# Twin Roller Carriage Familiarization, Design Criteria, and Visual Inspection

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## Foreword

Horizontal balancing machines employ two or more supports. Supports may accommodate a variety of tooling interfaces and tooling accessories. Custom Twin Roller Carriages are considered tooling that are often added and interchanged with saddles, V-Roller Carriages, and other Twin Roller Carriage designs. Additional information pertaining to tooling design characteristics can be found in SAE ARP4163™.

## Introduction:

A twin roller carriage is typically comprised of the following components:

- Bridge Plate
- Axial Thrust Device
- Safety Device to ensure Rotor Journal Retention
- Roller Axles
- Roller Bearings
- Rollers
- Felt Wiper Assembly.

## Bridge Plate Design Characteristics:

A bridge plate is mounted to a horn assembly using Kipp Handles that permit height adjustment to match the rotor centerline. The horn assembly may be integral with the balancing machine support or it may be supplied as a bolt-on accessory depending upon the horizontal balancing machine design. Typically, the bridge plate is used to mount the rollers, features a relief cut to clear the rotor shaft or tool journal, and mounting holes to accommodate both an axial thrust device and a safety retention device to ensure rotor journal retention.

## Axial Thrust Device Characteristics:

Typically employed with belt-driven applications, axial thrust devices limit the degree of travel the rotor journal is permitted to move along the rotor axis as it sits upon the twin rollers. Axial thrust devices usually incorporate a crowned roller bearing in conjunction with a spherical bearing element mounted in an end cap that locates the spherical element at the central rotor axis. An axial thrust device locating away from the rotor central axis may contribute to unbalance measurement error. The spherical element mounted in the end cap should be free to rotate, so it should be periodically checked for freedom of rotation. The user should maintain about a 0.125 inch gap between one of the two axial thrust devices to prevent rotor pinching, which can impede accurate measurement of the Couple component of the Dynamic unbalance measurement.

In addition to the axial thrust device design previously described, the machine operator may see two other axial thrust tool designs that are often used in specific balancing applications:

- Dual Bearing with Captured Flange Design is used with rotors having a castellated shaft on one end of the rotor
- A fixed Nylon Tipped Axial Thrust Post is most often used in dedicated balancing cradles or integral with fixtures used on flat-topped supports (Schenck HS-type supports)

Engineering design assistance for axial thrust devices and other rotor-specific tooling is available by contacting sales@schenck-usa.com

### Safety Devices to Ensure Rotor Journal Retention

In broader terms, these safety devices are employed to prevent the rotor journal from bouncing or hopping off the rollers, potentially damaging the rotor and/or becoming a safety hazard to personnel in relatively close proximity to the balancing task. The balancing machine operator may see one of three types:

- Safety Hold Down
- Negative Load Bearing
- Twin Counter Bearing Assembly

A **Safety Hold Down** is used for rotors featuring a positive load upon twin roller carriages. It features a Phenolic tip located above the rotor's bearing journal to prevent scarring of the rotor journal. For a Safety Hold Down to be most effective, it must be located <u>directly</u> above the bearing journal contact line, and adjusted to have a .125 inch gap clearance with the bearing journal.

A **Negative Load Bearing** is typically used to restrain a cantilevered (a.k.a. overhung) rotor whose center of gravity is typically located outside of the balancing machine supports. Each Negative Load Bearing has a defined maximum weight capacity, and the negative load for each rotor must be calculated to confirm this negative load will remain contained by the Negative Load Bearing supplied with the particular size and model of balancing machine.

**<u>NOTE</u>**

Two Negative Load Bearings are often used instead of two Safety Hold Downs when rotor balancing speeds are calculated to somewhat exceed the $Wn^2$ value of the balancing machine. In this case, a gap between the roller and the bearing journal is maintained. To be most effective in this case, the Negative Load Bearing roller must be located directly above the bearing journal contact line and must be adjusted to have a .125 inch gap clearance with the bearing journal.

A **Twin Counter Bearing Assembly** is employed when the negative load of a cantilevered (a.k.a. overhung) rotor exceeds the weight capacity of a standard Negative Load Bearing. The standard Negative Load Bearing, incorporating a single-roller that is often supplied with the particular size and model of your balancing machine is replaced with a custom-designed twin roller carriage that is essentially inverted to restrain the top surface of a rotor journal exhibiting a substantial negative load.

## Twin Roller Carriage Design Criteria:

### Felt Wiper Assembly Comments

A felt wiper assembly is comprised of a clamp that holds a thick felt pad. Felt wiper assemblies are designed to continuously apply a uniformly thin coating of lubricant to the roller bearing contact surface during rotation. Felt wipers also continuously wipe away particulate from the roller surface, keeping the roller crowns clean and free of debris.

**CAUTION**

Felt wipers should never be run dry without lubricant. Hot rollers operating at high rotational speeds generate enough friction heat to ignite a dry felt pad.

