



# SURFACE VEHICLE RECOMMENDED PRACTICE

J901™

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Superseding J901 JAN2007

(R) Articulating Joints and Driveshafts - Nomenclature - Terminology - Application

## RATIONALE

The Drivetrain and Driveline committees have been combined together as the Drivetrain Standards Committee. As such, the Drivetrain Standards Committee has the responsibility to update this document. SAE J901 has been updated to reflect the latest technological advances in articulating joints and drivetrain trends.

### 1. SCOPE

The following definitions and illustrations are intended to establish common nomenclature and terminology for driveshafts and their articulating joints used in various drivetrain applications. In addition, useful guidelines are included for the application of driveshafts and their joints. For more specific details, refer to AE-07.

### 2. REFERENCES

#### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

##### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

AE-07 Universal Joint and Driveshaft Design Manual

SAE J670 Vehicle Dynamics Terminology

### 3. DEFINITIONS

#### 3.1 DRIVETRAIN

An assembly of one or more power transmitting devices, such as a power transfer unit (PTU), rear drive module (RDM), transfer case, axle, driveshafts, and halfshafts. The driveshafts and halfshafts transmit torque and/or rotary motion at a fixed or varying angular relationship from one shaft to another and have provisions for axial movement.

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### 3.2 DRIVESHAFT ASSEMBLY

An assembly of one or more articulating joints connected by an interconnecting shaft member (see Figures 1 to 8) that transmits torque.

### 3.3 HALFSHAFT ASSEMBLY

Normally, one of two driveshaft assemblies with two articulating joints that connects the chassis-mounted drivetrain component to the independently sprung driven wheel of a vehicle (see Figures 6 and 7). Also known as a sideshaft.

### 3.4 AXLESHAFT ASSEMBLY

Normally, a driveshaft with one articulating joint is used with solid axles to allow for steering movement of the wheel. Sometimes called a steer axle assembly (see Figure 8).

### 3.5 AXLESHAFT

The interconnecting shaft on a halfshaft assembly or axleshaft assembly.

### 3.6 PROPSHAFT

A type of driveshaft that transmits torque along the longitudinal axis of the vehicle. Can exist as a single piece with two articulating joints and one interconnecting shaft or multiple pieces with more joints and interconnecting shafts with support bearings and brackets for vehicle attachment points. Also referred to as “propeller shaft” (see Figures 1 to 5).

### 3.7 LINKSHAFT/INTERMEDIATE SHAFT

An intermediate solid or tubular shaft that connects a chassis-mounted drivetrain component to a halfshaft inboard joint. It is normally supported by a bearing and bracket attached to the powertrain. It allows the use of equal length (and possible common) halfshafts and aids in equalizing inboard joint angles (see Figure 9).

### 3.8 DRIVESHAFT LENGTH, CENTER-TO-CENTER

The distance between the articulating joint centers on a driveshaft. On driveshafts with variable length centers, it is expressed as both the compressed and extended lengths (see Figure 1).

### 3.9 SLIP

The permissible length of axial displacement (slip) between a driving and driven member of two components in a propshaft assembly (see Figures 1, 2, 3, and 5). This is normally achieved with splined components but is not limited to splines. This does not include the stroke or plunge distance of the end motion type joint (see 4.8).

### 3.10 STROKE OR PLUNGE DISTANCE

The permissible length of axial displacement of an end motion or stroking type articulating joint.

### 3.11 PHASE ANGLE

The relative rotational position of the universal, Cardan, or Hooke’s type joint yokes on a driveshaft or drivetrain (see Figure 1). If the inboard yokes have 0-degree phase angle, they are said to be “in-line” or “parallel.” If the inboard yokes are phased at a 90-degree angle, they are said to be “crossed.”

### 3.12 CRITICAL SPEED

The driveshaft rotational velocity coincides with the transverse (bending) natural vibration frequency of the driveshaft, causing the driveshaft to resonate.

### 3.13 BALANCING

A procedure by which the center of mass of a rotating body is measured and may be altered to be coincident with the center of rotation to reduce drivetrain vibration. Balance weights are placed with a specific mass and vector location on the circumference of the rotating component to correct mass offset of the components at a specific plane location. Plane separation between component locations is critical to ensure that the balance weight correction will allow a minimal threshold of correctability.

