

balancing news

Information for the quality and performance of rotating equipment - From the Schenck Balancing & Diagnostic Systems Group

New Integrated Process for Quality Control of Automotive Blowers

by Peter Boehm
Technical Sales Manager — Automated Systems Group
Schenck Rotec GmbH

For quality control to be cost effective, modern measuring processes must demonstrate a higher degree of complexity. While test methods for physical properties can produce precise and repeatable results, the measurement of vibro-acoustical properties, because of the accompanying subjectivity, has the possibility for greater improvement.


Noise, Vibration, and Harshness (NVH) can make even the most revolutionary product unacceptable in the marketplace. The expense of quality control in production continues to grow with customer demands. Global manufacturers must seriously evaluate the increasing demands for comfort and plan for extensive testing of either individual components or complete units before assembly. A low, controllable NVH-level in the automotive industry is the declared goal, and is vigorously sought after in the electrical industry by the automotive industry suppliers.



NVH test system for truck blowers

Intelligent Diagnostics Close Loopholes

As an example, this article will focus on cooling fans for truck engines. This application is known to have a very high quality requirement coupled with practical economical solutions. To revive product quality today requires total consideration without loopholes. Even when design and manufacturing methods are

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The New CS30 for Crankshafts...



The new CS30 dynamic balancing machine allows high-performance crankshaft manufacturers and overhaul shops to completely balance crankshafts at one convenient workstation. After one measurement cycle, corrections can be made directly on the machine...

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The New Turbocharger Balancer...



Designed for high-speed balancing of turbocharger assemblies at operational speeds of up to 200,000 rpm...

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Shop Balancing Measurements vs. Field Balancing Results

by Leo Milito, Sales Engineer



Field balancing is becoming more popular as plant managers look to improve efficiency and machine reliability. However, operators and technicians are sometimes confused by the readings that they may get from their balancing machine in the shop, versus the results that they get in the field. Many of those that work on both types of applications find themselves wondering if their rotor is really balanced. The calculations described below can be used as a "rule of thumb" to compare field balancing results vs. shop balancing measurements.

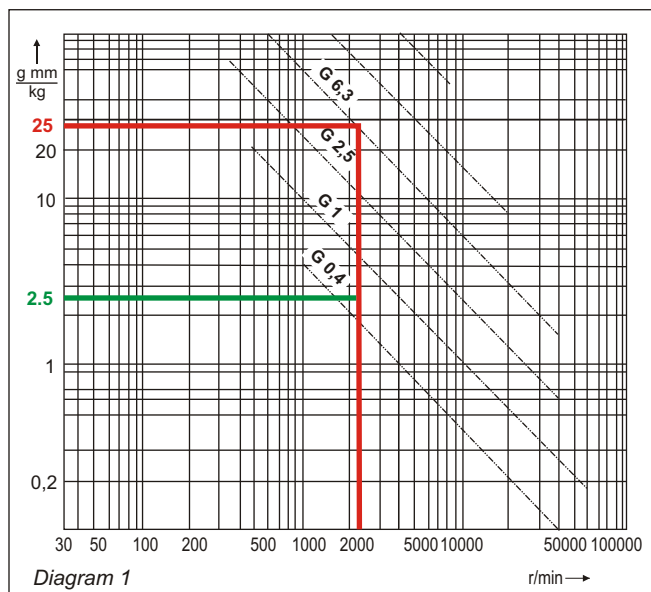
Portable field balancing units, such as our Vibrotest 60, prompt the user through the balancing process in a few simple steps. These units make field balancing quick and easy, but, it is also important that the user understands the theory behind the instrument.

When balancing rotors in the shop, the machine's instrumentation provides the operator with unbalance measurement results in ounce•inches or gram•millimeters, and an indication of whether the rotor is "in tolerance" or not. When field balancing, the measurement results are in vibration units such as mm/sec or in/sec, and a residual correction weight is obtained.

In the example described below, we will perform a field balancing job on a fan assembly and use a rough calculation as a guideline to see if the results are close to the ISO 1940 standard. (It should be noted that these calculations cannot be performed on machines with non-linear behavior).

Determining the correct quality grade

Before we begin any field balancing project, we need to determine the quality grade of the machine or component we are balancing based on the Quality Grade Standards from ISO 1940 (Diagram 1).



In our example, we will be field balancing an air conditioning fan assembly to ISO G6.3 which, according to the specifications from ISO, is acceptable for "Fans, flywheels and pump impellers."

The operating speed of the fan assembly in this case is 2200 rpm. The weight of the rotor is 420 kg and the radius that you will be making the corrections on is 500 mm. Therefore, the maximum permissible eccentricity (e_{per}) is 25 g•mm/kg (see red indicator in diagram 1).

