Double Flank Gear Roll Inspection Machines

The simple functional inspection
General Information

The basic principle of the double flank gear roll inspection is that a master gear (nearly perfect gear) and a workpiece gear are meshing free from backlash. One axis of rotation is mounted firmly and the other is mounted in a floating manner. The variations in distance when rolling the two gears are detected and form the basis for the evaluation of the gear profile with respect to the existing composite error caused by production.

When used with modern evaluation solutions such as a PC, hardware and software, the double flank gear roll inspection proves to be an efficient means of controlling the quality in a quick and easy way.

Advantages of FRENCO’s double flank gear roll inspection machines:

- Stable machines for the shop floor use.
- Customer-specific design: The machines are perfectly adjusted to the specimen to be measured and to the conditions of measurement.
- The measuring force is infinitely variable.
- Rapid lift-off of the measurement carriage.
- Using non-rotating tips and mounting mandrels, the runout deviation is kept low.
- Special master gear pair for calibration.
- With the evaluation software 'FGI pro' being in-house developed, quick support is available should any issues arise.
- The master gears are manufactured in-house at FRENCO in Altdorf, Germany.
- On request, we can upgrade older double flank gear roll inspection machines with FRENCO measurement electronics and the FGI evaluation software.
Measurement of Geometries

- spur gears
- helical gears
- worms
- pinion and gear
- pinion and worm
- oil pump gear
Product Overview

ZWP 06

ZWP 14/24 M/MP

ZWP 30

ZWP 18

Special appliances

ZWP 14 A
## Features

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<th>ZWP 14 (24 M/MP)*</th>
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<tr>
<td>single end</td>
<td>between tips</td>
<td>single end</td>
<td>between tips</td>
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<tr>
<td><strong>Range of centre distance</strong></td>
<td>12 – 85 mm</td>
<td>12 – 85 mm</td>
<td>50 – 320 (50 – 390)* mm</td>
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<tr>
<td><strong>Minimum centre distance (special fixtures required)</strong></td>
<td>10 mm</td>
<td>10 mm</td>
<td>20 mm</td>
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<tr>
<td><strong>Max. diameter of specimen</strong></td>
<td>80 mm</td>
<td>80 mm</td>
<td>400 mm</td>
</tr>
<tr>
<td><strong>Centre height size with steady centre attachment</strong></td>
<td>-</td>
<td>40 – 100 mm</td>
<td>-</td>
</tr>
<tr>
<td><strong>Range for height adjustable single end mounting</strong></td>
<td>•</td>
<td>on request</td>
<td>100 mm</td>
</tr>
<tr>
<td><strong>2nd steady centre attachment</strong></td>
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<td><strong>Adjustment of measuring force</strong></td>
<td>0 – 5 N</td>
<td>3 – 30 N (adjustable by cylinder MP)*</td>
<td>0 – 15 N</td>
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<tr>
<td><strong>Glass scale</strong></td>
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<tr>
<td><strong>Sensor for corrections of deviations of master gears</strong></td>
<td>on request</td>
<td>o</td>
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<tr>
<td><strong>Range of application</strong></td>
<td>small workpieces and plastic gears</td>
<td>large workpieces; robust for shop floor use</td>
<td>medium-sized workpieces; suitable for inspection laboratories</td>
</tr>
<tr>
<td><strong>Motor drive</strong></td>
<td>•</td>
<td>o</td>
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</table>

• standard  
o optional

The specified technical data are standard values and can be adjusted on request to customer wishes.
**ZWP 06**

The universal measuring machine for small yet highly precise gears

The double flank gear roll inspection machine is specially designed for small high-precision gears. It is also suitable for plastic gears. The measuring force can be lowered to 0 N.

The sophisticated design is extraordinarily precise and sensitive. The measuring carriage is supported free from backlash on four leaf springs. This so-called parallelogram suspension is very sensitive and registers even the smallest change in centre distance.

The measurement process is motor driven by default. We recommend the FRENCO Software ‘FGI pro’ for the evaluation. This will enable you to control the quality of your workpieces easily, efficiently and reliably.

