Pinion shaft and ring gear, adjusting

Notes:

- *Careful adjustment of the pinion shaft and ring gear is essential for the service life and smooth running of the final drive. For this reason, the pinion shaft and the ring gear are matched together during manufacturing and checked to ensure a good mesh pattern and quiet running in both directions of rotation. The position of quietest running is found by moving the pinion shaft in an axial direction, and at the same time lifting the ring gear out of the zero-play mesh position by the amount necessary to maintain the backlash within the specified tolerance.*

- *The goal of the adjustment is to reproduce the setting for the quietest possible running, as obtained on the test machine during production.*

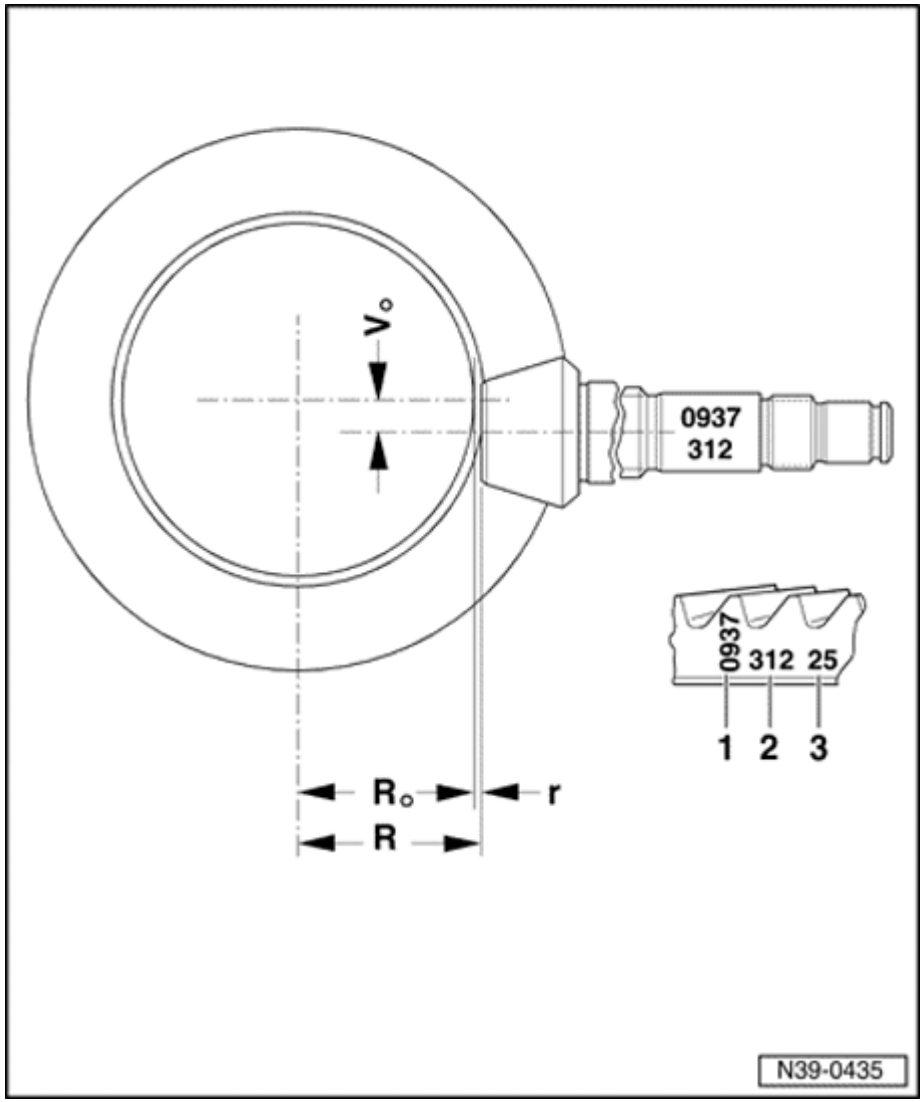
- *The deviation, or tolerance "r" which is based on the master gauge "R0" is measured for the final drive sets supplied as replacement parts and marked on the outer circumference of the ring gear. The final drive set (pinion shaft and ring gear) must only be replaced together as a matched pair.*

- *Observe the general repair instructions for*

tapered roller bearings and adjustment shims.

- *The friction torque measurement only serves as a final check of the adjustment.*

39-30



Adjustment and marking of final drive gear sets

1 - Identification "0397" signifies an Oerlikon gear set with a ratio of 37:9

2 - Pairing number (312) of final drive gear set

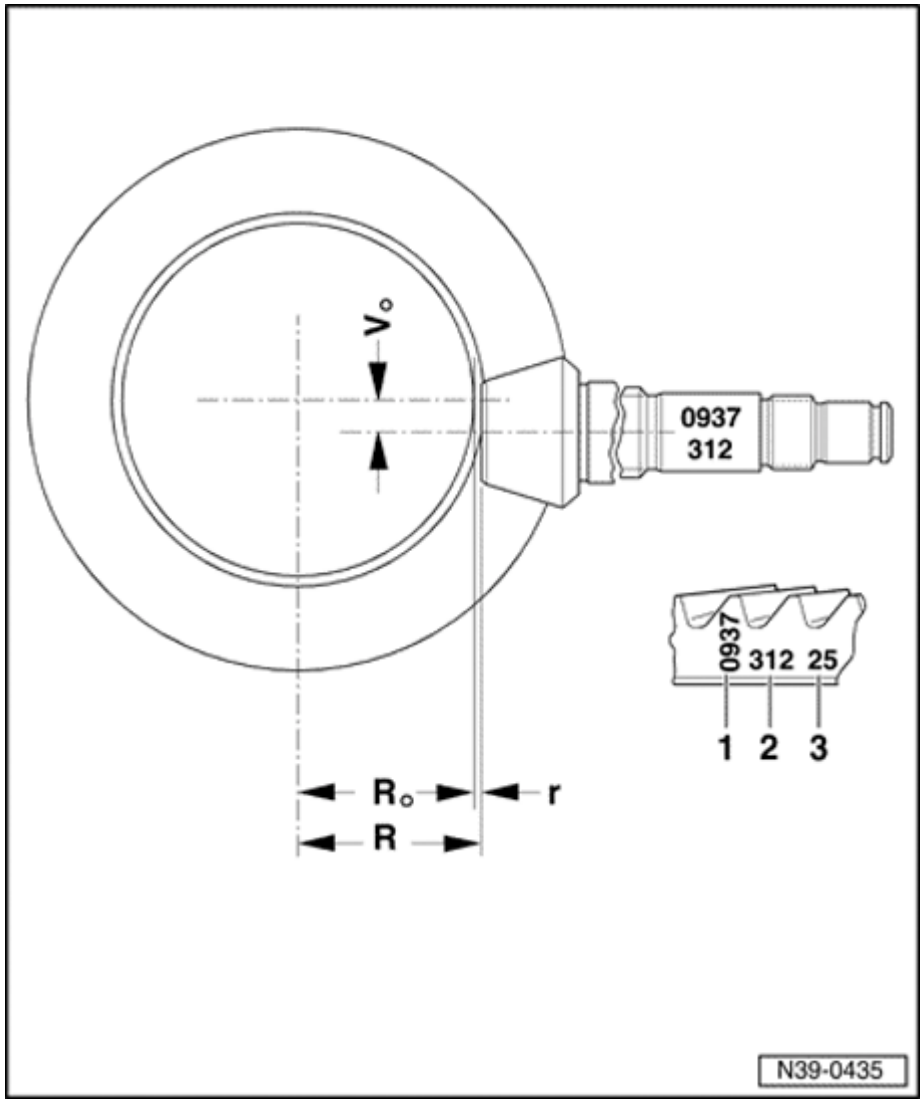
3 - Deviation (tolerance) "r" is based on the test machine master gauge used during production. The deviation "r" is always given in 1/100 mm. Example: 25 signifies "r" = 0.25 mm