Felt Wiper Assemblies are custom fitted to each twin roller carriage design and pay for themselves quickly. Felt wipers most often extend roller lifespan and improve unbalance measurement integrity. By clearing particulate away from the contact surface of the roller bearing, felt wipers preclude sudden momentary jumps in unbalance measurement caused by embedded particulate between the roller contact surface and the rotor journal surface. Because unbalance measurement data is averaged over time, sudden momentary jumps in unbalance indication are averaged into the unbalance measurement, potentially resulting in a false unbalance measurement.

### Roller Spacing:

Twin Roller Carriage design begins with the Rotor journal diameter range. The ideal roller contact angle is 45 degrees for maximum force transmission between the rotor journal and the roller bearings. For a height-adjustable roller carriage, the contact angle can range from 30 degrees to 60 degrees. Any roller contact angle less than or greater than that contact angle range has the potential to either permit the rotor to over-run the rollers resulting in rotor escape and liberation; or otherwise the rollers will trap the rotor journal, impeding motion about the vertical axis and hence, impede Couple unbalance measurement.

## Roller Characteristics, Design, and Visual Inspection

### Crowned Roller Bearing Geometry and Selection:

In general, the wider the roller bearing, the greater the weight capacity; the narrower the roller bearing, the greater its contribution is to measurement sensitivity. This is because a wider roller bearing features a more gentle crown, resulting in a wider rotor journal contact area. This results in a higher weight capacity, but is more resistant to changes in Couple motion (freedom of rotation about the vertical axis). Wide Roller Bearings are best used for heavier loads and longer usable lifespan.

Conversely, a narrower roller bearing features a sharper crown with a narrower rotor journal contact area that reacts more quickly to force transmission and freedom of rotation about the vertical axis. Narrow Roller Bearings are best used for rotors having tight unbalance tolerances, or when monitoring and controlling Couple unbalance is of great interest. This is often the case when balancing turbine rotors with a long shaft. These rotor configurations are often Statically balanced while strictly limiting the permissible Couple unbalance.

**NOTE**

Please be aware that a narrow roller with a sharp crown radius will show pronounced wear more quickly, and the roller will need to be replaced more frequently than a wide roller with a gentle crown radius. In addition, a narrower crown radius is more likely to mark a rotor bearing journal.

Roller crowns ensure some amount of angular contact freedom and can tolerate a bit of misalignment. A roller without any crown (a flat roller) will only be capable of measuring Static unbalance. Further, the sharp edges of a flat roller may cause damage to the rotor journal surface if contact is less than square. **Only use crowned rollers for your balancing applications.**

**Roller Material**

A roller is manufactured using bearing steel with a hardness of 57 to 63 on the Rockwell C scale. The roller should be harder than the rotor (or tooling) journal surface as each rotor journal surface does not endure too much time in contact with the rollers of a balancing machine.

Under no circumstances should the roller hardness be equal to the journal hardness of the rotor (or tool). This will result in significant galling of both roller surface and journal surface resulting in a very short roller lifespan.

If the rotor journal surface is harder than the roller, the roller will wear more quickly. For roller longevity, it is much better to run a roller upon a surface fabricated from tool steel than directly upon an ultra-hardened rotor journal surface or a coated journal surface.

A coated journal surface is susceptible to localized point stress and will flake off bits of coating during rolling contact with your rollers. The particulate buildup from a flaked coating will grind away at the roller contact surface with each full rotation. Eventually, the roller bearing will fail due to severe particulate accumulation upon the roller surface and potentially infiltrate the shielded roller bearing.

## Roller Diameter

The roller diameter should be at least 10 percent different than the rotor journal (or tool journal). The balancing machine instrumentation is designed to filter out roller bearing noise caused by bearing play and residual roller unbalance as long as the rotational frequency of the roller does not coincide with the rotational frequency of the rotor journal. Without that 10 percent diametral difference, *low-level* unbalance measurements will appear to orbit and oscillate during steady-state, constant speed rotation. This has the potential to affect the automatic-sensitivity selection feature of your balancing instrumentation and may impair the ability to reach the rotor unbalance tolerance.

## Visual Inspection:

The roller crown exists to provide freedom of motion about the vertical axis for measuring Couple unbalance, which is one vector component of Dynamic unbalance. The roller crown typically spans the middle third of the roller width. Based upon roller speed, rotor mass, and rotor material properties, the roller will wear with usage. Therefore, one cannot characterize the life of a roller based upon hours/cycles/number of measurements.

However as the roller wears, the wear track will grow in width indicating consumption of the crown and eventually result in a flat roller.

To determine if any portion of the roller crown remains, place a precision straight edge across the width of the roller and upon the crown location and then shine a penlight behind it. As long as light shines past the straight edge at each adjacent third to the center of the roller, there remains a crown in the center third. A roller crown is required to permit the rotor journal to pivot (upon the crown) and measure the Couple component of unbalance.

In addition, a quick visual inspection to spot any nicks, raised metal, or axial scratches is recommended, as these types of damage may result in a false unbalance indication with each rotation. So nicks, raised metal, or deep axial scratches in the roller contact surface are cause for concern and should trigger an immediate roller replacement.

Replacement rollers and other spare parts can be purchased from Parts@schenck-usa.com