An extensive range of accessories meets all requirements.
Accessories

steady centre attachment

\[
s = 40 - 100 \text{ mm} \\
a = 40 \text{ mm}
\]

For small centre distances:

Pin arbor attachment

Pin
\[d = 0.6 - 8 \text{ mm}\]

centre fixture

\[
s = 15 - 50 \text{ mm} \\
a = 20 \text{ mm}
\]

fixture for internal gears and splines

\[d = 8 \text{ mm} \\
e = 60 \text{ mm}\]

fixture for worms, fixture between tips

\[
s = 15 - 50 \text{ mm} \\
a = 16 \text{ mm}
\]
ZWP 24 M/MP

Simple, robust, designed for shop-floor use

The ZWP 14 is the most robust double flank gear roll inspection machine of this product family and ideal for use on the shop-floor.

This machine can be driven manually or by motor. The centre distance can be adjusted manually via an adjustable adapter disc.

The ZWP 14 is also available as ZWP 24 M in modular, longer construction and additionally as ZWP 24 MP with pneumatic slide.

The measurement results are displayed on a dial indicator. An evaluation using our software FGI Pro is only possible if the machine is motorised.

The extensive range of accessories allows an individual customization to your requirements. Individual solutions for your measuring tasks are also possible.
**Accessories**

**steady centre attachment small**

\[ s_{\text{MAX}} = 370 \text{ mm} \]
\[ a = 82 \text{ mm} \]

**steady centre attachment large**

\[ s_{\text{MAX}} = 420 \text{ mm} \]
\[ a = 160 \text{ mm} \]

**Adapter for small centre distances: centre fixture**

\[ s_{\text{MAX}} = 140 \text{ mm} \]
\[ a = 46 \text{ mm} \]

**Fixture for worms, mounting between tips**

\[ s_{\text{MAX}} = 150 \text{ mm} \]
\[ a = 40 \text{ mm} \]
\[ w = \pm 45^\circ \]

**Fixture for worms, mounting trough prisms (bearing seat as reference)**

\[ s_{\text{MAX}} = 250 \text{ mm} \]
\[ a = 40 \text{ mm} \]

**Fixture for worms, height adjustable through crank handle, fixed version**

**Adjustable quill**

**Fine adjustment**

Adapter for small centre distances:
**Pin arbor attachment**

- **pin**
  - **d = 1-16 mm**
- **pin**
  - **d = 4-22 mm**
ZWP 18

Highest precision and comfortable handling

The high quality ZWP 18 features a sophisticated setup and allows high precision measurements.

The centre distance can be changed easily and quickly by adjusting the measuring carriage with a hand-wheel. The adjustable mandrel allows simple and convenient adjustment of the height of the gears to be inspected. Many accessory items can easily be attached to the instrument.

The drive is integrated into the device. To ensure highest precision, the measuring carriages are mounted on very smooth guideways.

ZWP 18 with worm inspection fixture  
ZWP 18 with steady centre attachment
### Accessories

#### steady centre attachment
- $s_{\text{MAX}} = 370 \text{ mm}$
- $a = 82 \text{ mm}$

#### Adapter for small centre distances: centre fixture
- $s_{\text{MAX}} = 140 \text{ mm}$
- $a = 46 \text{ mm}$

#### Fixture for worms, Mounting between tips
- $s_{\text{MAX}} = 150 \text{ mm}$
- $a = 40 \text{ mm}$
- $w = \pm 45^\circ$

#### Fixture for worms, mounting trough prisms (bearing seat as reference)
- $s_{\text{MAX}} = 250 \text{ mm}$
- $a = 40 \text{ mm}$

#### Fixture for worms, height adjustable through crank handle, fixed version
- Stroke = 100 mm

#### Mounting for internal gear inspection, for mounting of master gear
- $s_{\text{MAX}} = 140 \text{ mm}$
- $a = 46 \text{ mm}$

#### Adapter for small centre distances: Pin arbour attachment
- $e_{\text{MIN}} = 16 \text{ mm}$
- $e_{\text{MIN}} = 22 \text{ mm}$
ZWP 30
The specialist for large gear wheels, shafts and worms

With ZWP 30 it is possible to measure gears with a tip diameter of up to 500 mm and shafts with a length of up to 750 mm.

The design is stable and optimized for the shop-floor use. The workpieces large dimensions and heavy weight require special components to be installed.

A granite construction forms the base of the ZWP 30 onto which the measurement carriage and mounting attachments for the workpiece and master gear are installed. Despite heavy weight loads, it is important for the measurement carriage to move smoothly, precisely and free from backlash, which is ensured by the cross roller guides.

