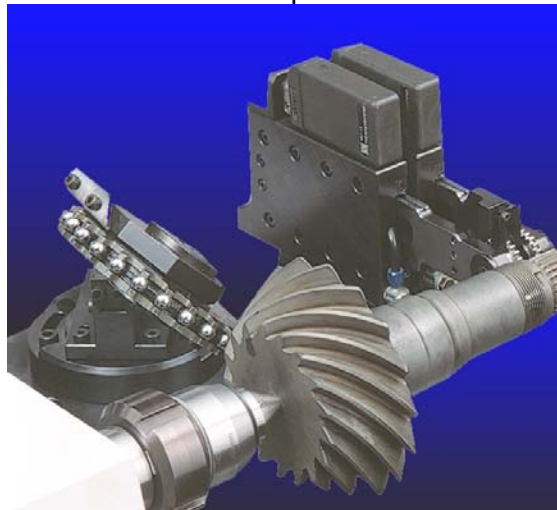


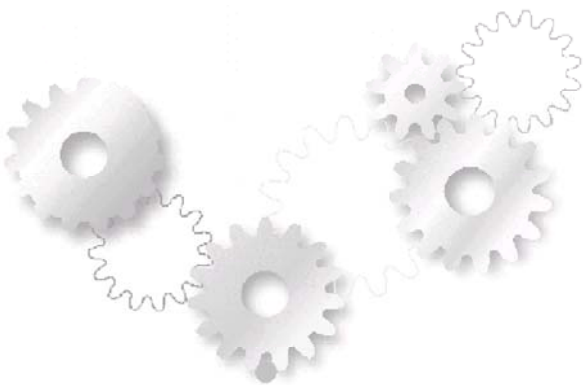


Universal Rotation Measurement

URM-R



*Rotating simultaneous
measurements*




*pure
perfection*

FRENCO

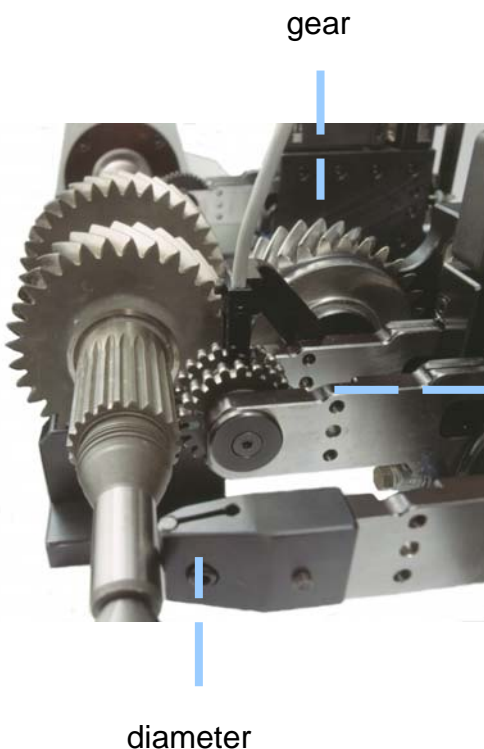
Function

The inspection of work pieces is made within a continuous rotation of 360°. The work pieces are scanned by radially assembled measuring carriages, each equipped with an own sensor and powered by a central encoder.

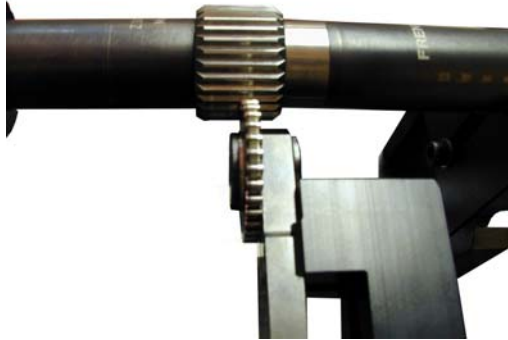
The alignment of several different measuring carriages enables the execution of different measuring tasks within one single rotation. The measuring datas are processed simultaneously in the measuring electronic MEG32.

The different measuring carriages can be combined arbitrarily. The positions of axis are determined and the different geometries are clearable among each other.

	URM - R		
	measuring wheel	master gear	measuring edge
Geometry to be inspected	splines and bevel gears	gears	diameters and plane face
Contact	double flank contact point contact	double flank rolling contact cover > 1	point contact
Probe	pin	master gear	edge or pin
Way of measurement	detection of the turning point during a continuous rotation	distance of axis during a continuous rotation	scan of diameter during a continuous rotation
Flexibility	The using range of URM-R is larger if it has less simultaneous measuring points		
cycle time of measurement	3 sec.		
Frequency	100% measurement		
Inspection features			



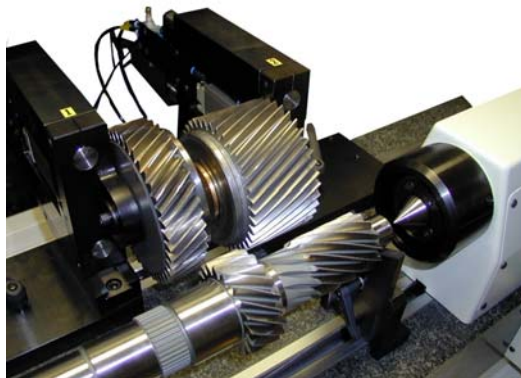
Measurement of geometries



spline



2x spline



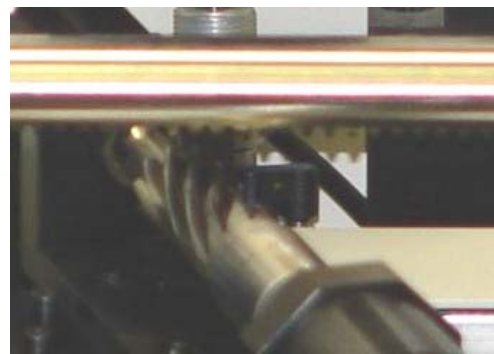
2x gear



bevel gear



diameter



rack

Types of URM-R machines

Contents

URM-R horizontal	5
URM-R vertical	6
URM-R rack	7
Software	8
Precision of measurement	9
The method of measurement	11
Measurement of diameters	13
Rolling ball inspection	14
Double flank gear roll inspection	19

