Detents ARRES
Synchronisation in manual transmissions

SCHAEFFLER GROUP
AUTOMOTIVE

Foreword

As a development partner to the automotive industry, Schaeffler Group Automotive develops and manufactures components and systems that take account of requirements for increased performance density and the reduction of factors such as mounting work and overall costs.

Higher performance engines, increased torque loads on transmissions and the demand for reduced design envelope are just a few of the defining conditions.

In this TPI, we aim to show the advantages that our detents ARRES make possible for the design of manual transmissions in this environment. The performance capacity of the various types and the specific advantages of the relevant designs are explained in detail.

In addition to the points mentioned above, we also consider the subject of gearshift comfort and present appropriate solutions.

Further information

Detents are components from our comprehensive product range. TPI 125, INA selector hub assembly, describes the function of a synchronisation system, presents the components required and gives a detailed explanation of their interaction.

Safety guidelines and symbols

High product safety

Our products correspond to the current level of research and technology. If the bearing arrangement is designed correctly, the products are handled and fitted correctly and as agreed and if they are maintained as instructed, they do not give rise to any direct hazards.

Follow instructions

This publication describes standard products. Since these are used in numerous applications, we cannot make a judgement as to whether any malfunctions will cause harm to persons or property.

It is always and fundamentally the responsibility of the designer and user to ensure that all specifications are observed and that all necessary safety information is communicated to the end user. This applies in particular to applications in which product failure and malfunction may constitute a hazard to human beings.

Definition of guidelines and symbols

The warning and hazard symbols are defined along the lines of ANSI Z535.6–2006.

The meaning of the guidelines and symbols is as follows:

In case of non-compliance, damage or malfunctions in the product or the adjacent construction will occur.

Note There follows additional or more detailed information that must be observed.

① Numbers within a circle are item numbers.

Detents ARRES

Product overview Detents ARRES

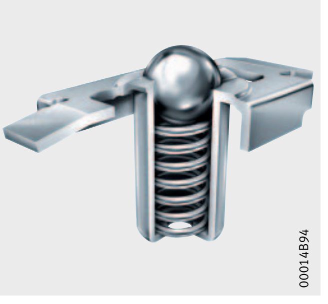
ARRES

Standard

ARRES-B

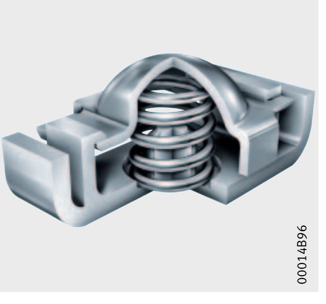
With wings

ARRES-W

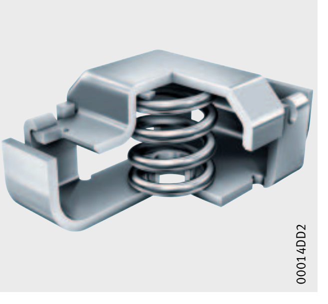


Flat design

ARRES-BL



ARRES-RL

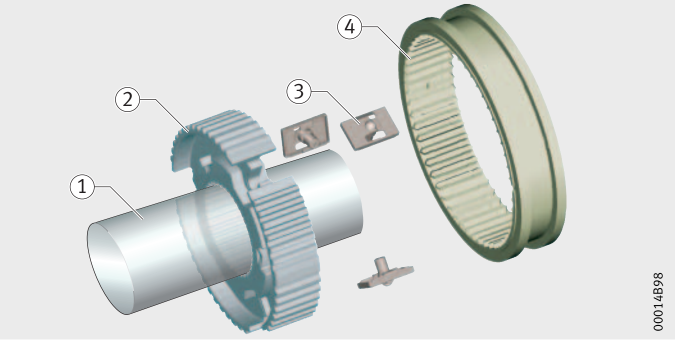


Detents ARRES

Features

Axially movable detents are used for the presynchronisation system. The detents are located in recesses around the circumference of the selector hub, *Figure 1*. The detent element is preloaded by a spring against a recess in the selector sleeve.

For further information on the subject of synchronisation, see TPI 125, INA selector hub assembly.