The changeover for the inspection of other specimens is easily and quickly to handle. The measurements are carried out automatically. The evaluation is carried out via FRENCO’s FGi pro software.
Software „FGI pro“

The software FGI pro includes both, the control of the drive and the evaluation of data. The software is in-house developed and programmed by our specialists for applications software. With the actual values being marked in colour, the specimen can quickly be evaluated as ‘Pass’ (green) or ‘Fail’ (red).

The software determines the following values:
- total radial composite deviation $F_i''$
- tooth-to-tooth radial composite deviation $f_i''$
- runout deviation by composite test $F_r''$
- short-wave component $f_k''$

Additionally, when machine has been calibrated:
- centre distance $A_a''$
- dimension over balls $M_dK$
- tooth thickness $S_n$
- span size $W_k$.

Further software properties:

- Easy input and amending of inspection options
- After the inspection, the workpiece will be turned to the position of maximum deviation (values are selectable)
- Language features:
  - German, English, Spanish, French, Portuguese, Polish, Hungarian and Chinese are available
  - Program language and output language can be selected separately (Unicode support)
  - Easy data exchange when corporate languages are different
- Archiving function: every single measurement data is saved
- Central, statistical analysis due to interfaces (qs-STAT®, CASQ-it 9000 and internal Ethernet-systems)
Retrofit

FRENCO retrofits earlier double flank gear roll inspection testers with the powerful measuring electronics MEG 32 and the evaluation software FGI pro. The retrofit is possible for all below mentioned machine types. No matter if they ran until now with manual evaluation, pen recorder or earlier electronics.

For retrofitting, please send the machine to FRENCO GmbH. The device will be dismantled, cleaned and smaller repairs will be carried out. Furthermore, probe and motor will be replaced and an emergency-stop button will be installed (unless one is already installed).

The double flank gear roll tester will be completely refurbished!

The following devices can be retrofitted:

- Mahr 894B, 896B, 898B, 898C
- Hommel ZWG8305, ZWG8315
- Höfler ZW300
- other types on request
Centre Distance Inspection

Indirect determining of dimension over two balls and base tangent length

If the actual centre distance is to be measured, it is necessary to calibrate the machine with known centre distances. The easiest way to do that is by using shafts, discs and gauge blocks. Please note that the measurement uncertainty increases when tolerances (e.g. of the bore) are large.

Characteristics

Radial composite deviation $F_i$“

$F_i$“ is the variation of the centre distance $a_0$, i.e. it is the difference between the maximum and the minimum centre distance within one revolution of the test object (DIN 21772/3963).

Tooth-to-tooth radial composite deviation $f_i$“

$f_i$“ is the greatest difference of the centre distance within an angle of rotation corresponding to the pitch (DIN 21772/3963).

Runout by composite test $F_r$“

$F_r$“ is the long-wave component in the checking diagram for the radial composite deviations. It is obtained by plotting the smoothed reference line in which the short-wave components are suppressed (DIN 21772/3963).
Traceability

The Physikalisch-Technische Bundesanstalt (PTB, the national metrology institute in Germany) does not offer traceability for double flank gear rolling inspection parameters. This means that the PTB does not calibrate $F''$, $f''$, $F_r''$ or $f_k''$.

FRENCO is probably the only company worldwide that is able to calibrate the double flank gear rolling test parameters $F''$, $f''$, $F_r''$ and $f_k''$.

To this end, a highly precise limit calibration set MPE, consisting of 5 master gears, was measured approximately 2,000 times under repeatability conditions on 75 different double flank gear rolling testers from around the world.

All measurement results were analyzed using statistical methods. Outliers were eliminated and arithmetic mean values and control limits were calculated.

Finally, the calibration values $F''$, $f''$, $F_r''$, $f_k''$ and the measurement uncertainties $U_F''$, $U_{f''}$, $U_{F_r''}$ and $U_{f_k''}$ were calculated using these values.

There are 12 such limit calibration sets MPE worldwide, five of each, with various geometries, are held by FRENCO.

What are the calibration values used for?
- Calibration of Double Flank Gear Rolling Testers (ZWP)
- Evaluation of ZWP
- Determination of measurement uncertainty of ZWP
- Conformity assessment (Fail/Pass)
Calibration set MPE

A complete calibration of double flank gear roll inspection machines is only possible with a limit calibration set MPE. Such a set consists of 5 master gears.