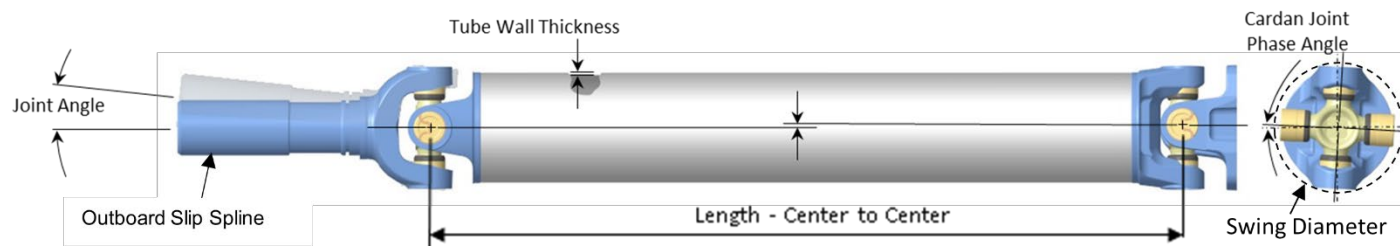


**Figure 1 - Two joint outboard slip driveshaft**



**Figure 2 - Two joint inboard slip driveshaft**



**Figure 3 - Single joint coupling shaft**



**Figure 4 - Single joint coupling shaft**

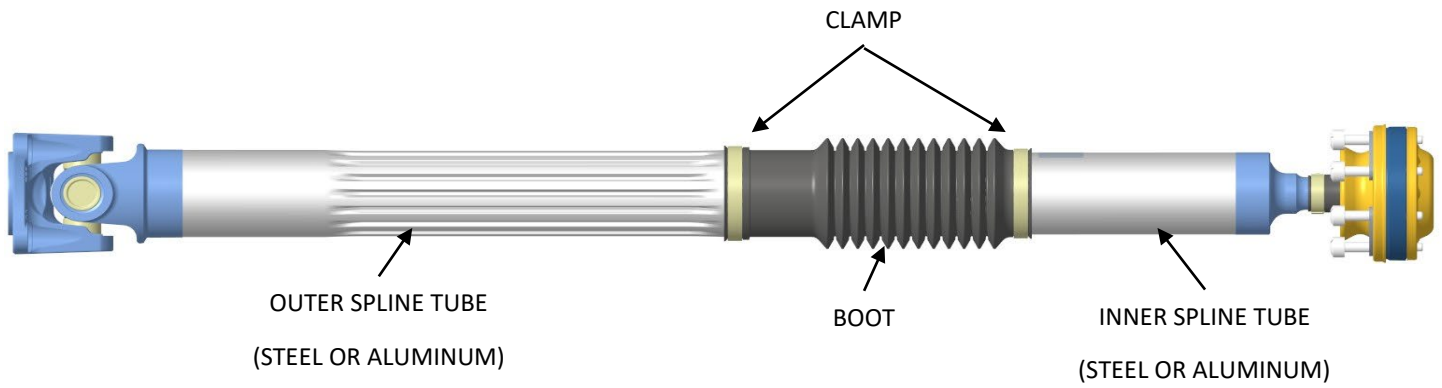


**Figure 5 - Slip-in-tube driveshaft**

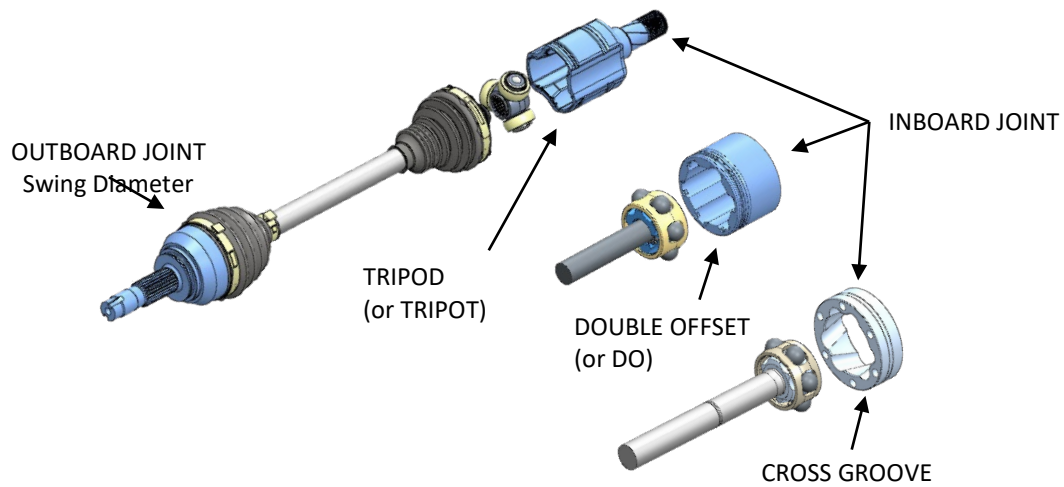


**Figure 6 - Typical front-wheel-drive halfshaft with alternate inboard end motion constant velocity joints**



**Figure 7 - Typical rear-wheel-drive halfshaft with end motion constant velocity joints (cross groove type shown)**

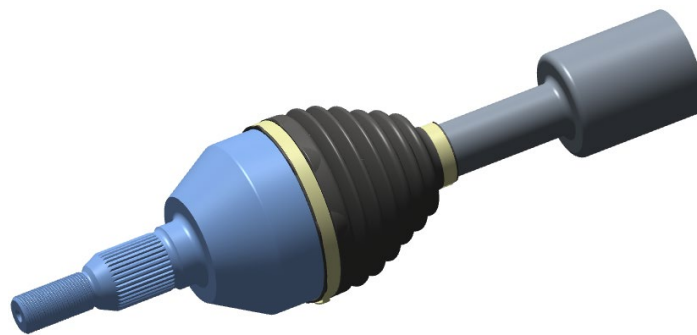


**Figure 8 - Axle assembly or steer axle assembly**

### 3.14 MASS DAMPER

A concentrated mass generally clamped on an axleshaft midway between the articulating joints. It is used to reduce and/or tune the natural bending frequency of the axleshaft assembly or halfshaft assembly below a disturbing frequency (see Figure 10).

### 3.15 TORSIONAL DAMPER OR VIBRATION ABSORBER

A type of torsional vibration absorber that generally consists of an outer member and an inner member with an elastomeric material between the inner and outer members. The elastomeric material is designed to be tuned to a specific disturbing frequency. The torsional damper assembly is typically assembled to the drivetrain by attaching the inner member or mounting directly on the elastomeric material (see Figure 8).

### 3.16 BENDING DAMPER OR ABSORBER

A type of vibration absorber tuned to the bending frequency of the driveshaft. The absorber assembly generally consists of an inertia member supported by elastomeric material. The absorber assembly is normally mounted internally or externally to a tube shaft or externally to a solid shaft by interference fit and/or clamping (see Figures 11 and 12). See 6.6 for additional details.

### 3.17 ISOLATION DAMPER

A mechanical torque transmitting device incorporated in a drivetrain that functions as a disturbance isolator. It eliminates undesirable throttle or shift-induced noises or transaxle or axle gear lash or noise by means of an elastomeric material bridging the driving and driven members (see Figures 13 and 14).

## 3.18 LINER

A compliant absorbing material (i.e., cardboard, foam, cork, rubber) typically added to the interior of the tubeshaft assembly prior to welding for the purpose of attenuating undesirable NVH (i.e., ringing). Tubes under torque create a “breathing” mode shape of the tube; these deployed absorbing materials attenuate this issue. Liners are used within the tubeshaft assembly depending on the driveline sensitivity at the vehicle level (see Figure 12).