In practice...

In field balancing we can only measure the effect of the unbalance and the other sources of vibration relative to the position where the vibration sensor is located. The vibration level is an indicator of the unbalance of the machine, but is dependent on the machine speed and the measuring point.

As part of the field balancing procedure we do an initial run, which measures the effect of the unbalance on a machine. This gives us the measurement with an amplitude (ips, mm/s) and a phase angle for the

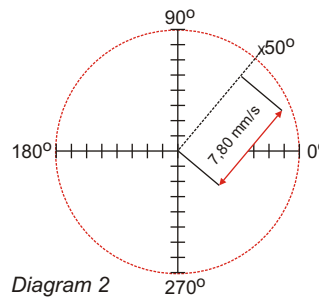


Diagram 2

An initial run results in a vibration amplitude of 7.80 mm/s at 50°

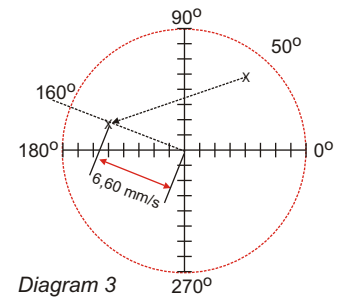


Diagram 3

A test mass of 40 g mass at 0° is used in our example.

initial vector (Diagram 2). We then place a test weight of a known mass at a given position on the rotor and this information is input into the unit. The machine is brought back to the same speed as the initial run and the effect of this test mass is obtained as a second amplitude and a phase angle (Diagram 3). The unit then calculates a solution as a correction mass and an angle at which to place it. After the correction is made, a final "check" run is then conducted.

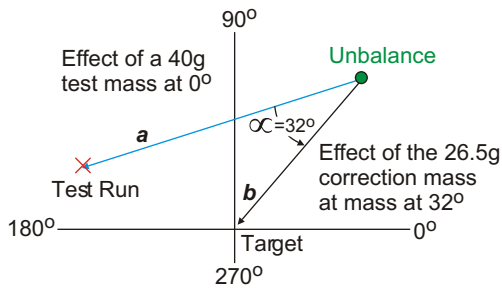


Diagram 4

The effect of this test mass "shifts" the vector to a different location and gives a new vibration amplitude of 6.60 mm/s at 160°. By drawing a line from the initial point to the test run point and turning the line into the target, we can obtain the angle that the correction mass has to be placed.

In theory...

This angle in our example was calculated at 32°. Theoretically, by rotating the vector 32° we now have the vector line passing through our "target." This line is at the correct angle, but is too long. By using the ratio of the two vectors from the initial run and the test run with the 40g weight, we can calculate the actual correction mass (see below).

$$U_a = m \frac{b}{a}$$

Where...

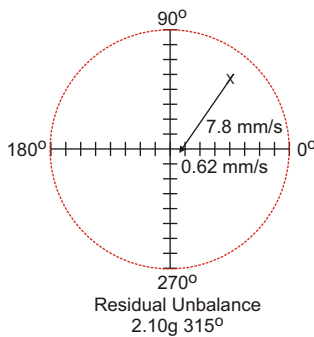
- U_a** = correction mass
- m** = test mass in grams
- a** = length of test vector
- b** = length of initial vector

Or...

$$U_a = 40g \frac{39mm}{59mm} = 26.5g$$

As you can see, the original vibration level of 7.80 mm/s has been reduced to 0.62 mm/s (Diagram 5). The important thing to remember is that the correction mass must be placed properly. By moving the weight further in or out the effective centrifugal forces are changed and if the mass is not placed at the proper angle it can cause a degradation of the balance results (vector angle error).

Diagram 5



Having gone through both runs we know that the residual correction mass is 2.10 g, and the new effective amplitude after balancing has been reduced from 7.8 mm/s to 0.62 mm/s. This is a reduction of approximately 13 times. But what does that mean?

On a shop balancing machine the instrumentation would automatically provide the measurement results in gram•millimeters or ounce•inches. In field balancing, a simple calculation will provide the residual unbalance, or eccentricity, and the results will be in gram•millimeters per kilogram.

Calculating the residual unbalance...

To calculate the eccentricity, take the correction mass times the radius (which is unbalance) and divide by the mass of the rotor.

$$e = \frac{\mu r}{M}$$

- e** = displacement of the center of gravity
- μ** = residual unbalance in grams
- r** = correction radius in mm
- M** = rotor mass in kilograms

Therefore, if we calculate the initial eccentricity e_{init} , the result is 31.54 g•mm/kg, which is outside the permissible limit of 25 g•mm/kg.