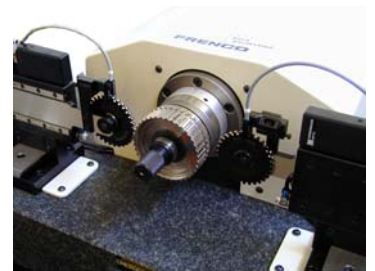
URM-R

horizontal

between centers



unsupported



vertical

between centers



unsupported



rack



URM-R horizontal

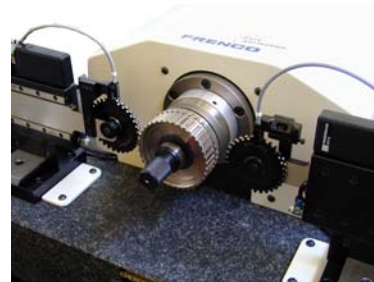
Mounting: between centers
Use shown: measurement of a crankshaft.

Measuring slide for spline
Measuring slide for straight sided spline
with index measurement relative to each other



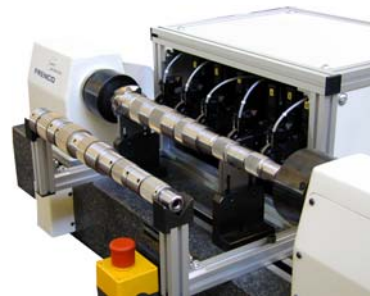
Mounting: unsupported chuck
Use shown: measurement of spline

2 x measuring slide for splines with index measurement.



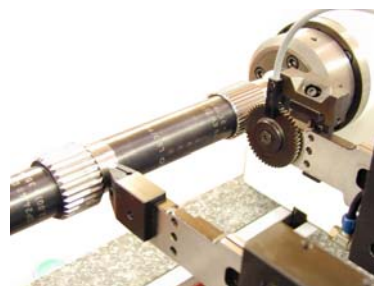
Mounting: between centers
Use shown: measurement of a shaft.

5 measuring slides for 5 splines with index measurement. Automatic loading is applicable.



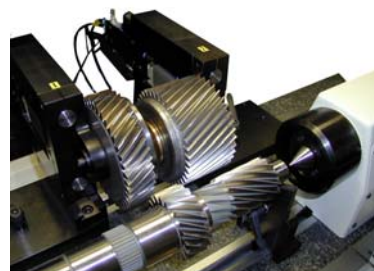
Mounting: between centers
Use shown: measurement of a shaft.

1x measuring slide for spline with index measurement
1x measuring slide for diameter



Mounting: between centers
Use shown: measurement of a gearshaft.

2x measurement of gears with double flank gear roll inspection by master gears



URM-R vertical

Mounting: between centers
Use shown: measurement of a gear.

1x measurement of gear with
double flank gear roll inspection
with master gear



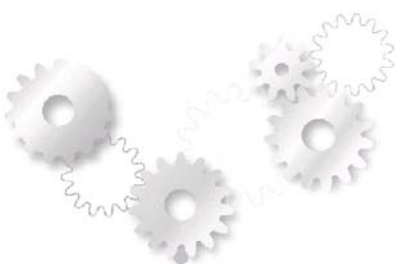
Mounting: unsupported chuck
Use shown: measurement of 3 different
gears

3x measurement with a measuring wheel,
each type of gear with its special
measuring slide



Mounting: unsupported chuck
Use shown: measurement of interrupted
gear

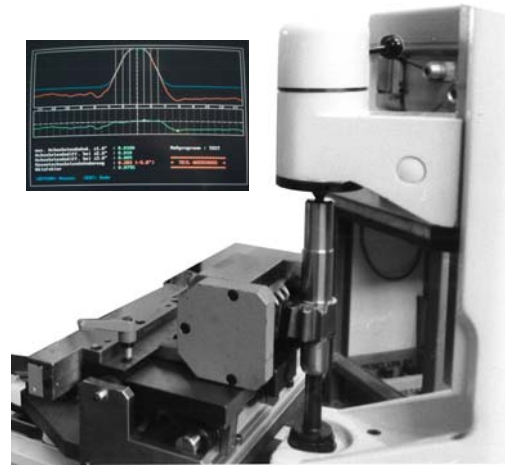
1x measurement of gear with double flank
gear roll inspection and interrupted
measuring cycle.



URM-R rack

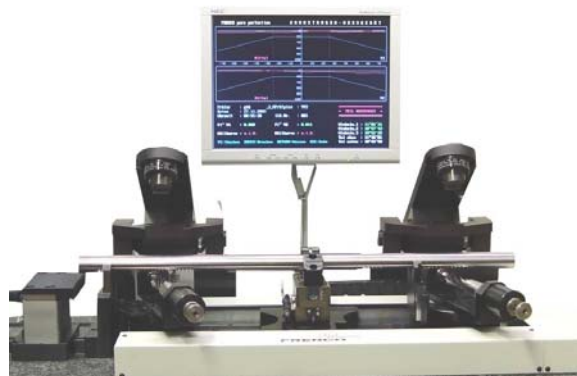
URM-R rack
for steering pinions.

1x double flank gear roll inspection and
special analysis.



URM-R rack
for double rack shaft

2x simultaneous double flank gear roll
inspection
with special analysis.



URM-R rack
for single rack.

