



AEROSPACE INFORMATION REPORT

AIR6975™

Issued

2021-05

Hard Bearing Balancing Machine Technology - Proper Use of Rotor Type-Specific Calibration

RATIONALE

Modern hard bearing balancing machines employ computer-based measuring units that permit optimizing and adjusting the measuring result to reflect unusual conditions that would otherwise complicate measurement results and impair the balancing process. Hard bearing balancing machines feature a “permanent calibration” that is suited for a wide variety of common rotor configurations. However, certain rotor balancing configurations operating under challenging conditions require special compensation to achieve unbalance tolerances as quickly and as accurately as possible. The purpose of this report is to inform and instruct the reader in the proper application and use of unique adjustments to obtain accurate measurement results as quickly as possible.

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FOREWORD

Modern hard bearing balancing machines are commonly equipped with digital measuring units configured with a variety of software features and extensions. Software extends the capabilities of modern balancing machines to address unique rotor attributes and facilitate balancing of unusual rotor geometries.

Modern hard bearing balancing machines are calibrated using an ideal SAE rotor configuration (refer to ARP4162) to balance a variety of rotors of varying size and configuration. Despite being suited for a wide variety of common rotor configurations, the measuring results of hard bearing balancing machines under some conditions may need to be improved. To name but a few of these challenging conditions:

- Narrow plane separation (i.e., small distance between correction planes in relation to bearing distance)
- Outboard or overhung rotors
- Offset (protruding) roller bearings
- Dynamics of the machine with the installed rotor
- Tooling having insufficient rigidity

The software extension used to address and optimize results from these challenging balancing conditions goes by different names depending upon the manufacturer of balancing machine instrumentation. The machine operator may find software extension names including:

- “Rotor Specific Calibration” or “RC”
- “Self Calibration”
- “Unique Calibration”

For the purposes of this document, the software function will be generically referred to as “rotor type-specific calibration.”

1. SCOPE

The scope of this SAE Aerospace Information Report includes practical applications, theory, process management, audit and control recommendations, recommended validation intervals, verification and validation, file setup parameters, additional considerations, and process documentation.

1.1 Practical Applications

Modern hard balancing machines use computer-based measuring units that allow one to optimize and adjust the measuring result to reflect unusual conditions that would otherwise complicate measurement results and therefore impair the balancing process. Certain rotors demand special adjustments to achieve unbalance tolerance as quickly and accurately as possible. Rotor type-specific calibration is designed to optimize the results of a balancing process incorporating one or more of those challenges.

1.2 Theory

Rotor type-specific calibration is an optimized adjustment to enhance the measured results. Where permanent calibration applies to the full range of the machine, rotor type-specific calibration takes the unique conditions of a balancing system for a particular rotor type into account to yield optimized results that are otherwise impossible using hard bearing calibration. This is accomplished by overlaying and improving the permanent calibration with influence coefficients for the particular system configuration including rotor, tooling, machine, and foundation characteristics.

1.3 Process Management, Audit, and Control Recommendations

Caution should be exercised regarding who is authorized to perform a rotor type-specific calibration. Modern PC-based measuring instruments feature multiple user levels to define different levels of authority and limit access for modification in relation to the process specific task. This document provides recommendations for applying such a structure.

1.4 Recommended Validation Intervals

In the case of repair or replacement of critical parts in the measuring functionality of the balancing system, all machine calibration protocols are to be reestablished and validated. During production, the frequency of validation depends on usage (stored or individual) and management policy. The intended result is a stable and safe outcome that can be easily verified with the existing process documentation.

1.5 Verification and Validation

Repeatability and stability of the process can be validated by the application of known trial masses performing a response/wax check. Reproducibility is achieved by using more than one example of the same rotor type in case of stored rotor type-specific calibration.

1.6 File Setup Parameters

All weights and actual dimensions should be recorded and traceable to a file setup using a calibrated master with certification history and reference to source data.

1.7 Additional Considerations

For components that are not fixed and immobile, the process will benefit from an averaged measurement based on data from multiple runs. For some rotor behaviors, rotor type-specific calibration will benefit from further compensation and characterization of these types of rotor behaviors. The objective is to integrate these considerations into the rotor type-specific calibration process to enhance the quality of the rotor type-specific calibration.

1.8 Process Documentation

All process parameters shall be recorded and traceable to a known source. All critical data necessary to validate results contained in the printed report of the balancing process shall be meticulously documented.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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.

ARP4162 Balancing Machine Proving Rotors

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 21940-2:2017 Mechanical vibration - Rotor balancing - Part 2: Vocabulary

ISO 21940-21:2012 Mechanical vibration - Balancing machines - Description and evaluation

2.2 Definitions

CALIBRATION MATRIX: A group of influence coefficients particular to a rotor-type specific calibration.

CROSS EFFECT: When setting a test weight to one plane for calibration the change of indication on the other plane is called cross effect or plane influence.

FILE PARAMETER: Any file setting associated with the current balancing process.

INITIAL UNBALANCE TOLERANCE: Maximum permissible unbalance prior to unbalance correction as stated by the engine manufacturer.

NARROW PLANES: If the distance between correction planes (plane distance) is short compared to the distance of the measuring planes, this could be such condition. As a rule of thumb plane distances below 25 to 30% of measuring plane distance can be considered as narrow planes.

OUTBOARD ROTOR: On a horizontal machines the center of gravity is located outside of the machine supports. Occasionally referenced as a cantilevered rotor.

RESPONSE CHECK: Setting of test unbalance and comparison of change in unbalance reading to set unbalance (i.e., a calibration with a rotor module) at the end of a completed balancing procedure. This is also known as “wax check” or “pull check.”

SEATING CONDITION: Tooling fit and dimensional locating features that influence the system rigidity.

TARGET SPEED: Median speed of the balancing process. 3% deviation is acceptable.

TRIAL MASS: Test weight certified with serial number, mass, geometry, and its position is known and certified.

3. THEORETICAL BACKGROUND

There are a number of challenging and unfavorable conditions where the measuring quality may benefit from rotor type-specific calibration.

When permanent adjustment of the balancing machine is established, the appropriate SAE test rotor is used for the permanent calibration. Standard SAE rotor configurations have geometry settings thought best to represent ideal balancing conditions (Figure 1). As such, the established permanent adjustment will provide acceptable results for most balancing applications.

To adjust the balancing system to a different rotor configuration having a unique geometry, dimensions must be set to reflect the actual rotor geometry. The length dimensions define axial distances between measuring planes and the correction planes and act as a lever system to proportionately calculate and translate the measured unbalance values from the measuring planes to the correction planes.