① Transmission shaft
② Selector hub
③ Detents
④ Selector sleeve

Figure 1
Synchronisation system

Designs

Detents exist in both multi-piece and single-piece designs. The multi-piece design is being increasingly replaced by the single-piece design.

Multi-piece design

These detents comprise at least two individual parts. During mounting, the detent elements must in this case be fitted under spring tension, *Figure 2*.

This assembly work is not required when using ARRES, a development of the Schaeffler Group.

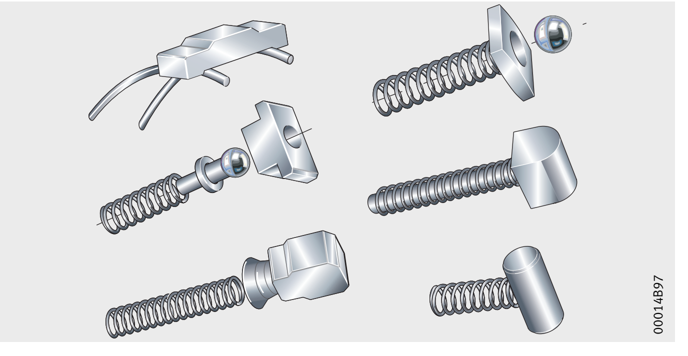
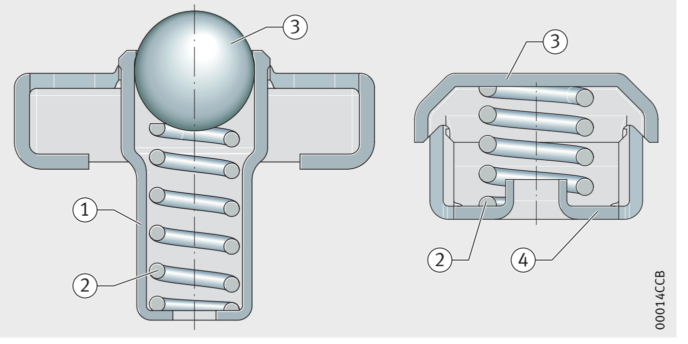


Figure 2
Conventional detents

Detents ARRES

Single-piece design

An ARRES comprises three components, *Figure 3*.
The components are rigidly connected to each other during production. Due to the single-piece design, less work is involved in transmission assembly. Furthermore, there is no need for holes in the selector hub and stockholding costs are reduced.



① Drawn cup
② Compression spring
③ Locking element
④ Base

Figure 3
Single-piece detent

Materials

Detents ARRES are made from high quality materials. The steel parts can be black oxide coated and the plastic bases can be produced in any colour.

Wear

Wear of the guide surfaces leads to a deterioration in synchronisation behaviour. The materials and surfaces developed for the synchronisation system keep wear to a low level. This allows consistent function over the whole life of the transmission.

Quality

All the components are manufactured by Schaeffler Group Automotive and are thus subject, from individual part production through to assembly, to continuous and complete quality control.

Gearshift feel

The displacement force curve that is decisive for gearshift feel is determined by the compression spring. In an ARRES, the spring force can be set at any point over a wide range. The desired gearshift feel can thus be set even shortly before the start of volume production.

ARRES-B

These easy-to-fit detents have proved themselves millions of times in practice.

Guidance

Good guidance in the selector hub is achieved by means of the large guidance surfaces, *Figure 4*.

Anti-lift device

High speeds in the transmission lead to large centrifugal forces. Secure function must be achieved even in these circumstances. Lifting, tilting and catching is prevented by the integral anti-lift device, *Figure 4*.

Mounting retainer

A mounting retainer can be integrated in order to ensure that almost rectangular detents are mounted quickly and in the correct position, *Figure 4*.