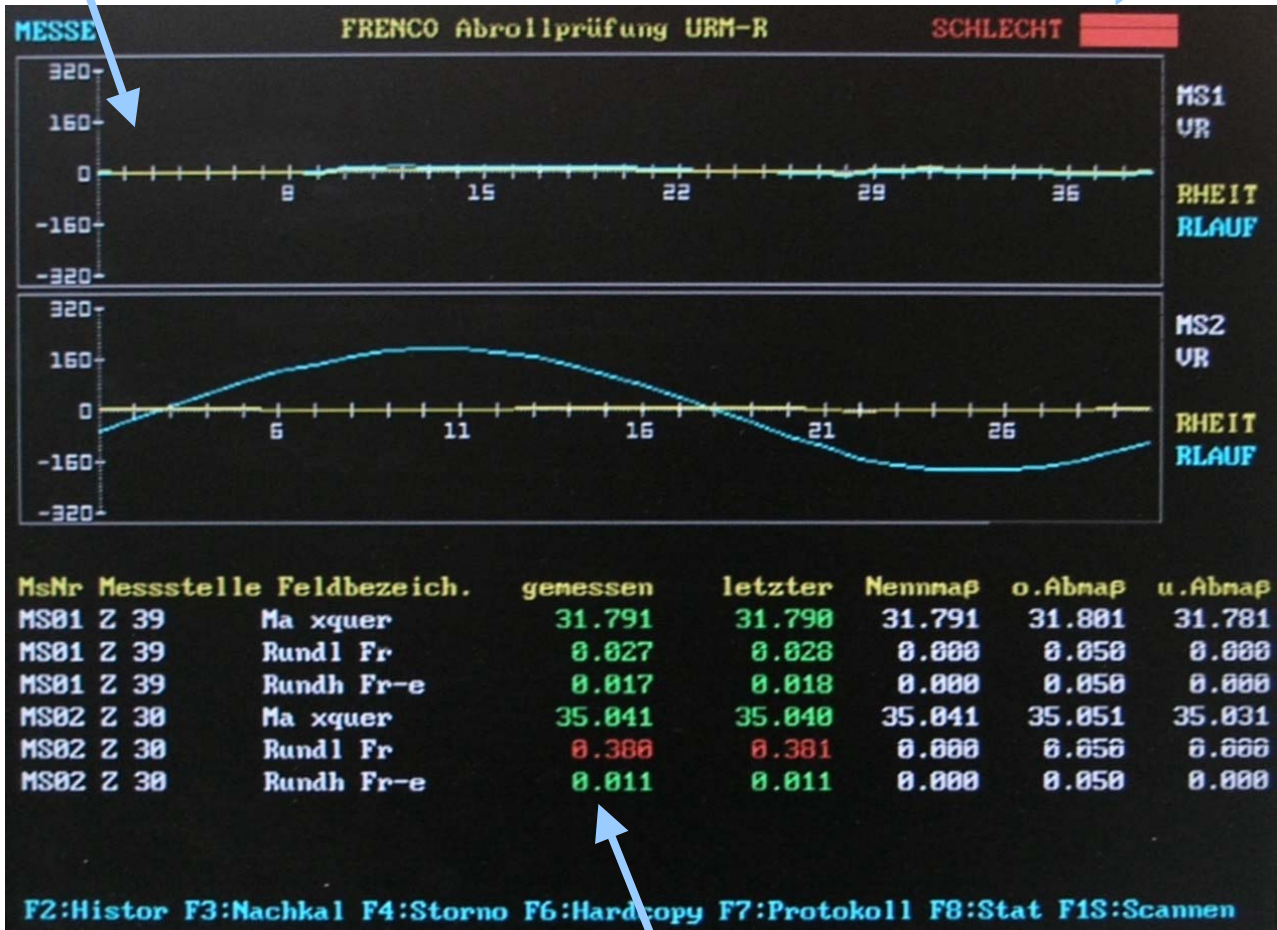
1x double flank gear roll inspection.



Software

graphical evaluation of the measuring values

displays whether the specimen is to accept or not



Displays of the most important measuring values, individual setting

The FRENCO measuring electronic MEG 32 controls the measuring slides, registers the measuring values and links with the integrated PC.



Precision of measurement

FRENCO measuring instruments are always calibrated by artefacts. The calibration of the FRENCO inspection artefacts is made in our own accredited calibration laboratory.

After the calibration these artefacts are measured 25 times with the FRENCO measuring instrument. Out of these measuring values the following statistical features are evaluated:

Repeatability:

The repeatability describes the range of measuring values around their average. It is calculated by this formula:

$$WBK = \pm 2 * k * s$$

k = factor to consider the number of measured values
(for 25 measuring values k = 1,32)

s = standard deviation calculated out of the 25 measuring values

Max. deviation of measurement:

The max. deviation of measurement describes the largest deviation of one single measuring value referred to the actual value of the inspection artefact. It is calculated by this formula:

$$MA = \pm \text{Max} (|X_{\text{Max}} - X_{\text{Normal}}| ; |X_{\text{Min}} - X_{\text{Normal}}|)$$

X_{Max} = biggest single value out of the 25 measurements

X_{Min} = smallest single value out of the 25 measurements

X_{Normal} = actual value of the artefact

Correction of the mistake of the measuring wheel:

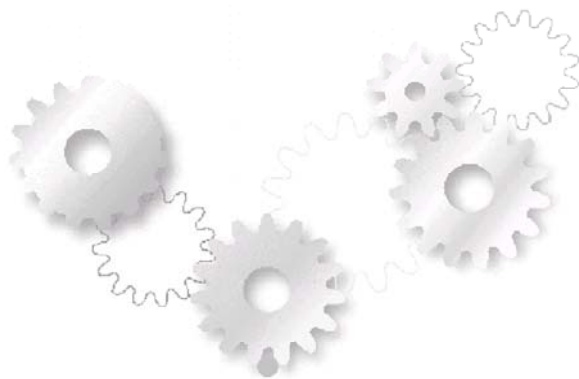
The precision of the URM-R measuring instruments depends among others on the precision of the used measuring wheels. These wheels are designed by FRENCO with highest precision. Nevertheless mistakes caused during the production (runout/ index) cannot be avoided. These inaccuracies of the measuring wheels make an impact on

the total accuracy of the measuring instrument. On request FRENCO offers a correction of the mistake of the measuring wheel. Thus it is possible to determine the mistakes of the measuring wheels by a special measuring cycle. This determined mistake can be cleared with the measuring results. That way the highest possible precision can be achieved.