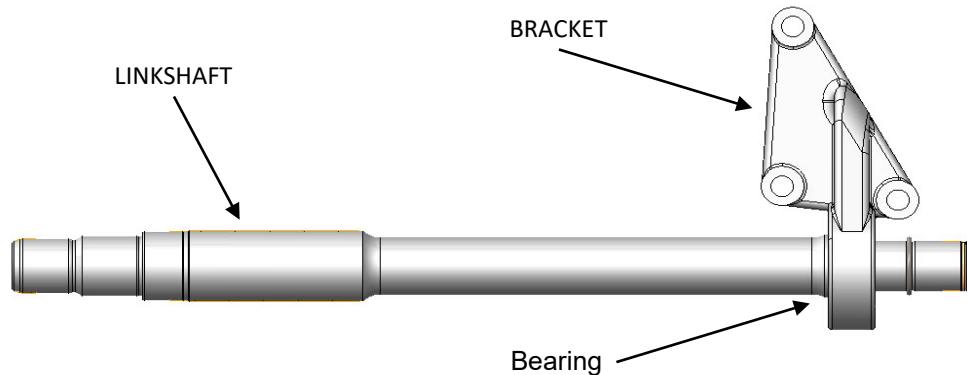


**Figure 9 - Linkshaft with bearing bracket**

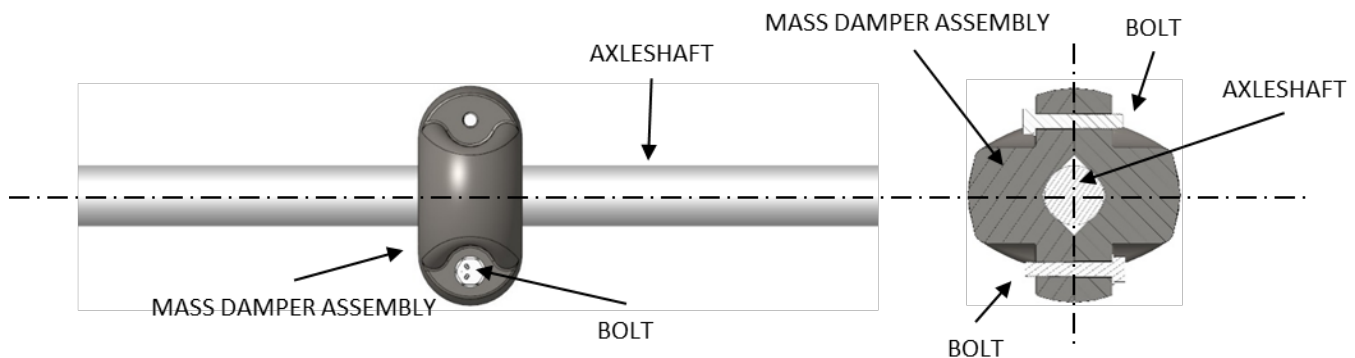


**Figure 10 - Axleshaft mounted mass damper**

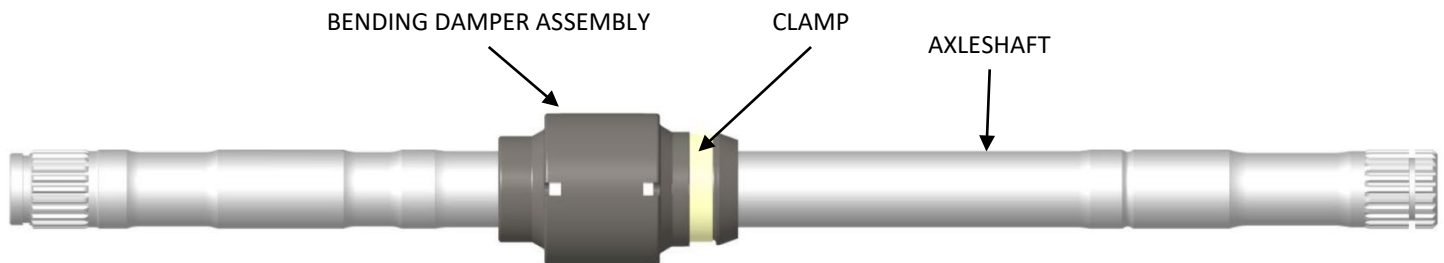


**Figure 11 - Axleshaft mounted bending (tuned) damper or absorber**

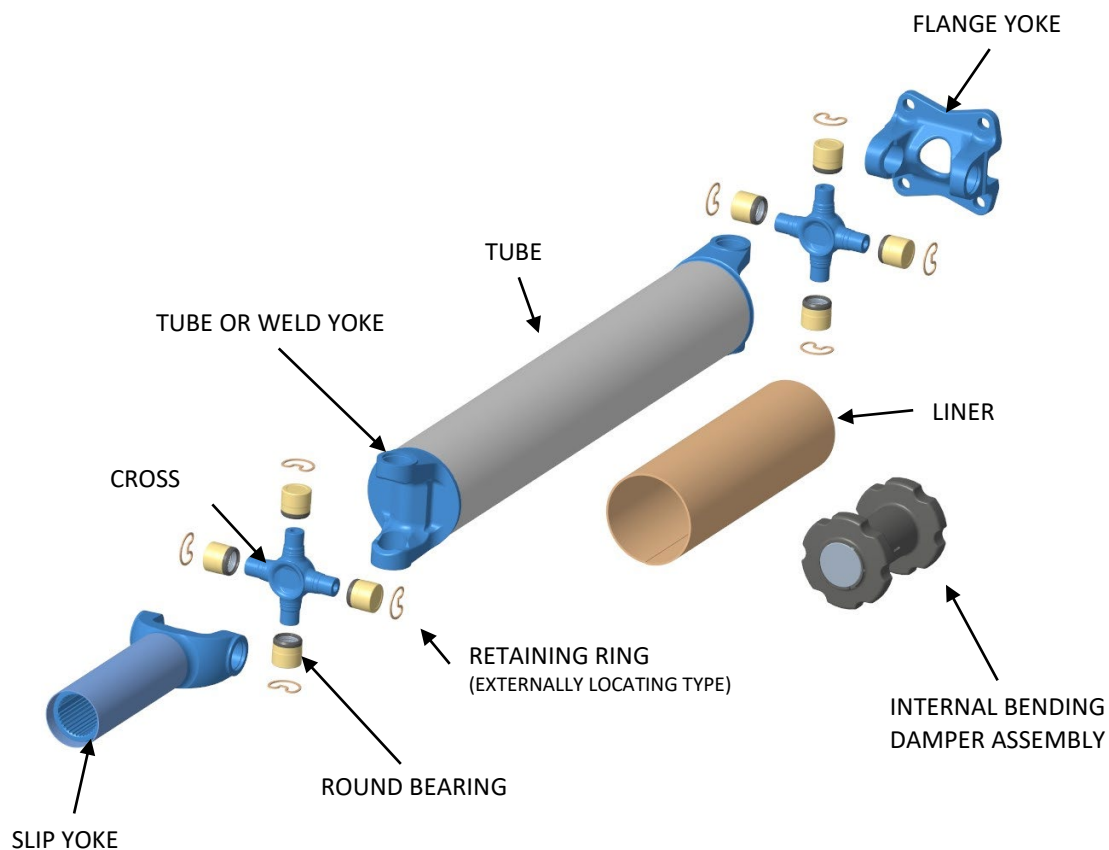


**Figure 12 - Typical two-joint outboard slip driveshaft (exploded view)**

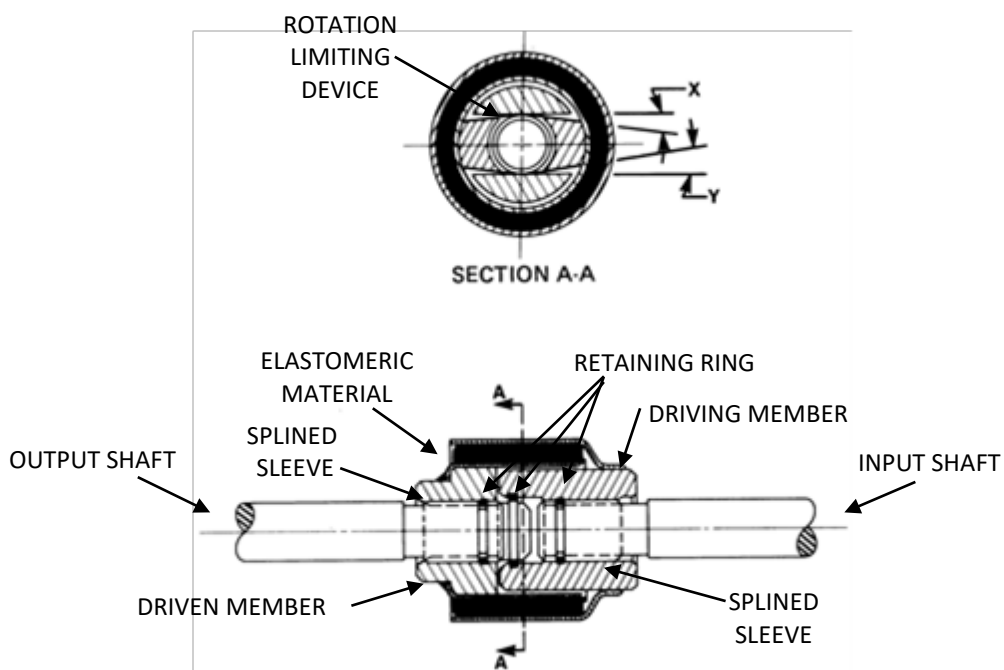


**Figure 13 - Split axle shaft mounted torsional damper**

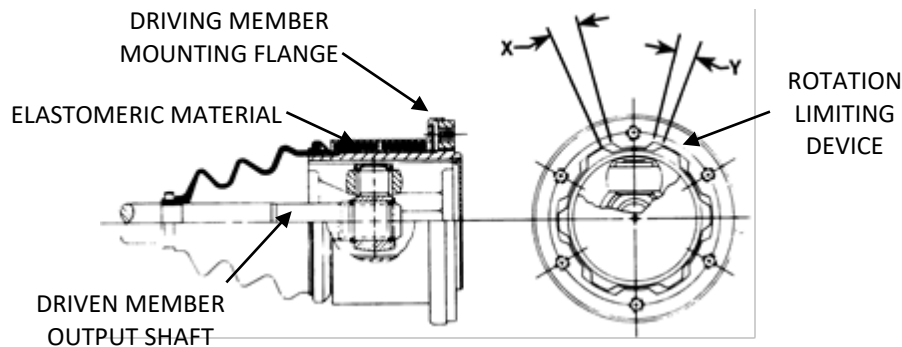


**Figure 14 - Inboard CV joint mounted isolation damper**

### 3.19 ARTICULATING JOINT

A mechanical device that can transmit torque and/or rotational motion from one shaft to another at fixed or varying angles of intersection of the shaft axes. There are many types of articulating joints, and they can be classified according to their motion transmission, supporting capability, joint center location, and joint operating angle.

### 3.20 NONCONSTANT VELOCITY ARTICULATING JOINT

An articulating joint that transmits rotational motion with a variation in angular velocity between the driving and driven members when operating at joint angles greater than zero. The average angular velocity ratio is unity (for example, the Cardan joint, Hooke joint, or rubber coupling).

### 3.21 CONSTANT VELOCITY OR CV ARTICULATING JOINT

An articulating joint that transmits rotational motion with an angular velocity ratio of unity between driving and driven members at joint angles greater than zero (for example, the Rzeppa joint; see Figure 30).

### 3.22 NEAR CONSTANT VELOCITY ARTICULATING JOINT

An articulating joint that transmits rotational motion with an angular velocity ratio of unity when operating at the design joint angle and at zero. When operating at other angles, the angular velocity ratio is near unity (for example, the Double Cardan joint; see Figure 21).