Ro - Length of test machine master gauge

Ro - Ring gear diameter 170 mm = 54.95 mm

Ro - Ring gear diameter 180 mm = 59.65 mm

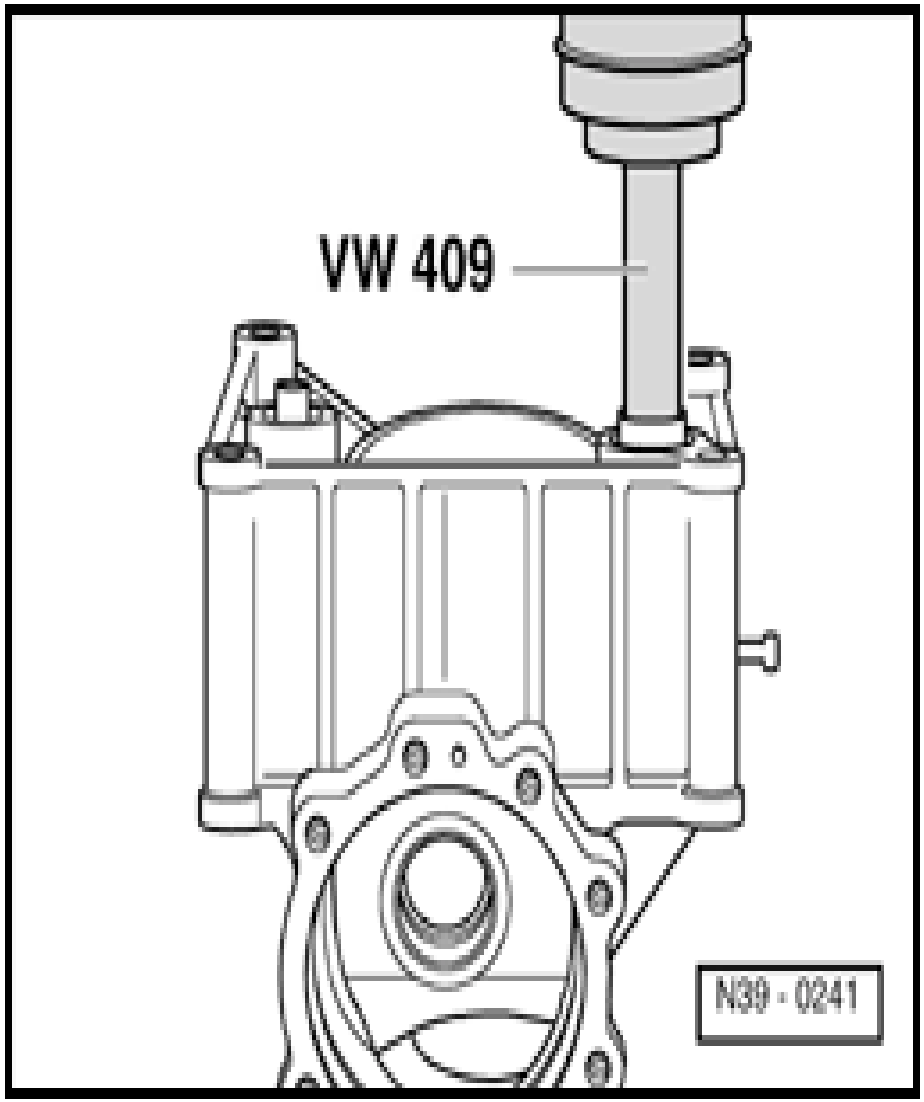
39-31



R - Actual dimension between ring gear axis and face of pinion shaft in position of quietest running for this gear set

Vo - Hypoid offset

39-32



Installation position of adjustment shims

Note:

List of adjustments when replacing individual components of transmission ⇒ *Page 39-33* .

S1 - Adjustment shim for ring gear in final drive cover

S2 - Adjustment shim for ring gear in transmission housing

S3 - Adjustment shim for pinion shaft in transmission housing

S4 - Adjustment shim for pinion shaft in transmission cover

39-33

List of adjustments

Note:

If repairs have been carried out on the transmission, it is only necessary to adjust the pinion shaft, ring gear or gear set if components have been replaced that directly influence the final drive adjustment. To avoid unnecessary adjustments, refer to the following table:

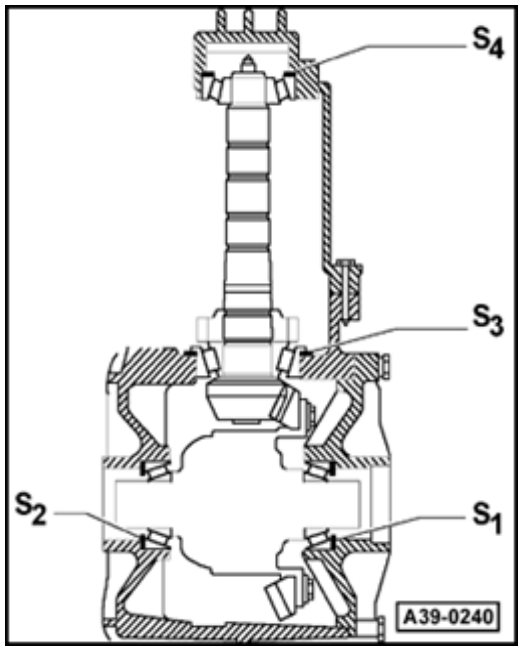
Component replaced: ▼	**Component to be adjusted:**			
	Ring gear "S1"+ "S2" 1) ⇒ Page 39-52	Pinion shaft "S3"+ "S4" 1) via deviation "r" ⇒ Page 39-35	Pinion shaft "S4" 1) ⇒ Page 39-49	Backlash measurement ⇒ Page ⇒ Page 39-58
Transmission housing 3)	X	X		X
Transmission cover			X	
Differential housing	X			X
Tapered roller bearing for pinion shaft		X		X
Tapered roller bearing for differential	X			X
Gear set 2)	**X**	X		X
Cover for final drive	X			X

1) Adjustment shims: installation position ⇒ Page 39-32 .

2) Replace pinion shaft and ring gear together as a set only.

3) If the transmission housing is replaced, adjust input shaft ⇒ Page 35-17 .

39-34



Sequence for adjusting gear set

If pinion shaft and gear ring have to be adjusted, the following sequence is recommended for maximum efficiency:

1.) Determine total shim thickness Stotal for S1 + S2 (adjusting preload for tapered roller bearing for differential) ⇒ Page 39-53 .

2.) Determine total shim thickness Stotal for S3 + S4 (adjusting preload for tapered roller bearing for pinion shaft) ⇒ Page 39-37 .

3.) Distribute total shim thickness Stotal for S3 + S4 so that the dimension between the center of the gear ring and the face of the pinion shaft equals dimension "R" which was determined during production ⇒ Page 39-45 .

4.) Distribute total shim thickness Stotal S1 + S2, so that the specified backlash between ring gear and pinion shaft is maintained ⇒ Page 39-61 .

Note:

Overview of components and shims ⇒ Page 39-32 .

39-35

Pinion shaft, adjusting

Procedures, after which the pinion shaft must be adjusted ⇒ Page 39-33 , table

Special tools and equipment

- VW204B installation tool for crankshaft seal
- VW296 removal tool
- VW385 universal gauge
- VW385/1 measuring bar
- VW385/2 centering disc (for transmissions without polygon bearing)
- VW383/3 centering disc (2x)
- VW385/14 measuring rod
- VW385/15 extension pin
- VW385/30 master gauge (adjustable)

- VW385/33 end gauge
- VW387 Dial Gauge Holder
- VW401 thrust plate
- VW407 punch

39-36

- VW519 sleeve
- VW792 installation arbor
- 3005 thrust pad
- Torque gauge 0-600 Ncm
- Dial indicator
- Dial indicator extension 9.3 mm
- Dial indicator extension 6.5 mm
- Dial indicator extension 30 mm

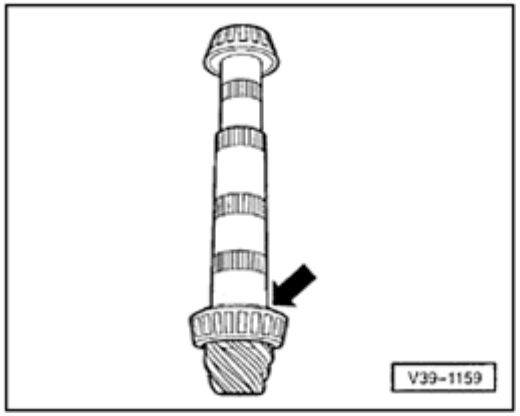
39-37

Determining total shim thickness Stotal for shims S3 + S4

- Adjust preload of tapered roller bearing for pinion shaft.

• Differential removed

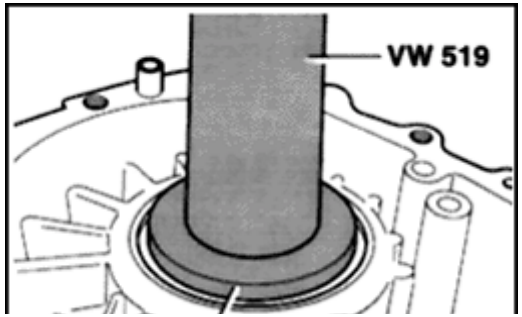
- Pressing on double tapered roller bearing inner race ⇒ Page 35-21 .



- Secure lower tapered roller bearing (arrow).

Note:

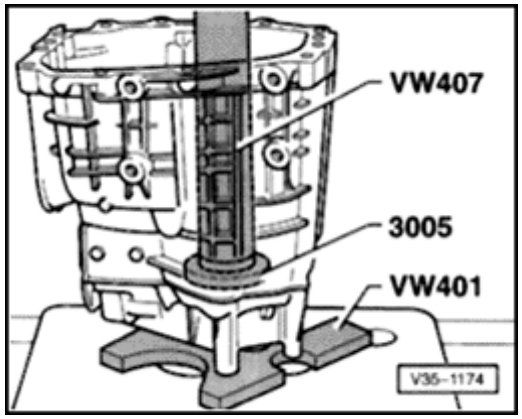
The illustration shows the pinion shaft without gears.



- Install tapered roller bearing outer race for pinion shaft without shims into transmission housing ⇒ Fig. 3, ⇒ Page 35-30 .
- Install rubber washer (item 40 , Page ⇒ Page 35-28) and pressure plate (item - 39 -, Page ⇒ Page 35-28) into transmission cover.

Pressure plates with a thickness of 14.8 mm or 15.3 mm can be installed.

39-38

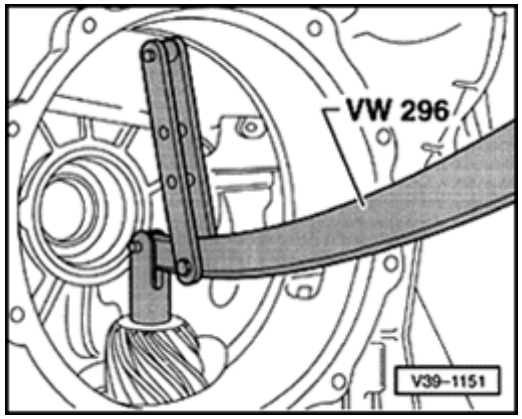


- Install tapered roller bearing outer race for pinion shaft with shim S4* (1.0 mm thickness) into transmission cover ⇒ Fig. 8, ⇒ Page 35-32 .