The following uncertainties are calculated for a URM-R with automatic measuring process (Values in brackets are without correction of the mistake of the measuring wheel) by one example:

Feature	mm	Repeatability	Max. deviation
size over/ between balls (average)	MdK	±0,002	±0,002
size over/ between balls min./ max.	MdK	±0,003	±0,003
eccentricity	e	±0,002 (±0,003)	±0,002 (±0,003)
runout	Fr	±0,003 (±0,005)	±0,003 (±0,005)
roundness	Fr-e	±0,002 (±0,004)	±0,002 (±0,004)
total index deviation	Fp / Fp-e	±0,003 (±0,005)	±0,004 (±0,006)
single index deviation	fp / fp-e	±0,002 (±0,004)	±0,003 (±0,005)

Feature	mm	Repeatability	Max. deviation
internal or external diameter (average)	∅	±0,002	±0,002
internal or external diameter min./max.	∅	±0,003	±0,003
eccentricity	e	±0,002	±0,002
runout/ axial runout	Fr	±0,003	±0,003
runout/ evenness	Fr-e	±0,002	±0,002



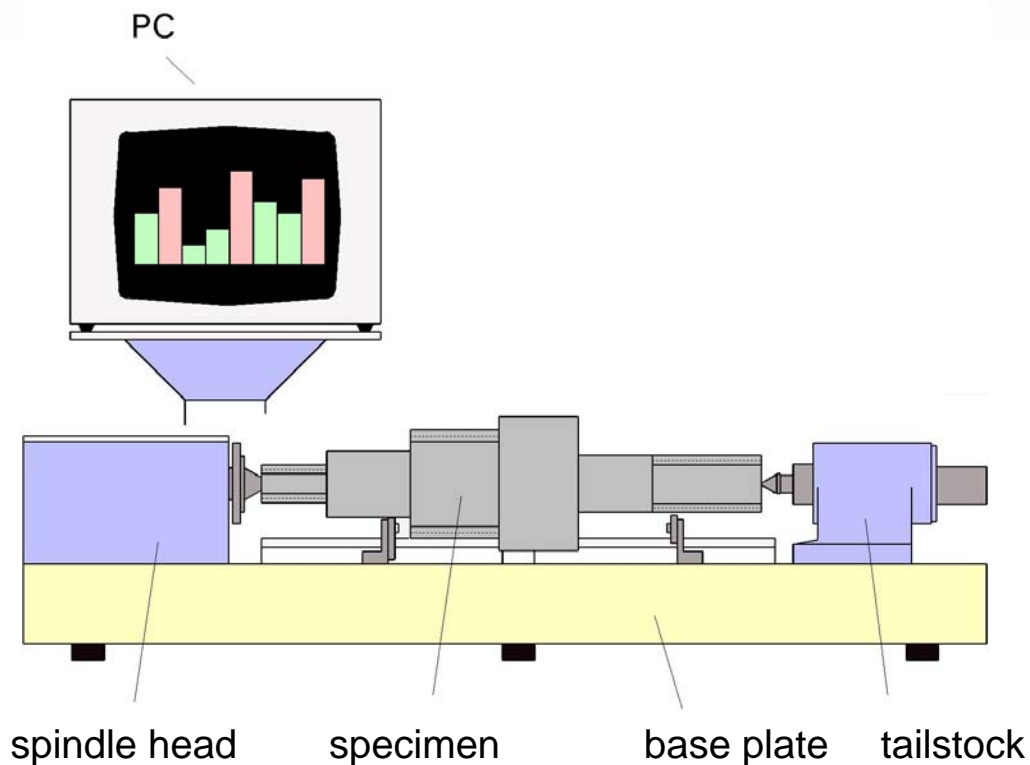
The method of measurement

The universal rotation measurement inspects the specimen during a continuous rotation of 360°. The work piece is mounted on a chuck or between centers. The work piece is scanned by aligned measuring slides with sensors.

The spindle head rotates the specimen. During this rotation the radial measuring value of the measuring slides and the angle of rotation are registered and evaluated to each other.

The processing of the registered values is made by the measuring electronic MEG 32. FRENCO has developed an evaluation software, that can analyze many different features of gears and splines.