### 3.23 SELF-SUPPORTING ARTICULATING JOINT

An articulating joint supported by internal means (for example, the Rzeppa type CVJ)

### 3.24 NON-SELF-SUPPORTING ARTICULATING JOINT

An articulating joint that requires an external means of support (for example, the formerly used Tracta joint). This type of joint requires fixing or locating at both the driving and driven members to maintain alignment of joint components.

### 3.25 FIXED CENTER ARTICULATING JOINT

An articulating joint that maintains the joint center at a fixed location and can resist axial thrust forces (for example, the universal, Cardan or Hooke joint, and/or Rzeppa joint).

### 3.26 END MOTION OR STROKING OR PLUNGING ARTICULATING JOINT

An articulating joint that permits relative axial movement between driving and driven members, resulting in a variable joint center location (for example, the tripot or tripod joint).

### 3.27 OUTBOARD JOINT

An articulating joint located at the wheel end of a halfshaft assembly or axleshaft assembly (see Figure 2).

### 3.28 INBOARD JOINT

An articulating joint located at the differential or final drive end of a halfshaft assembly (see Figure 2).

### 3.29 JOINT ANGLE

The acute angle described by the intersection of the rotational axes of the driving and driven members of an articulating joint and measured in the plane described by these axes (see Figure 1). This angle must be considered in 3D space. This is also referred to as the “Compound Angle.”

#### 3.29.1 SWEEP ANGLE

The acute angle described by projecting the joint angle onto the X-Y plane per SAE J670 (parallel to the road).

#### 3.29.2 FRONTAL ANGLE

The acute angle described by projecting the joint angle onto the Y-Z plane per SAE J670 (vehicle transversal plane).

#### 3.29.3 RUNNING ANGLE

The acute angle described in 3D space. This is the same as the joint angle (see 3.29).

### 3.30 SWING DIAMETER

The maximum diameter of the circular path described by a rotating articulating joint (see Figure 1); also referred to as the “rotation diameter.”