Note:

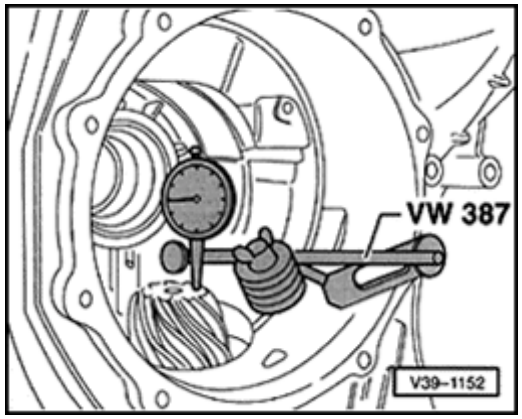
A shim S4 with a thickness of 1.0 mm is installed for initial measurement. It is referred to in the following text as S4. After determining measurement "e," S4* is replaced with the appropriate shim S4.*

- Install fully assembled pinion shaft into transmission housing.
- Install transmission cover and tighten to 22 Nm (16 ft lb).
- Turn transmission so that the transmission cover points downward.



- Press down on face of pinion shaft using VW296 removal tool until tapered roller bearing outer race contacts transmission cover.
- While maintaining pressure, turn pinion shaft by hand to seat tapered roller bearing.

39-39

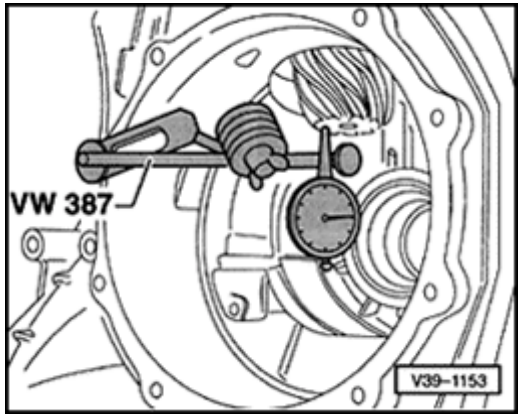


- Assemble measuring equipment, use 30mm dial indicator extension.
- Set dial indicator (3 mm measuring range) to 0 with 1mm preload.

Note:

Make sure dial indicator extension contacts machined surface on face of drive shaft.

- Turn transmission 180 ° , so transmission cover faces upward.
- Turn pinion shaft 5 rotations in each direction to seat the tapered roller bearing.



- Read play on dial indicator and note.

  Dimension in the following example: 0.45 mm

Note:

If the measurement has to be repeated, first turn pinion shaft 5 rotations in both directions to seat the tapered roller bearing. Set dial indicator to 0 with 2mm preload.

39-40

Formula:

"Stotal" = "S4*" + measured value + bearing preload

Example:

	Installed shim "S4*"	1.00 mm
+	Dimension (example)	0.45 mm
+	Bearing preload (constant)	0.15 mm
=	Total shim thickness "Stotal" for "S3 + S4"	1.60 mm

39-41

Determining thickness of shim "S3*"

Formula:

"S3*" = "Stotal" - "S4*"

Example:

	Total shim thickness "Stotal" for "S3 + S4"	1.60 mm
-	Installed shim "S4*"	1.00 mm
=	Thickness of shim "S3*"	0.60 mm

- Remove tapered roller bearing outer race, install shim "S3*" into transmission housing and re-install outer race ⇒ Fig. 3, ⇒ Page 35-30 .

- Install fully assembled pinion shaft into transmission housing.

- Install transmission cover and tighten to 22 Nm (16 ft lb).

39-42

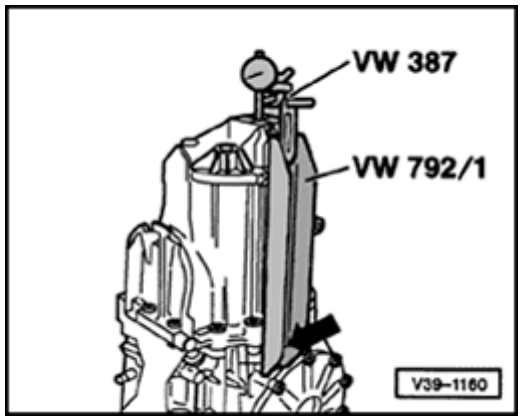
Checking preload for tapered roller bearing for pinion shaft

- Turn pinion shaft 5 rotations in each direction to seat tapered roller bearing.

Notes:

- *If the pinion shaft cannot be turned by hand, install a M10 x 20 bolt into face of pinion shaft and turn the pinion shaft at this bolt using tool.*

- *Remove bolt after turning pinion shaft.*



- Install measuring tools and secure to transmission housing with bolt (arrow).
- Attach dial indicator (3mm measuring range) to center of transmission cover and set to 0 with 2 mm preload.
- Loosen transmission cover bolts and turn pinion shaft.

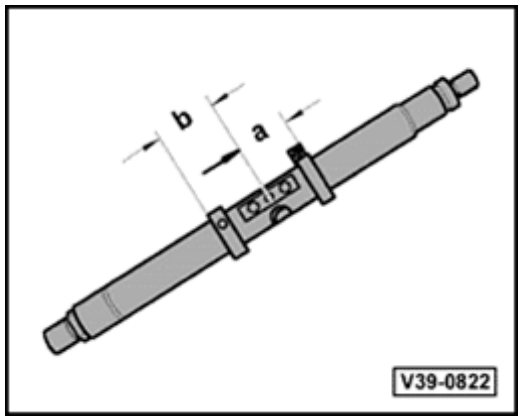
  If correct shims have been selected, dial indicator will now indicate the following value: 0.05-0.15 mm.
- Tighten transmission cover bolts to 22 Nm (16 ft lb).
- Remove measuring tools.
- Turn pinion shaft 5 rotations in each direction to seat tapered roller bearing.