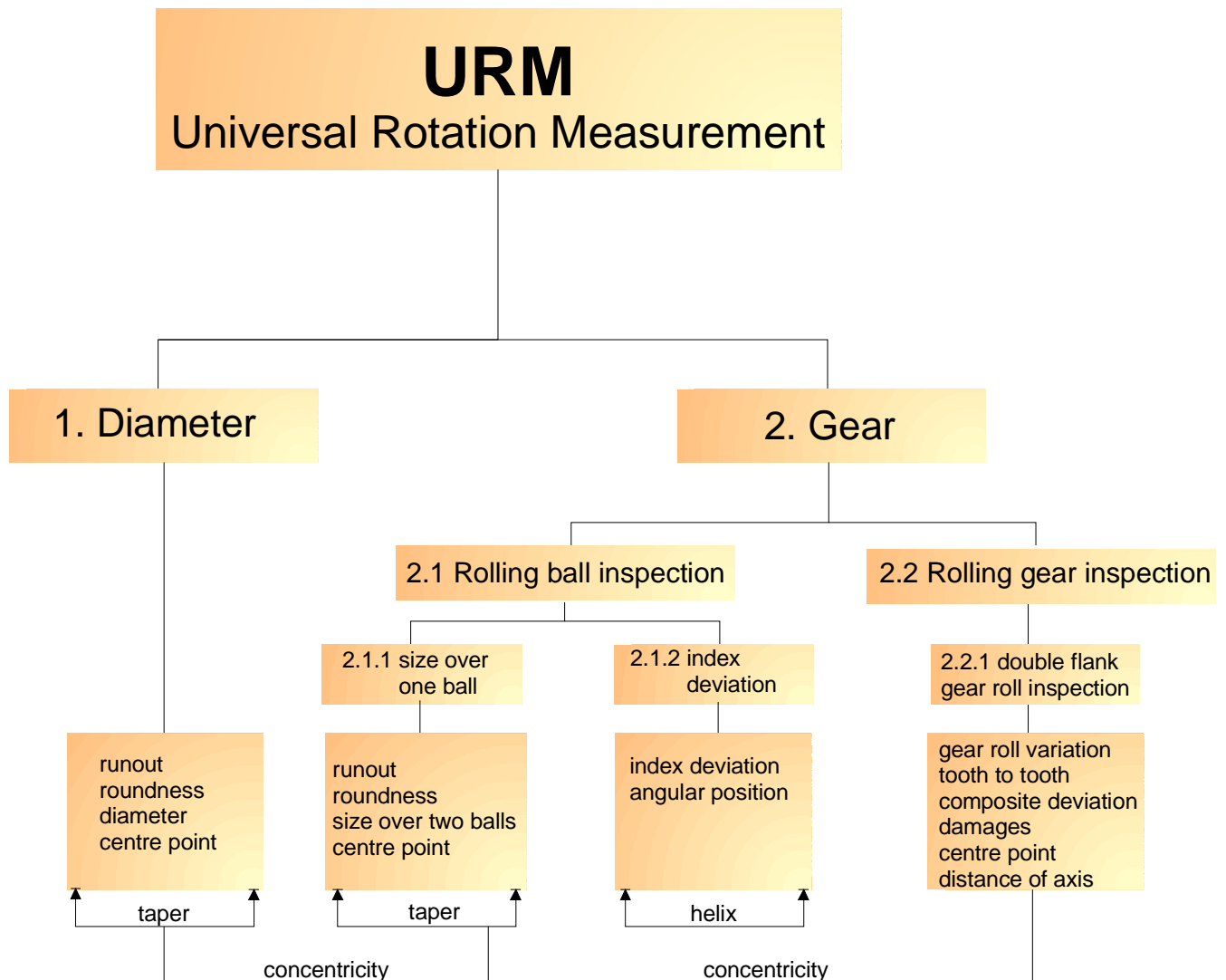
The MEG 32 can process the data of all measuring points at the same time simultaneously.



The universal range of application of the rotation measurement is nearly unlimited. The ability to measure multiple measuring points at the same time enable a production-related employment. Due to the high speed of measurement, the URM-R can be integrated in every process of production.

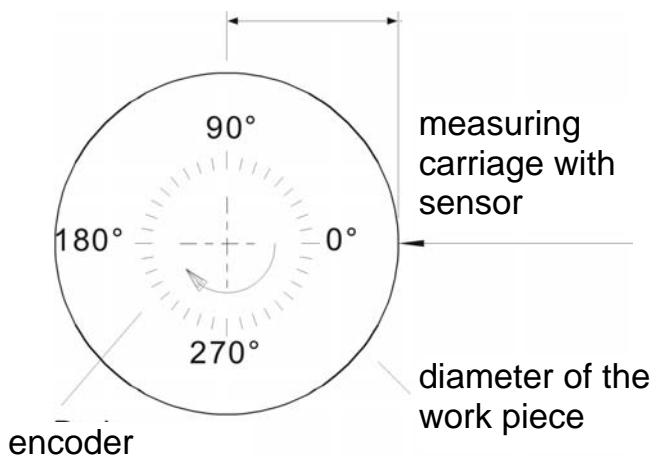
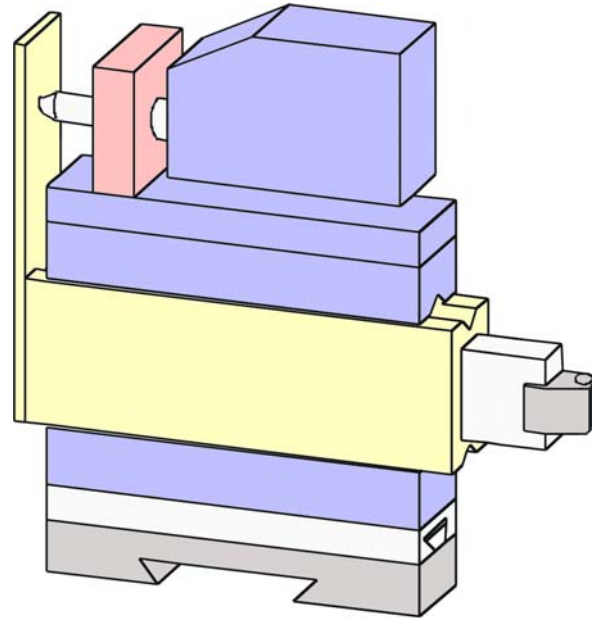
The manifold possibility of application can be demonstrated by the number of solvable problems. The most important specialty is the possibility to clear the measuring results of the different points of measurement with the MEG 32. Tolerances of location according to modern tolerancing of drawing are now easily and quickly testable.

Simultaneously solvable tasks at different points of measurement:



1. Measurement of a diameter

The measurement of a diameter is made by a measuring carriage, which has a vertically positioned short measuring pin as sensing device.