① Contact surfaces
② Guidance surfaces
③ Anti-lift device
④ Mounting retainer
⑤ Selector sleeve
⑥ Selector hub

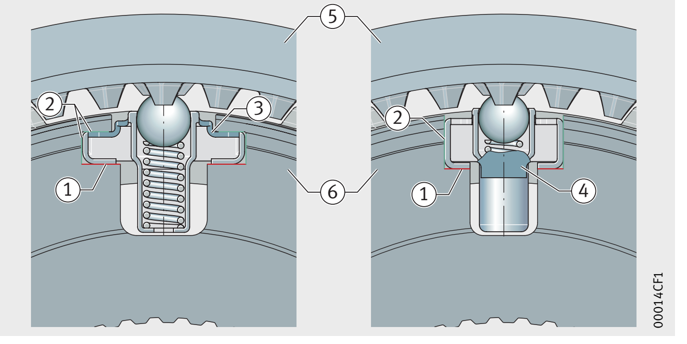


Figure 4
Guidance surfaces, retainers

Colour differentiation

Two ARRES of identical dimensions are mounted in one transmission. The only difference is in the compression springs fitted in each case. Optical differentiation is thus advisable. Black oxide coating of one variant is a proven method here, *Figure 5*.

① With black oxide coating
② Without black oxide coating

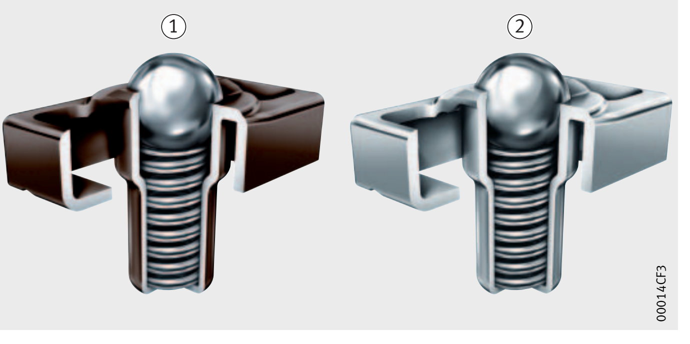


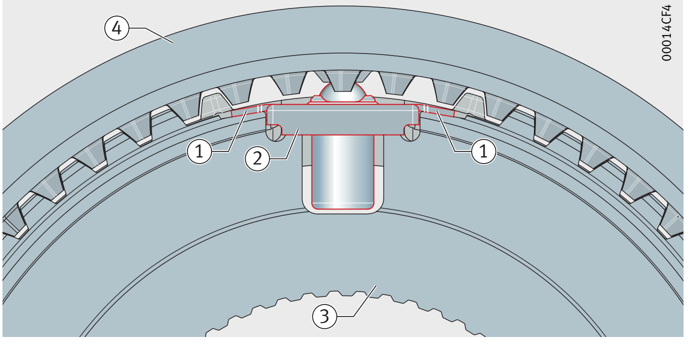
Figure 5
Black oxide coating

ARRES-W

This variant was derived from the basic ARRES design and incorporates the fundamental features of ARRES-B.

Wings

The special design feature is the two wings, *Figure 6*.



① Wings
② Retainer
③ Selector hub
④ Selector sleeve

Figure 6
Mounting situation

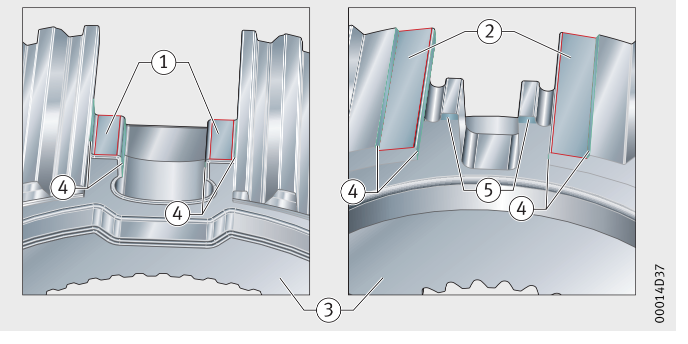
Anti-lift device

The wings prevent lifting from the contact and guidance surfaces, thus avoiding the resultant tilting. The components remain in their specified position even under high centrifugal forces. The length of the wings is matched to the tooth pitch of the selector sleeve.

Guidance surfaces

Selector hubs have large contact and guidance surfaces for the wings on ARRES-W. The contact and guidance surfaces are significantly longer in comparison with ARRES-B, *Figure 7*.