39-43

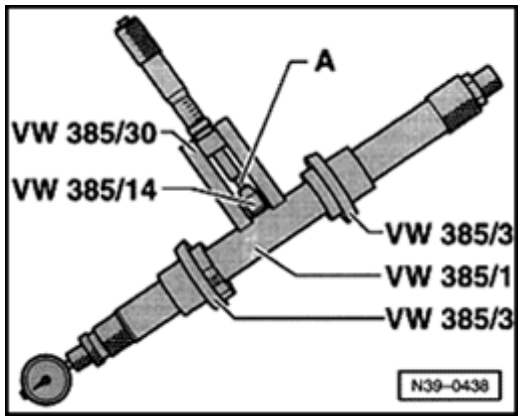
Calculating dimension "e"

Note:

Dimension "e" is required to determine the final shim thickness of S3 and S4.



- Set adjustment rings of universal mandrel using VW385/1 measuring bar to the following measurements:
  - Dimension -a- = 35 mm
  - Dimension -b- = 75 mm



- Assemble VW385/1 measured bar as illustrated:

Dial indicator extension A	Ro	Ring gear diameter
6.5 mm for VW385/30 master gauge	54.95	170 mm
9.3 mm for VW385/15 extension pin	59.65	180 mm

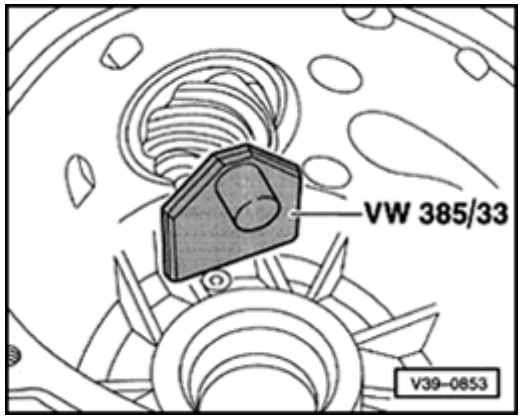
- Set dial indicator (3 mm measuring range) to 0 with 2mm preload.

Note:

For transmissions with drive flange without polygon bearing (⇒ Page 00-3) use VW385/2 centering disc instead of VW385/3 centering disc

opposite dial indicator.

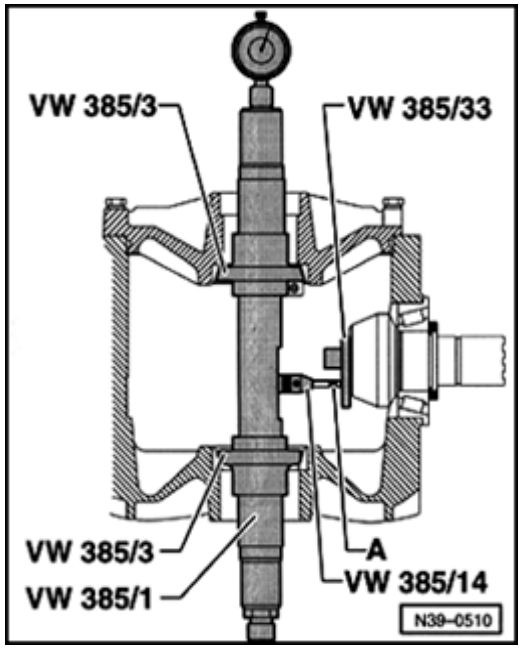
39-44



- Place end gauge on face of pinion shaft.

Note:

Make sure gauge contact surface is precisely installed and free of oil.

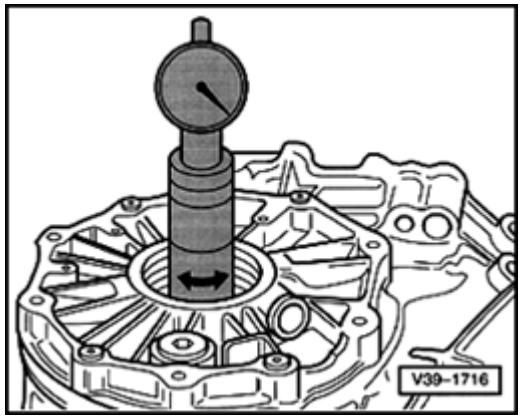


- Remove master gauge and install measuring mandrel into transmission housing.
  - Dial indicator extension -A- = 6.5 mm long must be installed
  - VW385/3 centering disc faces cover for final drive
- Install differential cover and tighten 4 bolts to 22 Nm (16 ft lb).
- Using adjustable ring, pull 2nd VW385/3 centering disc out as far as possible, so mandrel can only just be turned by hand.

Note:

For transmissions with drive flange without polygon bearing (⇒ Page 00-3) use VW385/2 centering disc instead of VW385/3 centering disc opposite dial indicator.

39-45



- Turn mandrel until dial indicator plunger tip touches end gauge on pinion shaft head, measure maximum runout (return point).

Measurement in following example "e" = 0.26 mm (red scale)

Note:

After removing universal mandrel, and with VW385/30 master gauge in place, check dial indicator again to see if it indicates "0" with 2 mm preload, otherwise correct adjustments.

Determining thickness of shim "S3"

Formula:

S3 = S3* + r + e

(-e- in black scale)

or

S3 = S3* + r - e

(-e- in red scale)

Notes:

- *The deviation "r" (tolerance) related to the VW385/30 master gauge "Ro" is measured for the final drive sets supplied as replacement parts and marked on the outer circumference of the ring gear.*
- *If measurements are based on red scale, subtract value "e."*
- *If measurements are based on black scale, add value "e."*

Example:

	Shim S3* installed	0.60 mm
+	Deviation r	0.38 mm
-	Value measured for "e" (in red scale)	0.26 mm
=	Thickness of shim S3	0.72 mm

- Determine shim(s) according to table. Part numbers ⇒ parts catalog

The following shims are available for "S3"

Shim thickness (mm)1)		
0.40	0.55	0.70
0.45	0.60	0.75
0.50	0.65	

1) Using shim tolerances it is possible to find the exact shim thickness required: insert two shims if necessary.

