Bogie subsystems
Articulation joints

Extract from the Railway technical handbook, volume 1, chapter 9, page 172 to 175
Articulation joints

Today, there is an increased public and political awareness of the need for collective mobility, especially in crowded urban and suburban areas. This opens new opportunities for further development of mass transit systems and, as a consequence, encourages the rolling stock industry to pursue novel solutions. Innovative vehicle generations provide superior quality, comfort and safety in transport.

Articulated vehicles

Modern articulated vehicle designs containing several body sections enable easy access inside the vehicle and contribute to passenger safety. The body sections are connected with articulation joints.

Modern mass transit vehicles such as multiple units, suburban trains, metro cars, light rail vehicles and trams are based on articulated body designs. There are different configurations on the market with 2 to 7 connected vehicle body sections. Previously, several independent vehicles such as powered cars and trailers were coupled to a train. The disadvantage of this is lower passenger capacity, no access inside the train and a diminished feeling of safety for the passengers.

Today, articulated mass transit vehicles offer new advantages that increase efficiency and provide higher passenger safety. Low-floor mass transit vehicles offer easy entry for passengers. The articulation joints of these sections contain special spherical plain bearing solutions developed by SKF.

Articulated vehicle bodies can be joined by using bogies underneath, known as Jacobs bogies (→ page 26). In this case, a larger number of bogies have to be applied, which increases weight and cost. Another design principle, which is used more and more, is to connect vehicle bodies directly with articulated joints and reduce the number of bogies. Articulated joints have to enable 3-dimensional movement of the two connected vehicle bodies.

The sliding angles and velocity are very low and depend on the track design such as curve radii in horizontal and vertical directions and the speed. In addition, important emergency buffer strokes in horizontal direction need to be considered. In most applications, the articulation joint is well protected and outside the body design. Maintenance is not easy and customers demand to avoid it wherever possible.
Articulation joint capabilities

Basic technical requirements like accommodation of various loads and motion cycles are designed according to:

- VDV 152, structural requirements for rail vehicles for the public mass transit in accordance with the German BOS trab light rail vehicle and tramway standard.
- EN 12663, structural requirements of railway vehicle bodies.
- In addition to these standards, the specific design of articulation joints is based on individual customer specifications.

When developing these special spherical plain bearing units, SKF has worked closely with leading vehicle manufacturers.

As the railway industry is one of the most sensitive concerning safety and LCC, it is crucial to provide reliable value-added integrated solutions at acceptable cost levels [35].

Articulation joint benefits

- reliable operation
- low life cycle costs (LCC)
- ready to built-in solution customized to the envelope space

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Buffer stroke in kN</th>
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<tbody>
<tr>
<td>P-II Multiple units</td>
<td>1 500</td>
</tr>
<tr>
<td>P-III Metro and suburban trains</td>
<td>800</td>
</tr>
<tr>
<td>P-IV Light rail vehicles</td>
<td>400</td>
</tr>
<tr>
<td>P-V Tramcars</td>
<td>200</td>
</tr>
</tbody>
</table>

Horizontal force – buffer stroke – EN 12663

Articulation joint, design principle features:

1. Case-hardened shaft washer with a hard-chromium plating on the ball-shaped raceway with precise interface diameter and threaded holes for connection
2. Housing washer
3. The housing washer inserts of high-performing PTFE-composite polymer shells
4. Central bolt acting as an anti-lifting device, with a ball-shaped head and is adjusted with clearance relative to the shaft washer
5. Lock nut (if the central bolt is not directly connected to the housing washer)
6. Flexible two-lip seal connected to the housing washer
7. Polymer cover sealing the top of the bearing
**Design features**

Modern computer simulations are used when designing railway articulation joints. This enables a calculation of the reaction forces, in particular for the worst case, which is the maximal emergency horizontal force combined with a minimum vertical load. The vertical reaction force has to be carried by the anti-lifting device and all bearing parts, and determines the necessary bearing size. In addition, the design of the adjacent parts or special mounting needs has to be taken into consideration. Although the bearing is customized and adapted to the operating conditions, it follows the basic design, which contributes to keeping the costs low.

The sliding material combination is the core of this particular bearing design.

It provides smooth, reliable operation for a long service life, even under dry or boundary lubrication conditions. The polymer material that is thoroughly anchored to its substrate is supplied with an effective wear thickness of approximately 2 mm.

The sliding material friction values are excellent, exhibiting low noise levels and no negative stick slip. The tribological behaviour of the articulation joint can be further improved when appropriate lubrication is applied. Even though the sliding material combination might also be operated completely dry, SKF supplies the bearing...

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**Articulation joint inside view, enhanced service life can be achieved by relubrication**

1. Lubrication holes
2. Lubrication grooves

**Articulation joint application benefits**

- reduced risk of disconnected joint in an emergency
- 3-dimensional functionality for cornering, rolling and pitching (tilting) from operation and distortion of the vehicles bodies
- compact and space-saving design
- easy integration of the articulation joint into existing supports with light alloy or cast iron
- operation without noise and stick-slip free
- insensitivity to cleaning media, salt-spray, corrosion attacks and contaminants
- low life cycle costs
with an initial grease fill and provides a possibility for re-lubrication.

Compared to other, thinner dry-sliding materials, the articulation joint is less sensitive to the entrance of abrasive particles and thus a better choice, especially when considering the requested reliability. The sliding material also exhibits quite good damping properties, which is beneficial for railway applications. And, the material has very good wear-resistant properties, with an almost linear wear rate, which facilitates service life prediction. Re-lubrication not only enhances the tribological mechanism but also gets contaminants out of the bearing and improves the protection against corrosion.

SKF has gathered very positive field experience with the sliding material combination steel/PTFE fibre-reinforced polymers in railway and mass transit vehicles. This experience is reinforced in applications with comparable dynamic operation, such as thrust spherical plain bearings in ladle turrets in steel mills, bascule bridges, cranes and ship loaders.

Wear measurements of inspected tram bearings after eight years of service and mileage of about 500 000 km showed an amazingly low amount of wear. The bearings were found to be in excellent condition and could continue to be used for some time. With its specific design, SKF has set an industrial standard for articulation joints.

Applications
Meanwhile, various articulation joint designs for 400 kN and 800 kN buffer strokes and for different vehicle configurations have been developed and manufactured. These designs are based on the same design principles, with the well-proven sliding material combination in its centre and the anti-lifting device as a ready-to-mount "black box".

From the first use of standard thrust spherical plain bearings, the articulation has evolved into a value-added unit fulfilling the ever-increasing requirements of the railway industry. The spherical plain bearing articulation joints supplied by SKF are contributing to the safe transport of passengers in cities all over the world.

Qualitative wear and friction behaviour of the sliding material combination:
- dry-sliding conditions
- lubricated conditions
The diagram shows characteristic linear wear curves and stable friction curves after the running-in phase.
The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

References