In the case of ARRES-W, tilting under long gearshift travel is prevented by the significantly longer contact and guidance surfaces.



① Contact surface of ARRES-B
② Contact surface of ARRES-W
③ Selector hub
④ Guidance surfaces
⑤ Locating surface for retainer

Figure 7
Guidance surface

Retainer

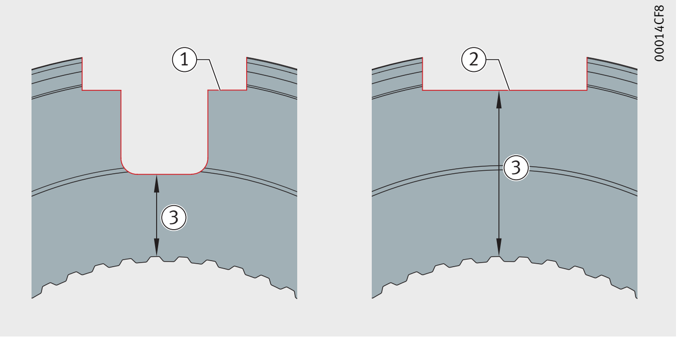
If ARRES-W is used for the reverse gear, the additional stop ring required for long gearshift travel is not required. A special selector hub for the reverse gear is no longer necessary. With a selector hub of the appropriate geometry, the integrated retainer fulfils its function, *Figure 6*, *Figure 7*.

ARRES-BL

These detents with a cap profile have the same functionality as our detents with a ball.

Section height

A significantly smaller section height is achieved since the volume under the cap can be used for the compression spring. The recess in the selector hub can thus be significantly smaller, *Figure 8*.



① Recess for ARRES-B and ARRES-W
② Recess for ARRES-BL and ARRES-RL
③ Critical cross-section

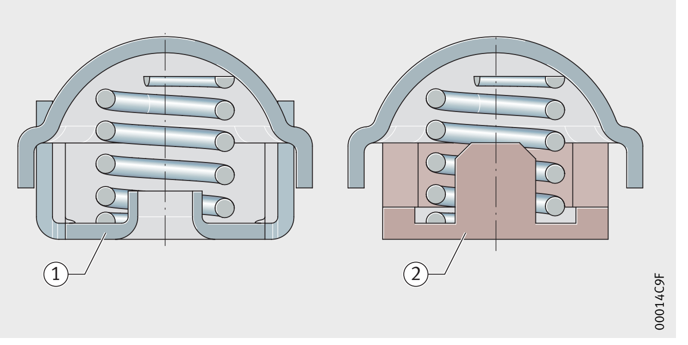
Figure 8
Recess, comparison

Flat recesses reduce the stresses in the critical cross-section by up to 25% and, with an otherwise unchanged transmission geometry, allow the selector hub to transmit greater torque. In new designs, the reduced dimensions allow transmission designs with compact dimensions and optimised mass.

Narrow design

With this design, the length of the transmission can be further reduced. The design envelope width from freewheel to freewheel can, in an ideal case, be reduced from 40 mm to 30 mm.
This can be achieved since the minimum width is determined from the total spring width and twice the sheet metal thickness.

Plastic base A plastic base can be used as an alternative to a steel base, *Figure 9*.



① Steel base
② Plastic base

Figure 9
Base material

Mass The mass is reduced by half compared to a steel base. This reduces the centrifugal forces and allows higher speeds in the transmission.

Colour If more than two flat ARRES of identical dimensions are used, we recommend the plastic base. Almost any colour can be selected for the plastic base.

Operating temperature ARRES with a plastic base can be used at operating temperatures from –40 °C to +140 °C.

Lubricants The plastic base has long term resistance to normal mineral and synthetic oils.

! Before using any special lubricants, please contact us for advice.