39-47

Determining thickness of shim "S4"

Formula:

S4 = Stotal - S3

Example:

	Total shim thickness Stotal for S3 + S4	1.60 mm
-	Thickness of shim S3	0.72 mm
=	Thickness of shim S4	0.88 mm

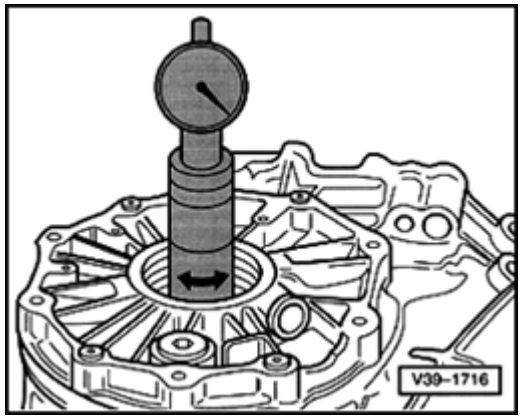
- Determine shim(s) according to table. Part numbers ⇒ parts catalog

Available shims for S4

Shim thickness (mm) 1)		
0.49	0.69	0.85
0.57	0.73	0.89
0.61	0.77	
0.65	0.81	

[1)] Using shim tolerances it is possible to find the exact shim thickness required: insert two shims if necessary.

39-48



Checking measurement

Checking dimension "r"

- Install pinion shaft together with measured shims S3 and S4 and turn 5 rotations in both directions.

- Install universal mandrel ⇒ Page 39-43 , Determining dimension "e"; and perform check measurement.
- Read dial indicator counterclockwise (red scale).
  - If shims have been determined correctly, deviation "r" (as marked on outer circumference of ring gear) should be indicated on dial within a tolerance of ± 0.04 mm.

Note:

After removing universal mandrel, and with VW385/30 master gauge or VW385/15 extension pin in place, check dial indicator again to see if it indicates 0 with 2 mm preload. If not, correct adjustments.

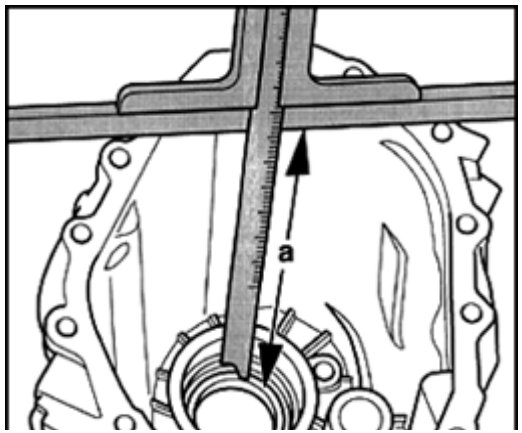
39-49

Re-determining "S4" after replacing transmission cover

Special tools and equipment

- VW387 dial gauge holder
- VW792/1 assembly tool
- Dial indicator
- Dial indicator extension
- Depth gauge with minimum 5/100 mm precision

- Clean housing mating surfaces.



- Measure difference in depth "a" on old and new transmission cover.

Example:

	Depth -a- (old transmission cover)	257.40 mm
	Depth -a- (new transmission cover)	257.55 mm
=	Difference	0.15 mm

- Install thicker shim "S4" if new transmission cover is deeper.

- Install thinner shim "S4" when the old transmission cover is deeper.

Example:

	Previous shim "S4"	0.95 mm
+	Difference	0.15 mm
=	New shim "S4"	1.10 mm

Available shims ⇒ Page 39-47 , table

- Install tapered roller bearing outer race with shim "S4" into transmission cover ⇒ Fig. 8 , ⇒ Page 35-32 .

- Install fully assembled pinion shaft into transmission housing.

- Install transmission cover and tighten to 22 Nm (16 ft lb).

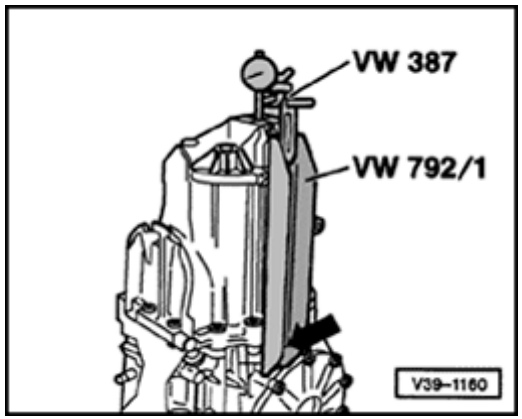
39-51

Preload for tapered roller bearing for pinion shaft, checking

- Turn pinion shaft 5 rotations in each direction to seat the tapered roller bearing.

Note:

The pinion shaft can be turned by simultaneously turning both drive flanges.



- Install measuring tools and secure to transmission housing with bolt (arrow).
- Attach dial indicator (3 mm measuring range) to center of transmission cover and set to 0 with 2 mm preload.
- Loosen transmission cover bolts and turn pinion shaft.

  If correct shims have been selected, the dial indicator will now indicate the following value: 0.05-0.15 mm.
- Remove measuring tools.
- Coat sealing surfaces with thin layer of sealant AMV 188 001 02.
- Tighten transmission cover bolts to 22 Nm (16 ft lb).

39-52

Ring gear, adjusting

Adjusting differential

For a list of the repairs which will require the ring gear to be adjusted ⇒ Page 39-33 , List of adjustments

Special tools and equipment

- VW382/10 dial indicator extension
- VW385/17 magnetic plate
- VW387 dial gauge holder
- VW388 measuring lever
- VW402 thrust plate
- VW408A punch
- VW472/1 pressure piece
- VW521 adjustment tool
- 3177 clamp

- Torque gauge 0-600 Ncm
- Dial indicator
- Dial indicator extension 30 mm

39-53

Determining total shim thickness Stotal for shims S1 + S2

(Adjust preload of tapered roller bearing for differential)

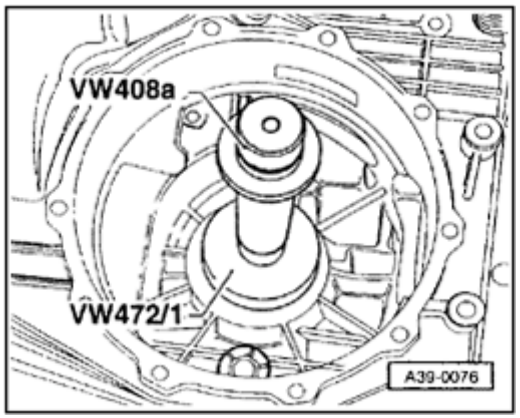
- Pinion shaft removed

Note:

If only the differential tapered roller bearings are to be replaced, remove ring gear from differential housing. The pinion shaft does not have to be removed.

- Remove seals and outer races from both tapered roller bearings for differential.

- Remove shims ⇒ Page 39-15 .