The reference master gear is the reference gear. It has got no modifications. Tooth No. 1 is marked. The four other master gears are rolled, measured and logged against tooth 1.

The \( F_r'' \) - master has got a radial run-out which presents itself as a long-wave sinusoidal \( F_r'' \) deviation.

The \( f_i'' \) - master has got variations in tooth thickness, which cause a short-wave \( f_i'' \) deviation.

The centre distance is calibrated with the setting master centre distance.

The check master has got a differing tooth thickness from that of the setting master centre distance. The deviation of the centre distance thereby caused has got a nominal size, which should present itself as the actual size during calibration. Deviations in the scale and linearity can thus be detected.

After every final inspection, maintenance and service a calibration certificate is issued containing all deviations. This certificate can be used as document for wear inspection, as the basis for audits and for certifications.
Measurement Uncertainty $U_{MS}$

The measurement uncertainty of a double flank gear rolling tester can be determined using the calibrated limit calibration set MPE. The standardised method $U_{MS}$ in accordance to VDA-5 is applied.

Parameters and tolerances that are used as the basis will be agreed with the customer.

The following parameters:
- dimension over/between balls $M_{dk}$
- tooth thickness $s''$
- centre distance $aa''$

are directly traced. So the determined measurement uncertainties are directly based on the dimension of the Physikalisch-Technische Bundesanstalt (the national metrology institute).

The following parameters:
- radial composite error $F_i''$
- tooth-to-tooth composite deviation $f_i''$
- composite runout deviation $F_r''$

are indirectly traced.

The procedure according to VDA-5 will determine measurement uncertainty $U_{MS}$, the capability ratios $Q_{MS}$ and $TOL_{MIN-UMS}$.

By knowing the measurement uncertainty $U_{MS}$, the inspection planner knows if the inspection equipment is applicable for the measurement. This is the reason for quality management systems requiring the determination of the measurement uncertainty $U_{MS}$, and it has to be proved during quality audits. $TOL_{MIN-UMS}$ is the smallest tolerance the measuring system is capable for.
Correction of Deviations of Master Gears

Master gears are manufactured with the same precision as gauges, they are high-precision items. However small form variations cannot be avoided. Especially the runout deviation causes a deviation in the double flank gear roll inspection which cannot be disregarded. The actual runout deviation of the master gear is considered in the measuring uncertainty with twice its value, because the deviations of the master gear and the workpiece superimpose each other positively or negatively depending on the angular position.

If the runout deviation of the master gear is 0.006 mm, the measuring uncertainty increases by 0.012 mm.

This influence can be minimized by an increased accuracy of the master gear (e.g. using quality A according to the DIN 3970 (FRENCO QF)). By applying the correction of deviations of master gears this influence can be nearly completely avoided.

Correction of deviations of master gears:

The master gear or the driver has got a marking for the angular position which is read by a sensor. With a check master fitting to the master gear (number of teeth of the check master and number of teeth of the specimen must not have a common divisor) a correction run with multiple rotations is carried out. During this process the correction values are calculated and saved in the measuring electronic. With these calculated values the following measuring results are fully automatically corrected.
Frenco Product Range

**High Precision Gears and Splines H**
- Gear and Spline Gauges
- Master Gears, Master Wheels
- Artefacts, Masters
- Punches, Dies & Electrodes
- Profiled Clamping Systems
- Gear and Spline Manufacture

**Rotation Measuring Systems R**
- Instruments with Measuring Circles
- Multiple Inspector
- Gear Flank Analysing
  - Linear Gear Flank Analyser Rack
  - Gear Flank Analyser
  - Double Flank Gear Roll Inspection

**Instruments for Size Inspection Series V**
- Measuring Pins and Ball Inserts
- Instruments, Rocking Type
- Instruments with Face Stop
- Instruments with Guiding Profiles
- Circumferential Backlash Instrument
- Customized Solutions

**Gear & Spline Inspection P**
- DAkkS-Calibration
- Monitoring of Inspection Equipment
- Workpiece Inspections
- Analysis of Deviations

**Know-How-Transfer K**
- Software
- Training, Seminars, Workshops
- Consulting and Calculations
- Literature and Documentations
- National and International Standards