### 3.31 CONSTANT VELOCITY, BISECTING ANGLE OR HOMOKINETIC PLANE

The plane described by all contact points of a constant velocity articulating joint which produces an angular velocity ratio of unity between the output and input members. This plane bisects the obtuse angle formed by the input and output member rotational axes and is perpendicular to the plane containing these axes (see Figure 15).

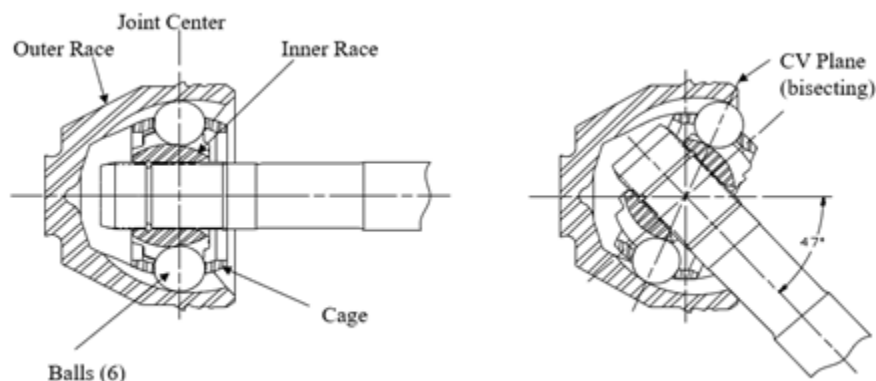


**Figure 15 - Ball joint bisecting angle or homokinetic plane**

### 3.32 TORSIONAL EQUIVALENT ANGLE

The joint angle of a single nonconstant velocity articulating joint which produces the same speed variation as a drivetrain with two or more nonconstant velocity articulating joints.

### 3.33 INERTIA EQUIVALENT ANGLE

The joint angle of a single nonconstant velocity articulating joint which describes the inertia effects of a drivetrain.

### 3.34 INERTIA DRIVE EQUIVALENT ANGLE

The joint angle of the first nonconstant velocity articulating joint in a two-joint system. In a three-or-more-joint system, it is the joint angle of a single nonconstant velocity articulating joint which produces the same maximum acceleration as the maximum of the sum of the accelerations of all but the last nonconstant velocity articulating joint in the drivetrain.

### 3.35 INERTIA COAST EQUIVALENT ANGLE

The joint angle of the last nonconstant velocity articulating joint in a two-joint system. In a three-or-more-joint system, it is the joint angle of a single nonconstant velocity articulating joint which produces the same maximum acceleration as the maximum of the sum of the accelerations of all but the first nonconstant velocity articulating joint in the drivetrain.

### 3.36 SECONDARY COUPLE

A bending moment on the driving and driven members of an articulated joint produced by an angular change in the direction of torque. It is primarily a function of torque, joint angle, and driveshaft length. In a nonconstant velocity articulating joint, the bending moment on the driving member oscillates from zero to maximum, while simultaneously on the driven member the moment varies from maximum to zero, twice per revolution. In a constant velocity articulating joint, the bending moment on both driving and driven members is constant (for a specific set of conditions) for all positions of joint rotation.

### 3.37 BEARING FACTOR

A size characteristic for comparing the various size Cardan and double Cardan type articulating joints relative to needle roller bearing capacity. It is the product of the projected needle roller bearing area on the cross trunnion times the torque radius (see Figure 16).

