings such as oils and fats properly. Improper disposal of the used materials is harmful to the environment. When you dispose materials, comply with national and local regulations.

Ensure that all national and local safety requirements are met:

- After discarding the rolling head, sorted disposal must be performed.
- Seperate iron, non-ferrous metals, etc.
- Grease, oils and objects and lines which are soiled with grease or oil must be disposed separately.

11 Troubleshooting

NOTE

Perform a visual and functional inspection prior to each troubleshooting.

Fault		Cause	Solution
1	Conical profile	Rolling head holder worn out	Replace the rolling head holder with a new holder
		Roll axis worn	Replace roll axis if wear Ø > 0.03 mm
		Misalignment of head and part (≥ 0.2 mm error)	Realign rolling system and part
		Blank diameter taperad	Manufacture a cylindrical blank diameter
2	Profile out of tolerance	Incorrect rolling head setting	Renew rolling head set up
		Incorrect blank diameter (too big/too small)	Accurate pre-machining
3	Pitch error	Misalignment of head and part (≥ 0.2 mm error)	Realign rolling system and part
		Wrong roll	Use correct roll
		Material not rollable	Check and follow (chapter 5.4)
		Incorrect feed	Choose feed rate according to chapter 5.2
4	Roll breakage	Inapproprate chamfer	Chamfering according to chapter 5.1
		Blank diameter too big	Accurate pre-machining of blank diameter (chapter 5.1)
		Rolling head setting too tight	Adjust the rolling head (chapter 4.3)
		Misalignment	Realign the machine
		Material too hard	Only roll on materials with max. material strength of 1000 N/mm² or lower
		Too much material transforming	Choose bigger rolling head
		Rolled with overload	Adjust the rolling head (chapter 4.3)
5	Extended roll wear	Material with bad rollability	Check and follow table 8
		Examination of rolling speed	Check and follow table 8
		Elongation properties inadequate	Choose different material
		Not enough coolant	Start using coolant, readjust coolant nozzles, increase coolant pressure
		Inapproprate chamfer	Chamfering according to chapter 5.1
6	Profile not smooth	Workpiece deflection	Increase workpiece support
		Inappropriate chamfer	Chamfering according to chapter 5.1
		Rolling speed too large or too small	Check and follow table 8
		Too much or too little power for pushing on to the workpiece	Adjust the pressing/psuhing force

Table 12: Troubleshooting

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