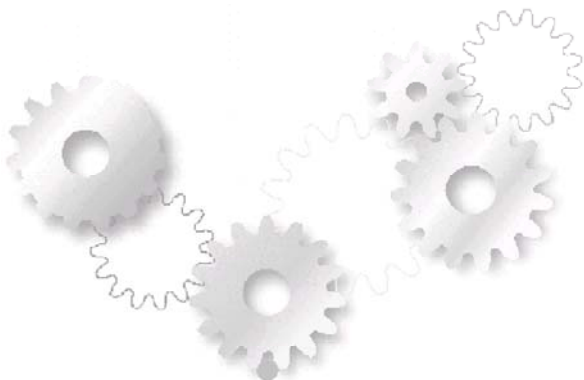


The measuring carriage is set radially to the diameter of the work piece, which is to be inspected. During a rotation of 360° the MEG 32 registers dynamically all angle of rotation and the corresponding measuring value of the diameter.

If the machine has been calibrated by a setting master used as a reference work piece before the measurement, the measuring value of the diameter is the real actual value.

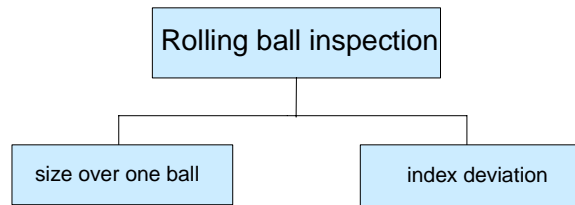
A setting master is not necessary if only the runout, the roundness or the position of the center is needed.

The corresponding values of the angles and the radial measuring values are filed during the measurement as a table.



2. Rolling ball inspection of splines

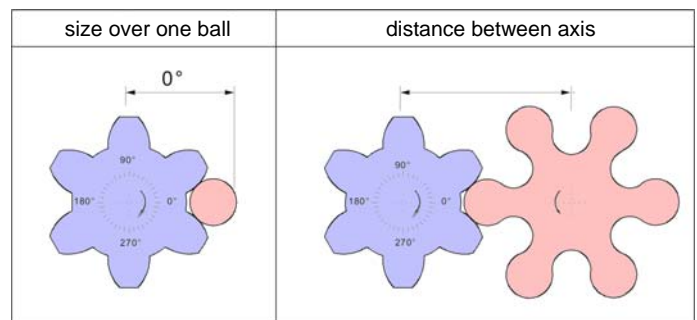
With the rolling ball inspection as well radial sizes over one ball as the index angle of the tooth spaces can be determined.



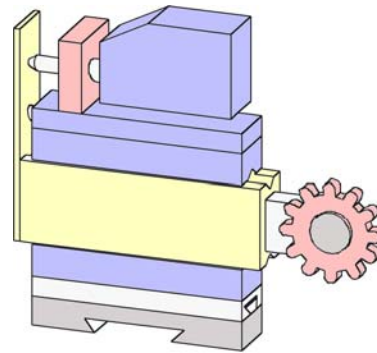
2.1. Measurement of the size over one ball

The basis of the rolling ball inspection is the principle of the measurement of the size over one ball. By inserting the ball into a tooth space the radial size over one ball is ascertained via the determination of the highest point of return. Thus the size over one ball referring to the center of the spline is known.

The rolling ball inspection does not work with single balls, but with wheels having a number of measuring pins, which are inserted one after the other into the tooth spaces. The wheels are made out of one piece.

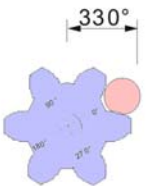
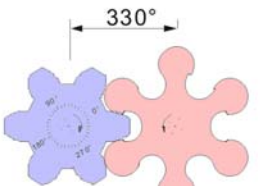
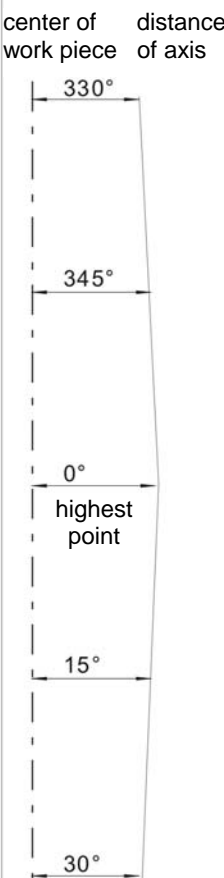
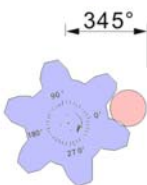
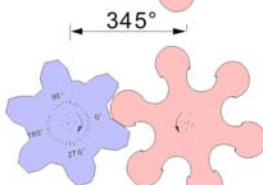
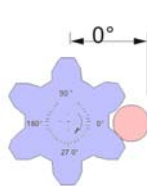
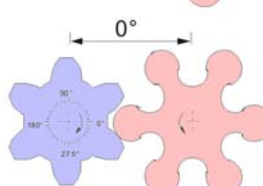
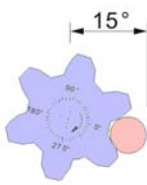
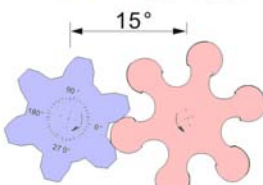
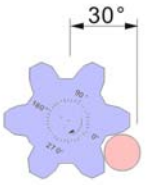
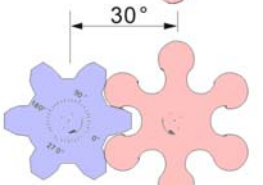


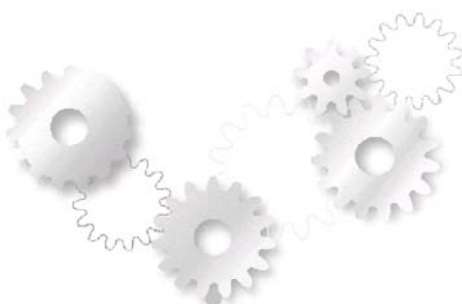
The measuring wheel is pivoted on a measuring carriage VR. The work piece is rotated by the spindle head. During the measurement the spring mounted measuring wheel is powered by the spline of the work piece.



measuring carriage VR with measuring wheel

Like during the determination of the size over one ball also during the determination of the distance of axis a highest point arises. During the rotation of the measuring wheel a oscillation of the distances of axis similar to a sinus occurs. The lower values results out of the correlation of a tooth of the work piece with a space of the measuring wheel. The higher values are correlation of a space of the work piece with a tooth of the measuring wheel. Only this biggest distance of axis is equivalent to the size over one ball. This highest point ist determined and filed by the MEG 32.