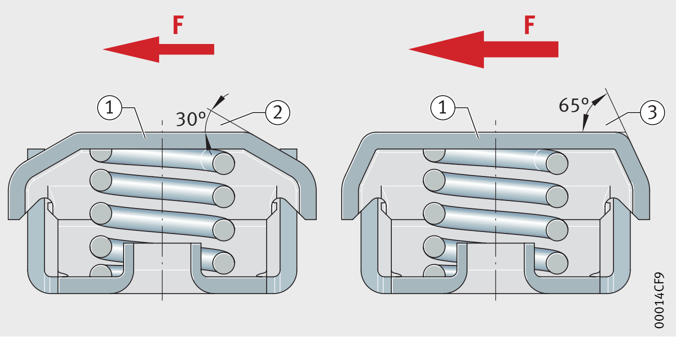
ARRES-RL

The design of this ARRES is based on that of ARRES-BL.
The locking element is different in that the locking profile is a ramp.

Displacement force

The displacement forces of the different ARRES designs are dependent on the relevant locking profile (ball, cap, ramp).
With a ramp profile, displacement forces at least twice as high can be achieved.

In the ARRES-RL, the displacement forces are dependent on the ramp angle. The more acute the ramp angle, the steeper the ramp and the larger the displacement force, *Figure 10*.



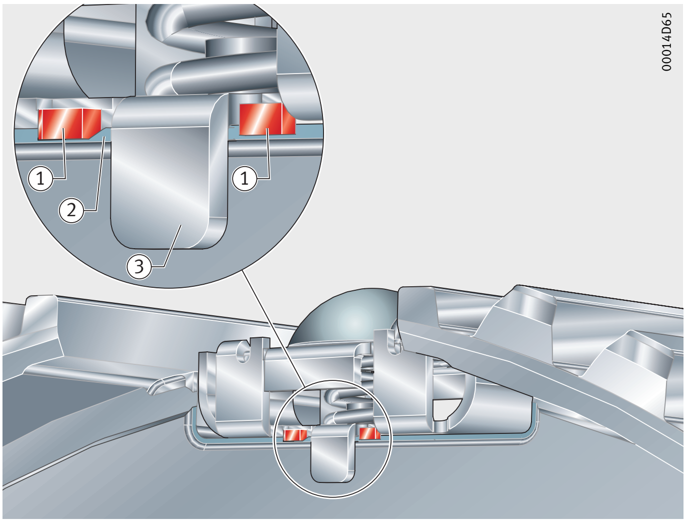
① Ramp
② Flat ramp angle
③ Acute ramp angle

Figure 10
Ramp angle

Detents ARRES

Centring

As early as the assembly stage, one advantage of the integrated centring mechanism becomes apparent, *Figure 11*.
Since the selector hub and selector sleeve are self-retaining, this unit can be mounted in the transmission without additional mounting aids.



① Centring at 4 points
② Selector hub, crosspiece
③ Retainer

Figure 11
Centring, retention

In operation, the centring mechanism supports positioning of the selector sleeve in the neutral position. If a centring mechanism is present, this prevents creep of the selector sleeve under vibration and the resulting contact between the detents and the synchro ring (synchro torque).

Retainer

If ARRES-RL with a retainer is used for the reverse gear, the additional stop ring required for long gearshift travel is not required.
A special selector hub for the reverse gear is no longer necessary.

Design

In the assessment of detents, the decisive factors are not only the design envelope but also the minimum and maximum value as well as the curve of the displacement force.

On the basis of geometrical data such as the diameter, the depth of the locking notch and the ramp angle as well as the specified speed and spring forces, it is determined whether the detents should be secured against lifting. Furthermore, the magnitude and curve of the displacement force are determined by the software, *Figure 12*.

This is also possible, however, in the opposite direction.
If the displacement force is specified, the spring forces can be determined.