To calculate the initial eccentricity e_{init}

$$e_{init} = \frac{26.5 \cdot 500}{420} = 31.54g \cdot mm/kg$$

Now, to calculate the final eccentricity e_{final} after balancing, we use the residual correction mass from diagram 5 (2.10g) in the calculation:

To calculate the final eccentricity e_{final}

$$e_{final} = \frac{2.1 \cdot 500}{420} = 2.5g \cdot mm/kg$$

Conclusion...

Looking back at the G6.3 quality grade from ISO 1940 we can see that we are within the acceptable limits. That means for a rotor of 420 kg running at 2200 RPM, the permissible eccentricity, or e_{per} , would be 25 g•mm/kg. With a residual unbalance of 1050 g•mm (2.1g @ a radius of 500mm), we get a residual eccentricity, or e_{res} , of 2.5 g•mm/kg (as seen in green in diagram 1). The e_{res} is 10 times better than the permissible eccentricity e_{per} .

New Integrated Process...

Continued from page 1...

correct, assembly errors can not be eliminated. Between individual test steps new errors can be found.

With blowers a classical sequential final test is possible; however, considering competition and shorter floor-to-floor times this no longer makes sense. The usual evaluation of the acoustical characteristics by personnel further reduce the effectiveness since it is based on a subjective measuring scale, "the Monday morning effect." Improvement can only be reached when individual groups are tested to prescribed quality levels before further assembly. (Fig. 1.) Schenck's integrated, objective test methods can close those existing holes in the process circle of quality control which have been developed through dialog with the users and many years of experience in the field of vibration measurement and control.

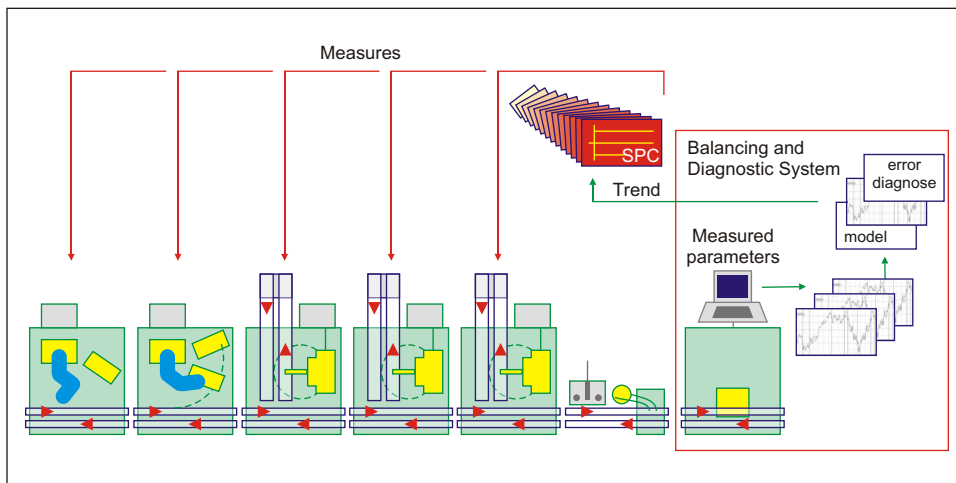


Figure 1: Quality cycle in the production of drive systems

Comprehensive Methodology to Curb Costs

Balancing and diagnostic systems must make it possible to conduct comprehensive product tests in production, whether electrical, mechanical, or electro-mechanical units are to be tested. These are great demands, which can only be achieved through a modular package of processes in one work step, and in some cases used individually or together (see Fig. 2).

A major component is objective noise testing or Vibro-Acoustic-Diagnostics (VAD). VAD testing makes it possible to analyze the sound spectrum produced by individual test pieces, and is applicable in many facets of industrial production. VAD is capable of learning and can also be trained to determine quality relevant and non-relevant noise segments after having been exposed to certain noise samples and a sufficient number of sample tests. The goal is to identify bad parts, which are identified by specific noise characteristics. A diagnostic system is completed through Parameter-Identification (PI).

It determines the characteristic parameters of an electric motor by comparing the system reply of the motor and a reference model to electrical impulses. Using a mathematical model's deviations of the actual motor signal from the target values and also the signal analysis of motor currents allows direct assessment of manufacturing errors.

By eliminating the mechanical load on the motor, the PI-method makes higher productivity possible as opposed to the conventional method of loading the motor.

A non-symmetrical distribution of mass caused by manufacturing errors is unavoidable. These unbalances negatively influence vibration, handling and product life. Even small amounts can have large consequences, so rotating parts must be carefully balanced. It makes good sense to incorporate this process into the test process of a product group.