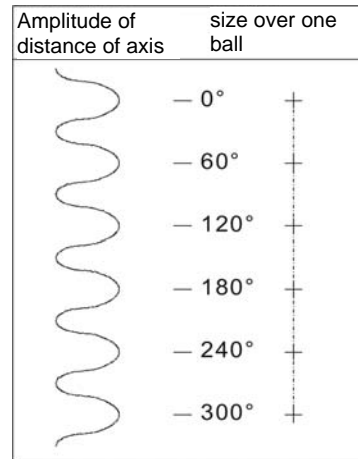
size over one ball	distance of axis	oscillation of the distance of axis
		<div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">center of work piece</div> <div style="text-align: center;">distance of axis</div> </div> 
		
		
		
		



During the rotation of 360° for each tooth space of the work piece this biggest distance of axis is determined. So a work piece with 6 teeth has six biggest distances of axis.

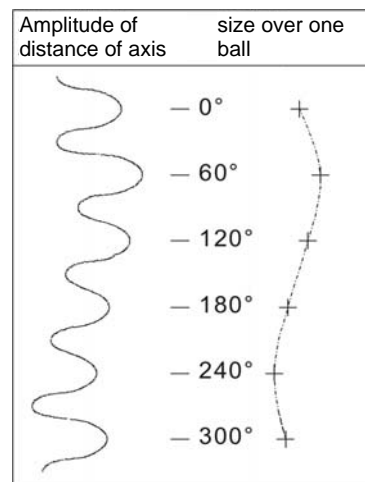
If the measuring machine is calibrated by setting master, the six biggest distances of axis is exactly equivalent to the six radial sizes over one ball.

If the work piece has no deviations of roundness or runout, the oscillation is homogeneous. All size over one ball are lying on one single line.



If there are deviations of roundness or runout, the sizes over one ball are not on a line any more.

The sizes over one ball RE of every tooth space is different. This is normal.



Like during the measurement of diameters the radii, the sizes over one ball are filed and evaluated.

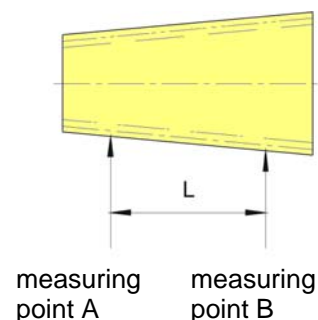
The equivalent to the angle of rotation is now the angle of index form space to space.

index angle [°]	size over one ball RE
0	19,986
60	19,992
120	19,994
180	20,006
240	20,002
300	19,984

If a spline is measured simultaneously with two carriages, with our evaluation software the taper can be calculated:

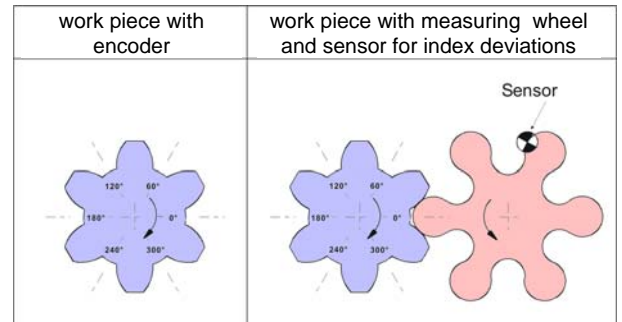
$$\text{Taper} = \text{Max}_q * A - \text{Max}_q * B$$

$$\text{Taper angle} = \text{atn}((B - A) / 2 / L)$$

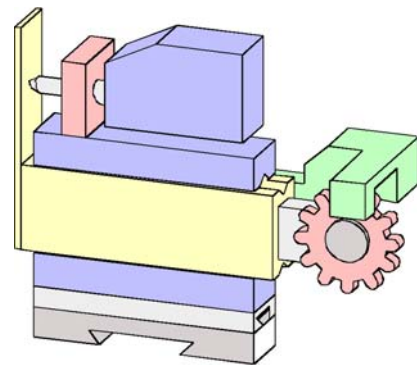


2.2. Measurement of index deviations

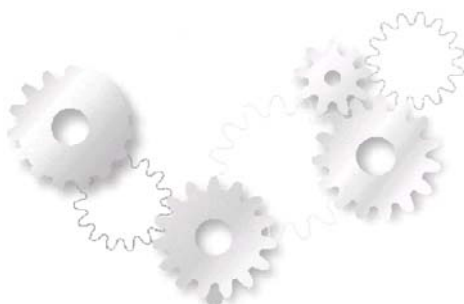
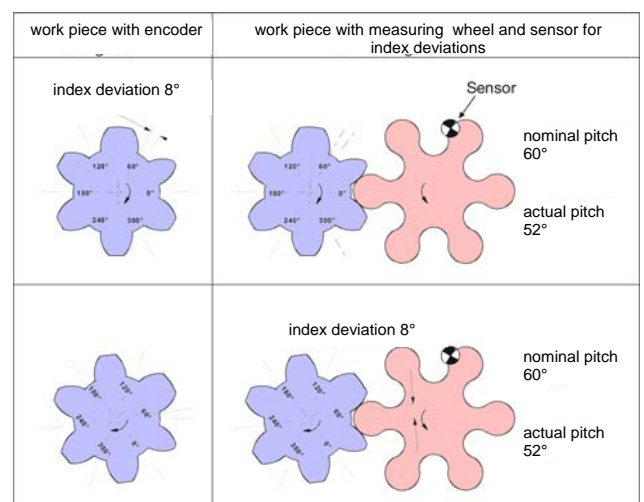
For the inspection of index deviations the index angles of all spaces of the work piece are compared to each other. For that purpose a sensor located at the measuring wheel is used. This sensor perceives the proper nominal pitch angles by the toothflanks of the correct measuring wheel. According to this cycle the actual angle of rotation of the work piece is read and saved by the encoder.