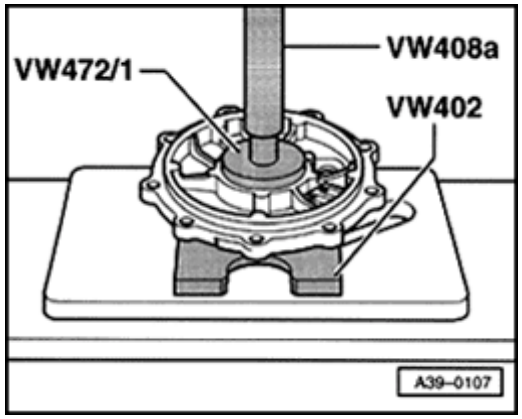


- Drive in tapered roller bearing outer race together with shim S2 into transmission housing ⇒ Fig. 3, ⇒ Page 39-23 . Use shim "S2*" with 1.20 mm thickness for measurement purposes (2 shims with 0.60 mm).

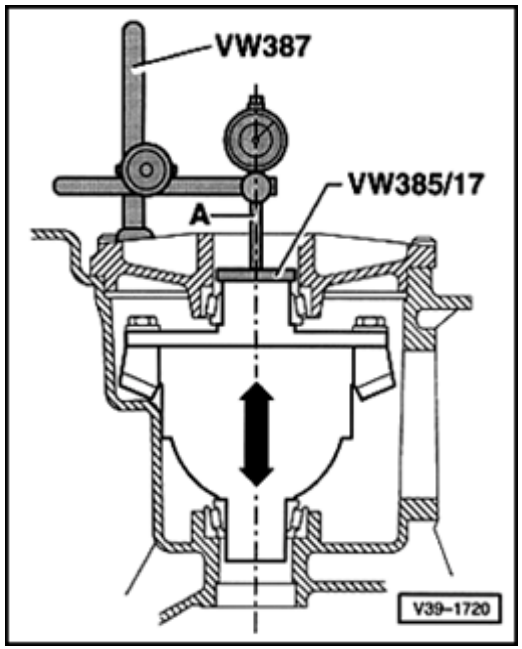
Note:

A shim S2 with a thickness of 1.20 mm is installed for initial measurement. It is referred to in the following text as S2. After determining backlash, S2* is replaced with the appropriate shim S2.*

39-54



- Press in tapered roller bearing outer race into differential cover without shim S1 ⇒ Fig. 9 , ⇒ Page 39-26 .
- Install differential into transmission housing without Vehicle Speed Sensor (VSS) -G22- gear drive. Ring gear is located on left side in front of final drive cover.
- Install cover for differential and tighten four bolts to 25 Nm (18 ft lb).
- Position transmission so that cover for differential faces upward.
- Turn differential 5 rotations in each direction to seat tapered roller bearing.



- Assemble measuring equipment, use 30 mm dial indicator extension.
- Set dial indicator (3 mm measuring range) -A- to 0 with 2mm preload.

Note:

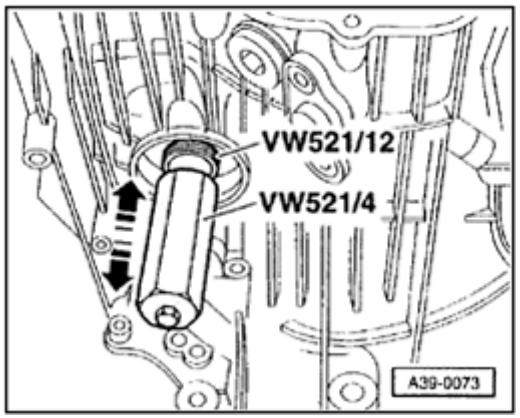
Tip of dial indicator must be positioned on the center of the differential.

39-55

- Lift differential without turning it, read play on dial indicator and note.

Dimension in the following example: 0.62 mm

Notes:



- *To lift differential, secure VW521/4 locking sleeve and VW521/8 bushing (for transmissions without polygon bearing) or VW521/12 (for transmissions with polygon bearing) to right side of differential (housing side).*
- *If measurement has to be repeated, turn differential again 5 rotations in both directions to seat tapered roller bearing.*

Formula:

"Stotal" = "S2*" + measured value + bearing preload

Example:

	Installed shim "S2*"	1.20 mm
+	Dimension	0.62 mm
+	Bearing preload (constant)	0.30 mm
=	Total shim thickness "Stotal" for "S1 + S2"	
		2.12 mm

39-56

Determining thickness of shim "S1*"

Notes:

- *"S1*" is used for the initial measurement. After determining backlash, "S1*" is replaced with final shim "S1."*
- *The total shim thickness "Stotal" remains unchanged.*

Formula:

"S1*" = "Stotal" - "S2*"

Example:

	Total shim thickness "Stotal" for "S1" + "S2"	2.12 mm
-	Installed shim "S2*"	1.20 mm
=	Thickness of shim "S1*"	0.92 mm

39-57

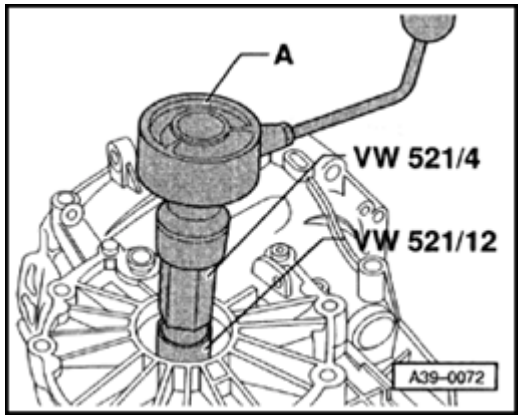
Measuring friction torque (check measurement)

Notes:

- *Tapered roller bearings for differential are low-friction. Measurement of friction torque only has a limited use as a check. Correct adjustment is only possible by determining the total shim thickness "Stotal."*

- *Do not lubricate new tapered roller bearings for measuring friction torque. The bearings have already been treated by a special oil by the manufacturer.*

- Pinion shaft removed



- Install torque gauge 0-600 Ncm -A- on differential.
- Read friction torque.

Friction torque specified values:

New bearings	Used bearings
200 - 350 Ncm	30 - 60 Ncm

Note:

For a readjustment of the gear set, the pinion shaft adjustment should now be checked ⇒ Page 39-35 .