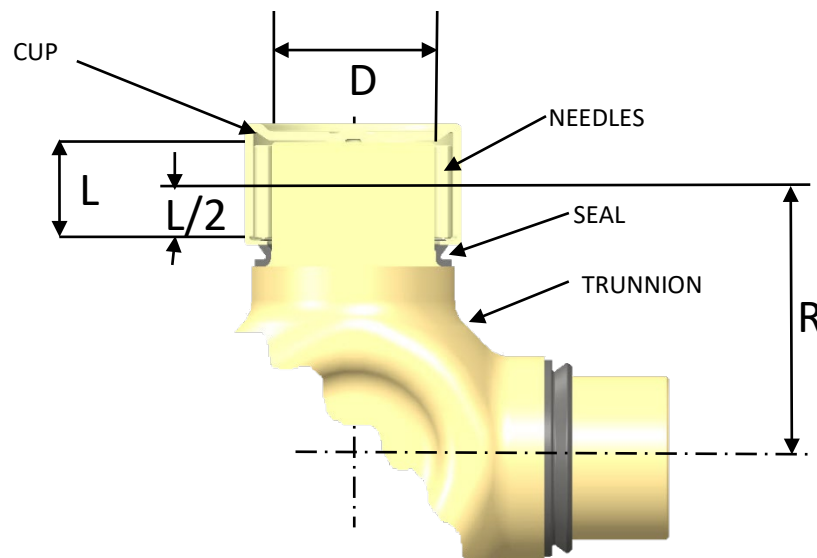


**Figure 16 - Needle roller bearing and cross configuration**

## 4. DRIVESHAFT ARTICULATING JOINTS

### 4.1 Nonconstant Velocity Types

#### 4.1.1 Cardan, Hooke or Universal Joint

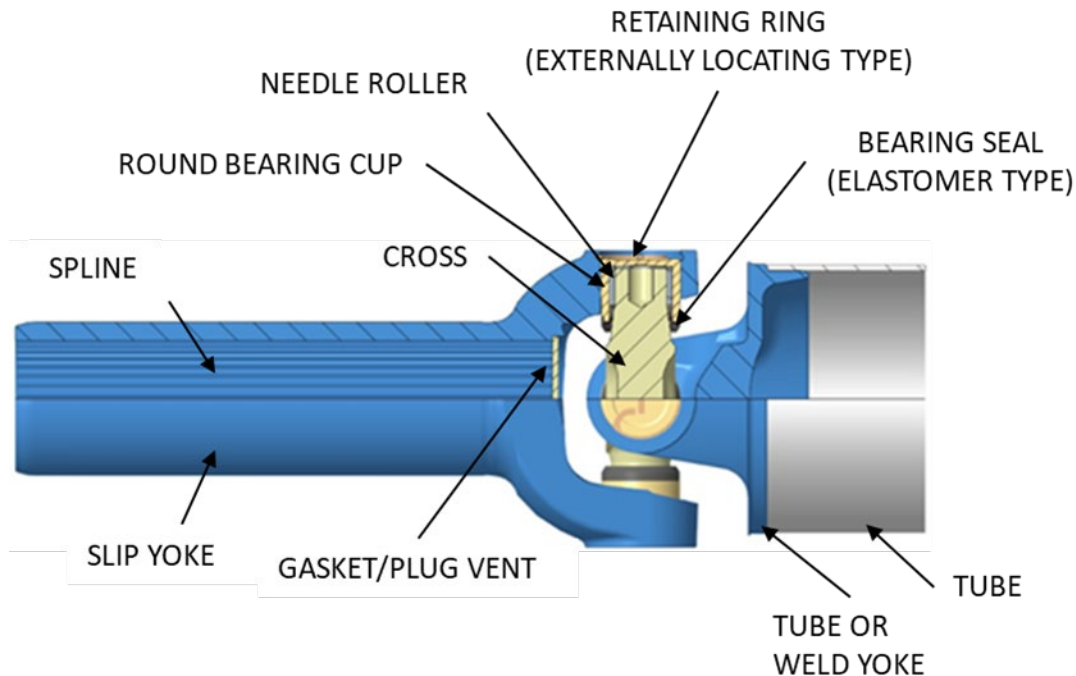


**Figure 17 - Cardan, Hooke, or universal joint**

A nonconstant velocity articulating joint that consists of a driving yoke connected to the driven yoke by a cross through four needle roller bearing cups, allowing angular motion (see Figures 16 and 17).

#### 4.1.2 Staked (Cardan, Hooke, or Universal) Joint

A type of joint assembly method that is permanent by means of deforming the yoke ear bore top perimeter to hold the bearing cup in place (see Figure 18).

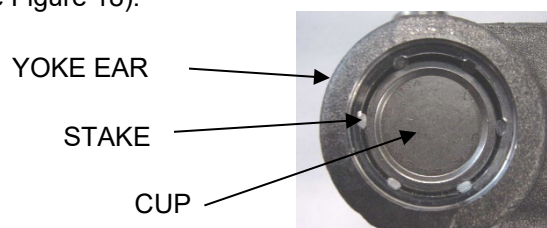


Image shows six stakes at the interface between the yoke ear bore and bearing cup to maintain joint assembly.

**Figure 18 - Stake Cardan joint**

#### 4.1.3 Circlipped (Cardan, Hooke or Universal) Joint

A type of joint assembly method that provides for disassembly by means of a retaining ring which retains the bearing cup in the yoke ear bore. This is also referred to as a serviceable joint (see Figures 1, 4 and 12).

#### 4.1.4 Joint Articulation Torque (JAT)

The amount of torque required to articulate the Cardan, Hooke, or universal joint perpendicular to the axis of the cross. Usually, this is measured in both axes of the cross. The joint articulation torque is an indication of the looseness of the joint. The looseness of the joint is controlled during the assembly process and optimized for proper joint function.

#### 4.1.5 Flexible Coupling Joint

A near constant velocity joint that transfers torsional load through winding packets that are vulcanized inside of rubber. The joint dampens vibrations, absorbs shock loads in the rotational, angular and axial directions and can be operated under a small deflection angle (see Figures 19 and 20).