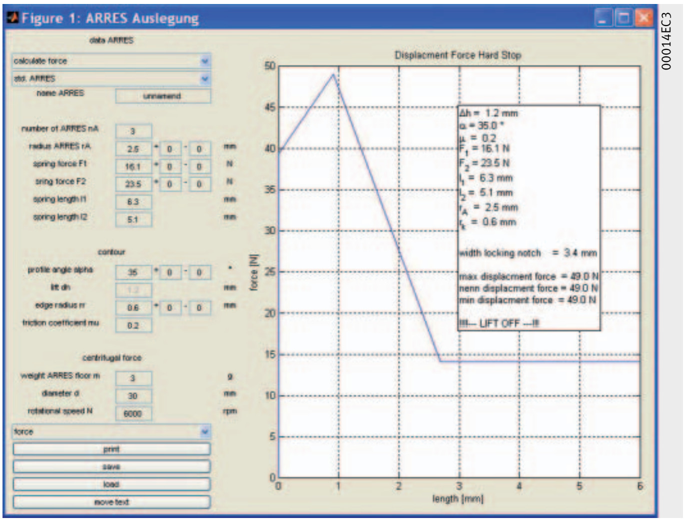
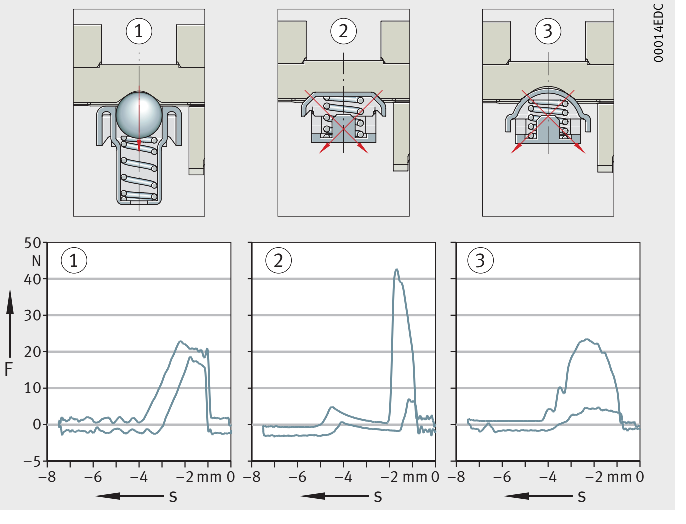


Figure 12
Design, applied software

Simulation

Before samples are produced, the behaviour of the components is checked using simulation software, *Figure 13*.



① ARRES-B and ARRES-W
② ARRES-RL
③ ARRES-BL

F = displacement force
s = displacement travel

Figure 13
Displacement force, simulation

Quality assurance

An integral part of a new development is quality assurance in the design of components. The calculated characteristics are subsequently checked in tests. Upon customer request, all or only some of the measures described are implemented in the case of standard components.

FEM calculation

If the components fulfil the requirements relating to function, the service life is investigated. The stresses present in the model are checked, *Figure 14*.

The strength analysis uncovers weaknesses. The model is modified accordingly until the required strength is achieved in calculation.

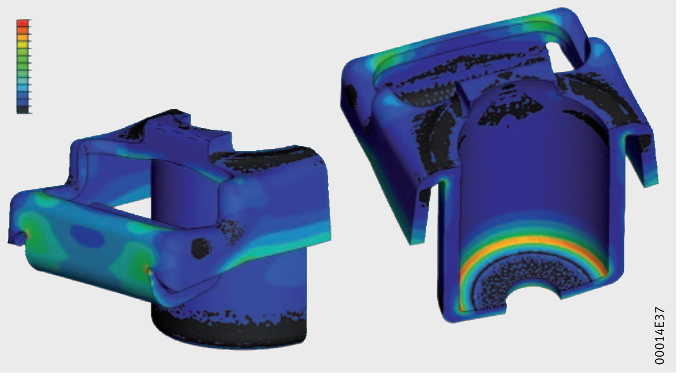


Figure 14
Strength analysis

Tests Sample parts and later production parts can be investigated on appropriate test rigs. Once the sample parts have passed the short term tests, this is followed by the system test.

Gearshift feel A final test would be an investigation of the sensory quality. Objective data can be fulfilled according to specifications. The requirements in terms of subjective data such as gearshift feel can also be checked on a test rig representative of practical conditions, *Figure 15*.