39-58

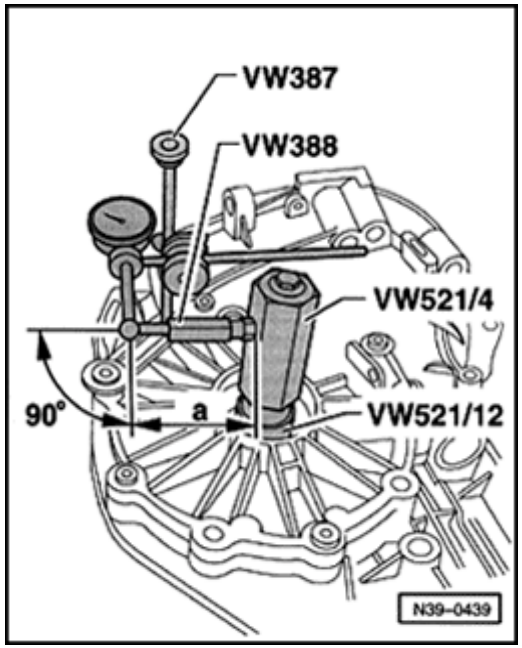
Measuring backlash

(Position of ring gear in transmission housing)

- Pinion shaft with shims "S3*" and "S4*" installed

- Install differential.

- Turn differential 5 rotations in each direction to seat tapered roller bearing.



- Secure VW387 dial gauge holder on housing.
- Install VW521/4 locking sleeve and VW521/8 bushing (for transmissions without polygon bearing) or VW521/12 (for transmissions with polygon bearings).
- Install dial indicator with VW382/10 extension pin, 6 mm.
- Set VW388 measuring lever to dimension "a:"

Dimension "a"	Ring gear diameter
67 mm	170 mm
72 mm	180 mm

39-59

- Determine play between teeth flanks as follows:

  - Turn ring gear until it contacts a tooth flank (end of backlash travel).

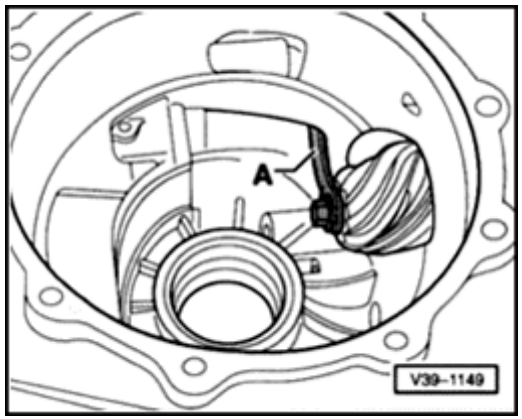
  - Set dial indicator to 0 with 2 mm preload.

  - Turn ring gear back until it contacts opposite tooth flank (backlash).

  - Read backlash and note.

  - Turn ring gear another 90° and repeat measurement 3 times.

Notes:



- *If pinion shaft turns when turning differential, install 3177 clamp -A- so that an exact backlash measurement can be made.*
- *Loosen clamping piece to turn the ring gear further.*
- *Differential must be installed with cutout for differential bevel gears facing pinion shaft.*

- If 3177 clamp is installed, install differential 180° to final position and repeat measurements.

Determining average backlash

- Add four measured values together and divide total by 4 to determine average.

Example:

	1st Measurement	0.28 mm
+	2nd Measurement	0.30 mm
+	3rd Measurement	0.30 mm
+	4th Measurement	0.28 mm
=	Total of measurements	1.16 mm

- Result: the average backlash is 1.16 mm ÷ 4 = 0.29 mm

Note:

If the measured values differ more than 0.06 mm from each other, the installation of ring gear or gear set itself may not be correct. Check installation and replace gear set if necessary.

39-61

Determining thickness of shim "S2"

Formula:

"S2" = "S2*" - backlash + lift

Example:

	Installed shim "S2*"	1.20 mm
-	Average backlash	0.29 mm
+	Lift (constant)	0.15 mm
=	Thickness of shim "S2"	1.06 mm

- Determine shim(s) according to table. Part numbers ⇒ parts catalog

Available shims for "S2"

Shim thickness (mm) 1)		
0.45	0.65	0.85
0.50	0.70	0.90
0.55	0.75	
0.60	0.80	

1) Using shim tolerances it is possible to find the exact shim thickness required; insert two shims if necessary.

39-62

Determining thickness of shim "S1"

Formula:

"S1" = "Stotal" - "S2"

Example:

	Total shim thickness "Stotal" for "S1 + S2"	2.12 mm
-	Thickness of shim "S2"	1.06 mm
=	Thickness of shim "S1"	1.06 mm

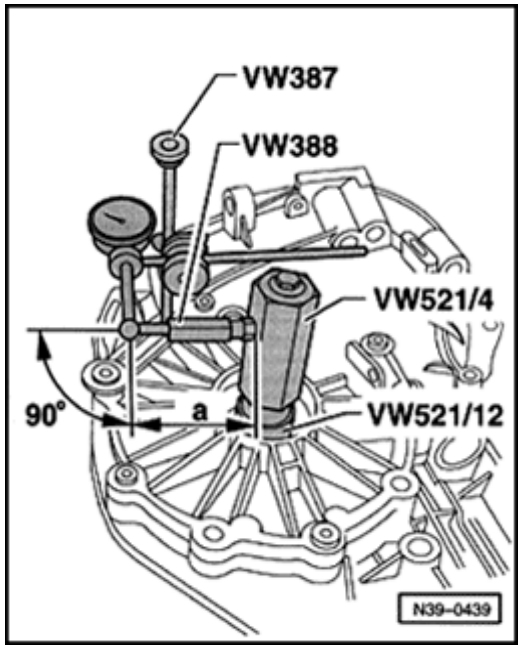
- Determine shim(s) according to table. Part numbers ⇒ parts catalog

Available shims for "S1"

Shim thickness (mm) 1)		
0.45	0.65	0.85
0.50	0.70	0.90
0.55	0.75	
0.60	0.80	

1) Using shim tolerances it is possible to find the exact shim thickness required; insert two shims if

necessary.



Checking measurement

- After installing shims "S1" and "S2," turn differential 5 rotations in each direction to seat tapered roller bearings.

Note:

For transmissions without polygon bearing, use VW521/8 bushing instead of VW521/12 shown.

- Measure backlash 4 times on circumference.

  Specification: 0.12-0.22 mm

Notes:

- *If backlash lies outside tolerance, repeat adjustments. Do not change total shim thickness "Stotal."*
- *The individual measurements must not vary more than 0.06 mm from each other.*