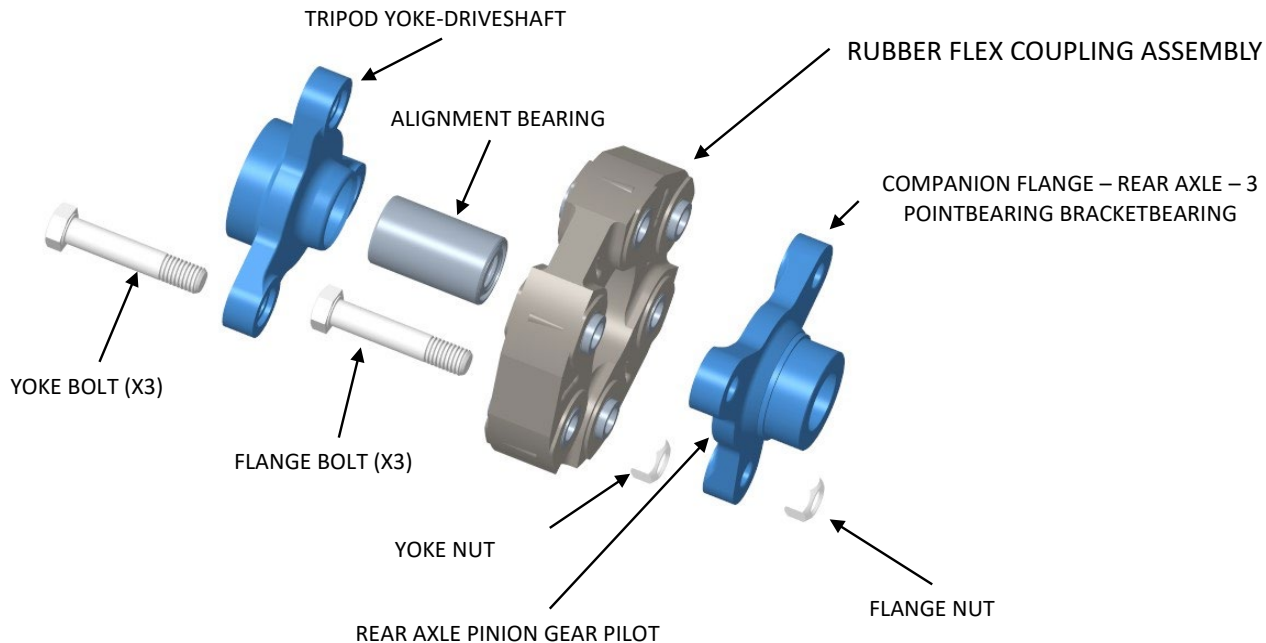


**Figure 19 - Flexible coupling exploded view**

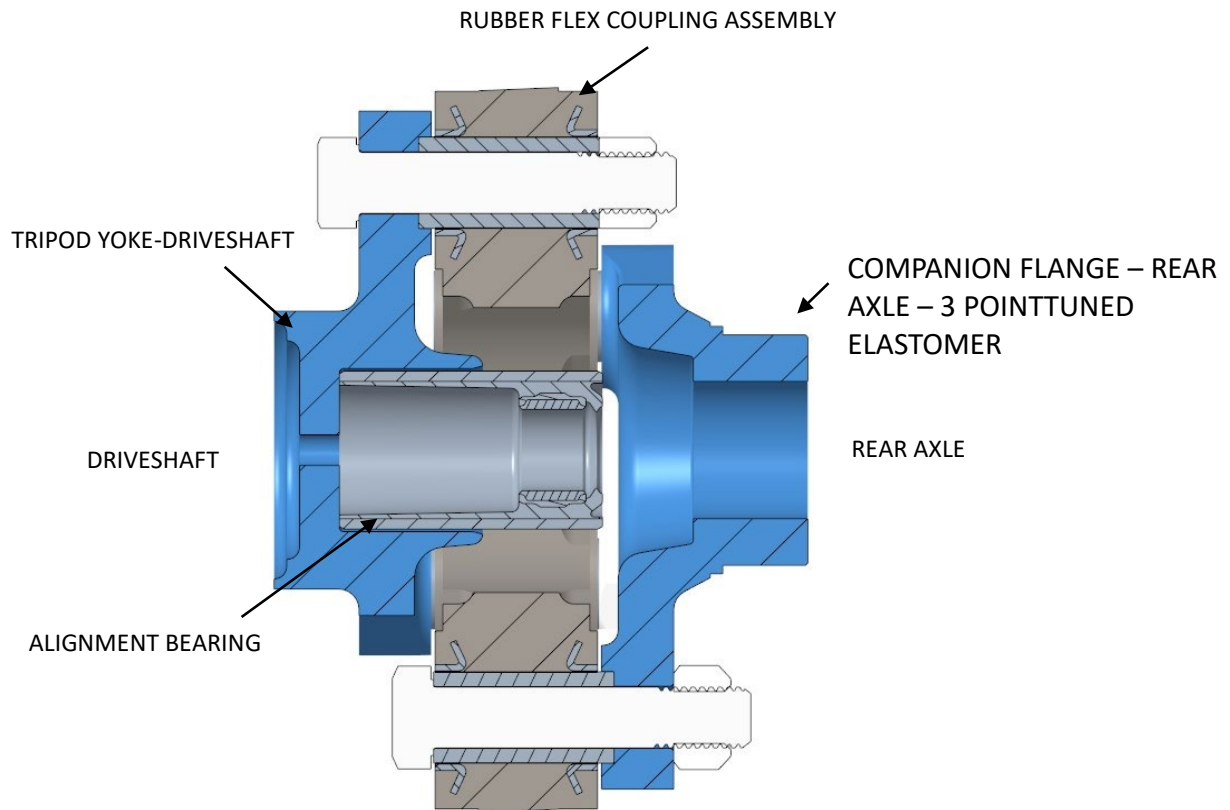


**Figure 20 - Flexible coupling assembly**

#### 4.1.6 Yoke

The basic torque and/or motion driving and driven member with means of attachment to transmit torque. Typically, the yokes will have some type of Cardan, Hooke, or universal joint between them.

##### 4.1.6.1 Slip Yoke

A yoke that accommodates axial movement (see Figures 12 and 21). This is typically referred to as end slip yoke.

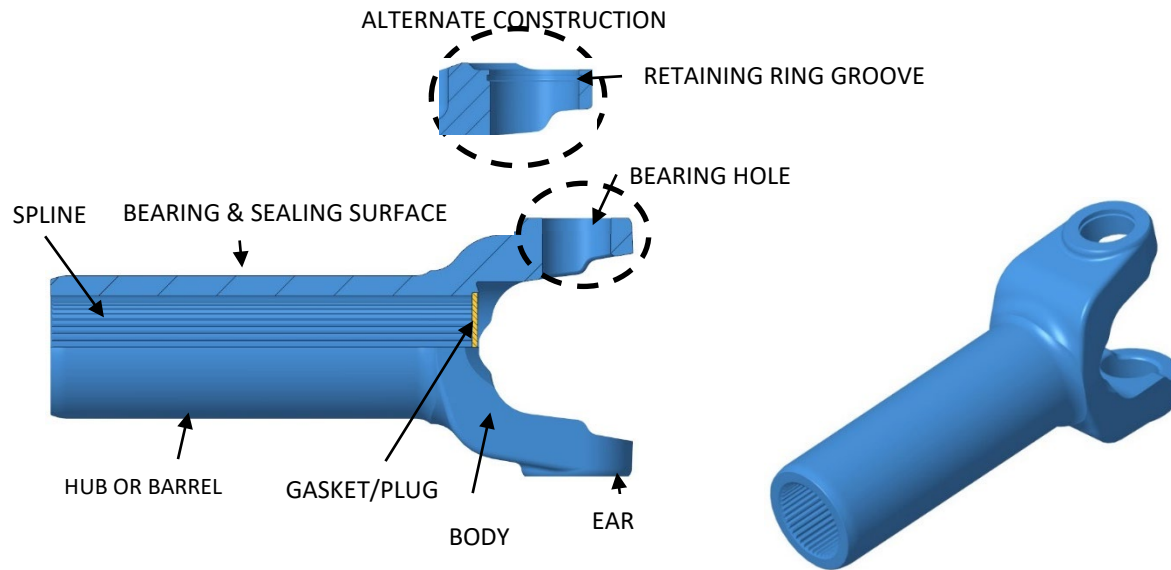


**Figure 21 - Slip yoke**

#### 4.1.6.2 Tube or Weld Yoke

A yoke with a piloting hub for attachment to a tube or other shaft member (see Figures 12 and 22).

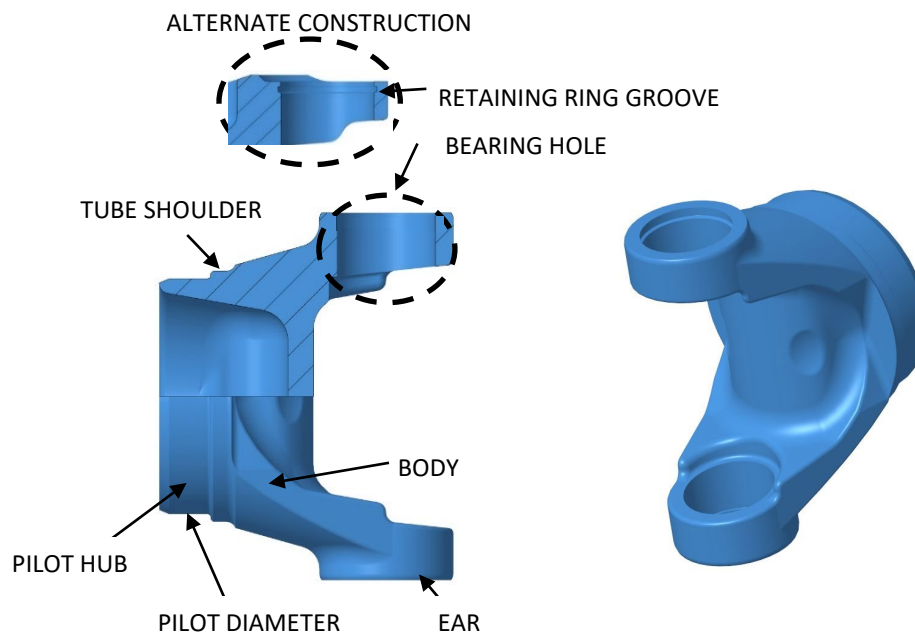


**Figure 22 - Tube or weld yoke**

#### 4.1.6.3 End Yoke

A yoke that attaches a driveshaft or propshaft to another drivetrain component (see Figures 4, 23, and 24) with the ability to transmit torque.