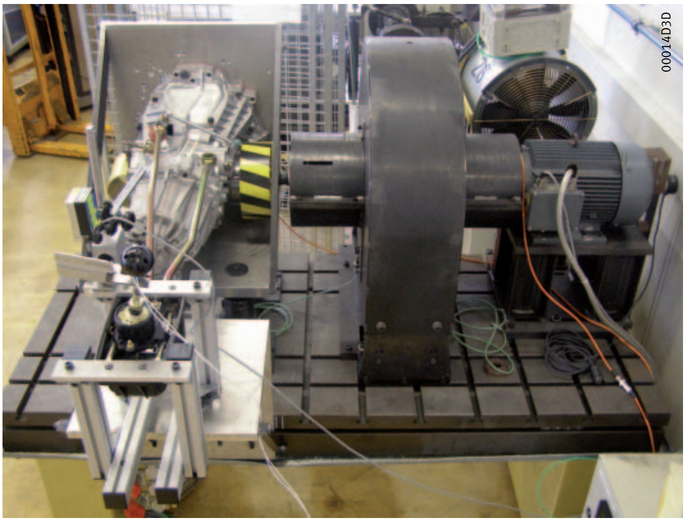
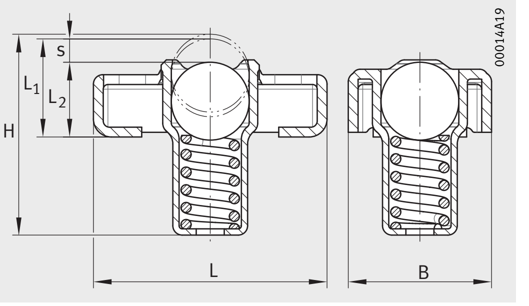


Figure 15
Test rig, gearshift feel

Test specification The tests are carried out in accordance with customer requirements or defined test specifications of the Schaeffler Group. These specifications have been developed on the basis of many years of experience and are continuously adapted to take account of new findings.

Detents ARRES

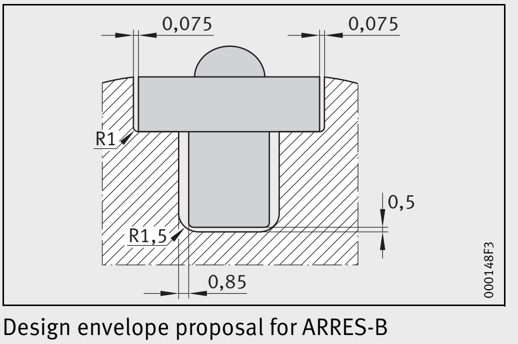
Standard



ARRES-B

Dimension table · Dimensions in mm									
Designation	Mass	Dimension					Forces		Stroke length
	m	L	H	B	L_1	L_2	F_1[1)]	F_2[2)]	s
	≈g						N	N	
ARRES-B1	3	11,8	13,8	10,35	7,25	5,56	13	22	1,69
ARRES-B2	3	11,8	13,8	10,35	7,25	5,56	7,5	15	1,69
ARRES-B3	2,5	11,8	13,8	10,35	6,77	5,6	19	26	1,17
ARRES-B4	3	13,95	12,9	11,45	6,3	4,8	12,5	20	1,5
ARRES-B5	2,4	13,95	12,9	11,45	6,3	5,35	12	15,6	0,95
ARRES-B6	1,8	14,65	9,2	7,95	7	6,05	12	15,6	0,95
ARRES-B7	2,5	14,95	10,9	9,65	6,6	5,4	10,65	16,8	1,2
ARRES-B8	2,2	14,95	10,9	9,65	6,6	5,4	14,2	22,4	1,2
ARRES-B9	2,3	15	12,9	9,2	6,3	4,8	10	16	1,5
ARRES-B10	2,4	15	12,9	9,2	6,3	5,1	12,5	18,5	1,2
ARRES-B11	2,4	15	12,9	9,2	6,3	4,8	12,5	20	1,5
ARRES-B12	2,5	15	12,9	9,2	6,3	5,1	14	20	1,2
ARRES-B13	2,3	15	12,9	9,2	6,3	4,8	14,3	25	1,5
ARRES-B14	2	15	12,9	9,2	6,3	5,1	14,7	26,5	1,2
ARRES-B15	2,3	15	12,9	9,2	6,3	5,1	16,1	23,5	1,2
ARRES-B16	2,4	15	12,9	9,2	6,3	4,8	16,1	25,4	1,5
ARRES-B17	2,4	15	12,9	9,2	6,3	5,1	16,5	22,5	1,2
ARRES-B18	2,3	15	12,9	9,2	6,3	5,1	18	31	1,2
ARRES-B19	2,5	15	12,9	9,2	6,3	4,8	18	34,5	1,5
ARRES-B20	2,3	15	11,7	9,9	7,21	5,84	12	22	1,37
ARRES-B21	2,8	15	12,9	12,3	6,3	4,8	10	16	1,5
ARRES-B22	2,5	17,4	13,1	11,2	6,3	4,8	12	20	1,5
ARRES-B23	3	13,95	12,9	18,75	6,3	4,8	13,5	21	1,5
ARRES-B24	3	13,95	12,5	21,35	5,9	4,65	15	22,5	1,25