The sensor is a high precision photoelectric barrier. It is integrated in the holder of the photoelectric barrier. A so equipped measuring carriage determines simultaneously the size over one ball and the index deviation.



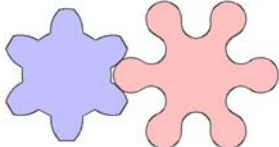
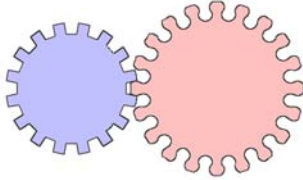
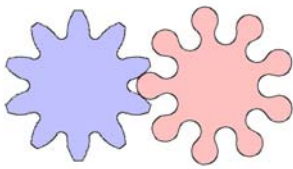
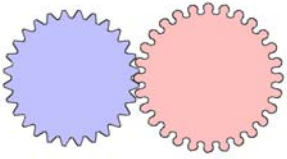
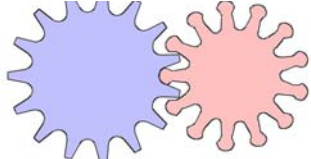
An index deviation of a work piece causes an eccentric position of the middle of the tooth space. The sensor never changing the position and the measuring wheel being quasi free of index deviations, the work piece will be in an differing angle by aligning the tooth space of the work piece and the measuring wheel. This deviation of the angle can be directly read off on the rotary encoder.



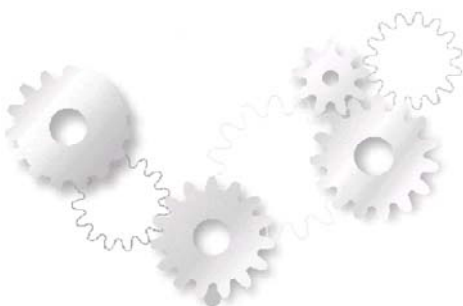
The software calculates the deviation of every space referring to the nominal pitch out of the angular position. The deviation of every space is accounted among each other. At the position of the angle of position 0° additionally the value of the angle referring to the center of the first tooth space is measured. Via PC this information enables the further determination of positions of angle even from one measuring carriage to the other. This information is needed for the ascertainment of helix deviation and tooth positions.

The following values can be determined by the index inspection:

- single index deviation
- tooth to tooth index variation
- total index deviation
- reference angle

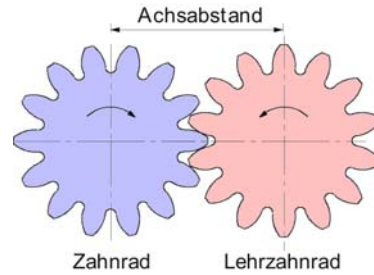
<p>Examples of different splines and fitting measuring wheels</p>	<p>involute spline</p> 
<p>straight sided spline</p> 	<p>gear</p> 
<p>serration spline</p> 	<p>chain wheel</p> 

The rolling ball inspection is especially appropriate to the inspection of splines.

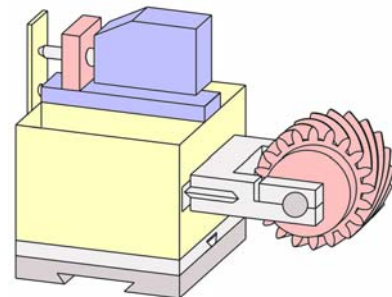


3. Double flank gear roll inspection

The gear rolling inspection of gears is general technical standard. The method is the inspection of summary errors and is executed by a master gear.

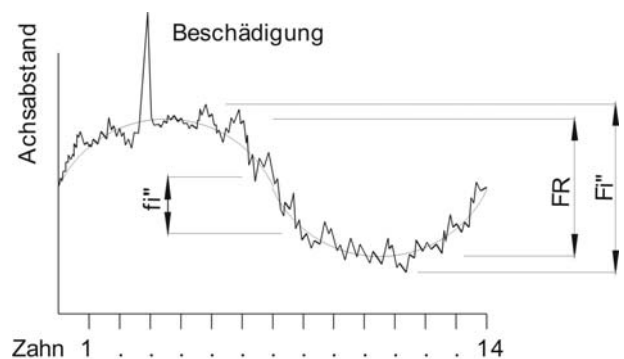


The measuring carriage VZW and the master gear is pneumatically set against the work piece. The work piece turns around 360° and actuates the master gear. The measuring values of the distance of axis is registered by a sensor which is connected to the MEG electronic.



The distance of axis of ideal work pieces without form deviations remains constant during a 360° rotation. In practice there are deviations within one pitch, from tooth to tooth and over all teeth.

During a rotation of 360° the distance of axis is filed dynamically with high frequency. After the measurement a software evaluates the results.



FRENCO Product Lines



Gear and spline high precision

Spline Gages
Master Gears, master wheels
Artefacts, masters
Profiled tools
Clamping systems
Gear and spline manufacturing



Instruments for size inspection Series V

Ball inserts and pins VRK
Instruments for rocking VA
Instruments with face stop VP
Indicating Gages VM
Variable 3-Disc Gages VD
Customized solutions VS



Rotation Measuring Systems

URM - K with balls and pins
URM - R with master wheels
EWP Single flank gear rolling
ZWP Double flank gear rolling
WS Gear Rollscan



Gear and spline inspection

DKD gear calibration
Gage wear inspection
Part inspections
Deviation analysis



Know-how transfer

Software for gear and spline calculating
Training, seminars and workshops
Consulting and calculations
Literature and documents
National and international standards



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