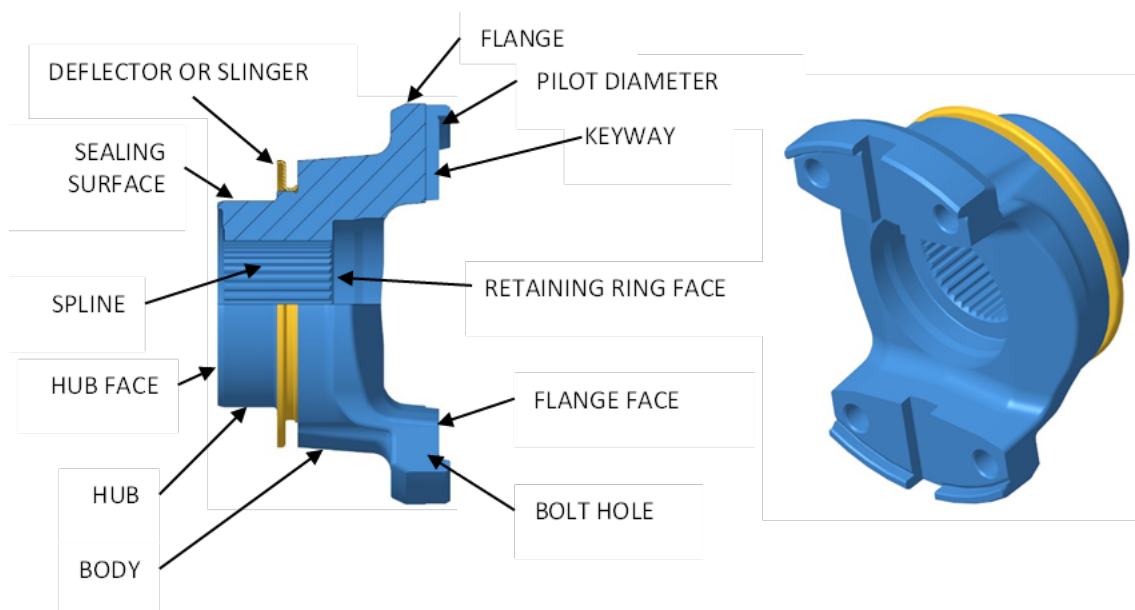


**Figure 23 - End yoke (wing bearing type)**

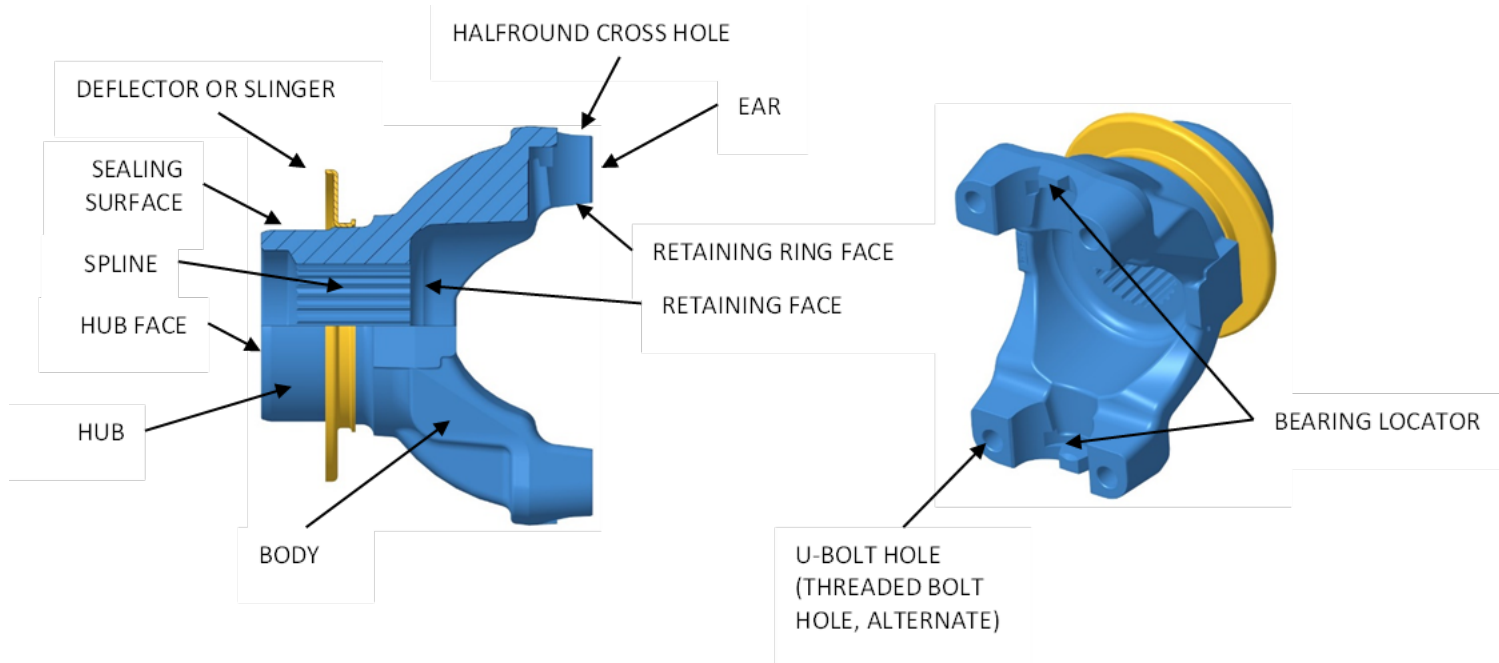


**Figure 24 - End yoke (round bearing type)**

#### 4.1.6.4 Flange Yoke

A yoke that attaches a driveshaft or propshaft to a companion flange (see Figures 4, 12, and 25) with the ability to transmit torque.