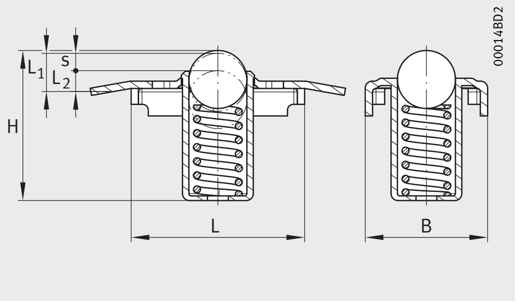
1) F_1 = force at L_1.
2) F_2 = force at L_2.



Design envelope proposal for ARRES-B

Detents ARRES

With wings



ARRES-W1

Dimension table · Dimensions in mm

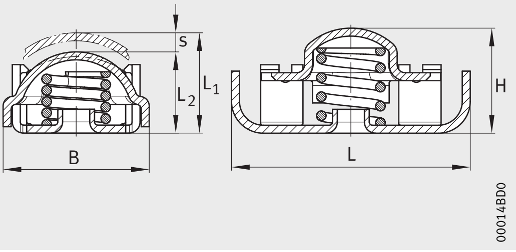
Designation	Mass	Dimension					Forces		Stroke length
	m	L	H	B	L_1	L_2	F_1 [1]	F_2 [2]	s
	≈g						N	N	
ARRES-W1	2,4	14,95	12,95	10,55	3,3	1,8	12,5	20	1,5

[1] F_1 = force at L_1.

[2] F_2 = force at L_2.

Detents ARRES

Flat design, cap profile



ARRES-BL

Dimension table · Dimensions in mm

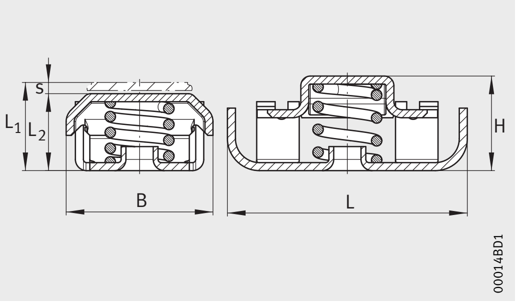
Designation	Mass	Dimension					Forces		Stroke length
	m	L	H	B	L_1	L_2	F_1 1)	F_2 2)	s
	≈g						N	N	
ARRES-BL1	1,2	15	6,6	6	4,8	5,5	13	23	0,7
ARRES-BL2	1,2	15	6,6	9,15	4,8	5,5	13	23	0,7

1) F_1 = force at L_1.

2) F_2 = force at L_2.

Detents ARRES

Flat design, ramp profile



ARRES-RL

Dimension table · Dimensions in mm								
Designation	Mass	Dimension					Forces		Stroke length
	m	L	H	B	L_1	L_2	F_1 [1]	F_2 [2]	s
	≈g						N	N	
ARRES-RL1	1,2	15	6,6	7	4,8	5,5	12	22	0,7
ARRES-RL2	1,2	15	6,6	9,15	4,8	5,5	12	22	0,7

1) F_1 = force at L_1.
2) F_2 = force at L_2.

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