Computer-Aided-Balancing (CAB) determines the static and dynamic unbalance of the test piece, calculates the necessary correction values and can control the entire process.

The combination of these tests closely oriented to the application is a very capable and economical method to realistically evaluate individual components or complete assemblies. Therefore, bad parts can be eliminated in the production process and expensive rejects can be eliminated early in the process. A considerable cost savings potential is in the reduction of

manufacturing steps, a minimum of scrap and an intelligent measuring technique, which can incorporate various methods in one test stand.

Fast Track for Valuable Blowers

The quality requirements for blower systems have increased constantly because trouble-free operation must be determined before installation. At the same time, the mounting conditions and the vibration isolation can change the characteristics of the test part. To reach satisfying running conditions by the usual methods, the tolerances have to be set so low that it is uneconomical.

"Fast-track" for efficient, objective and realistic quality control is provided by systems that integrate all the features mentioned above; mechanical and electrical testing through Parameter-Identification (PI), noise measurement by Vibro-Acoustical-Diagnostics (VAD), and unbalance evaluation and correction (via CAB).

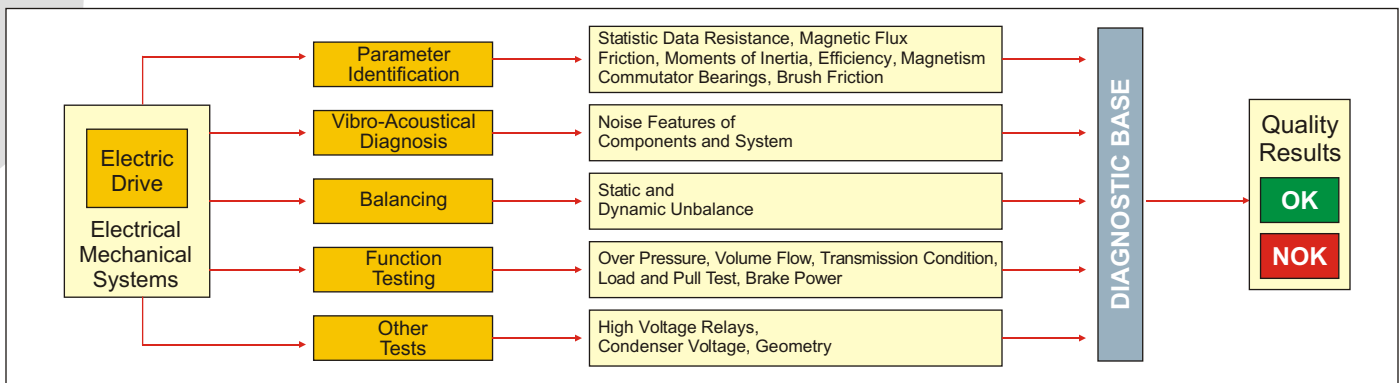


FIGURE 2: *Balancing & diagnostic system flow chart*

The actual measuring process takes only a few seconds. The electric motor is energized and its basic physical condition is compared to a mathematical reference model. One receives important parameters such as resistance, magnetic flux, inductance, iron loss, friction and moments of inertia. Actual motor data furnishes information about speed, power and degree of efficiency. By analyzing differences between the target data and the actual data, shorted or false windings, false magnetization, or too much bearing or brush friction can be determined. The whole diagnostic procedure is completed by noise analysis and the balancing process. Additional test steps may be necessary as well.

In the semi-automatic PI/VAD test stand the electro-mechanical assembly is mounted in the same position as in actual use because the installation can change the behavior and characteristics. This way, defects can be seen which would not be measurable in another position. These might include excessive axial play or blower blades contacting the housing. Also, swinging vibrations caused by aerodynamic forces can occur which can influence the actual unbalances. The computer aided measurement of unbalance and the manual correction is directed through on-screen instruction and is easily learned, even by inexperienced personnel.

Technically interesting is a test stand where the noise measurement is realized via a laser system. (Fig. 3.) Because of the complex construction of the blower unit, it is impossible to directly couple an acceleration sensor. The laser allows exact adjustment on the optimum measuring point, thus securing the necessary signal quality for further analysis steps.



Figure 3: *Test stand with laser system for noise measurement*

This newly developed system plays a big role when measuring points for a mechanical attachment are not available, or if production line floor-to-floor times do not allow additional handling to attach a sensor.

The concept for designing an integrated balancing and diagnostic system depends entirely on the individual application. The application spectrum varies quite a bit:

- From thumb-sized DC-motors with a power drawing less than one watt, to electric motors for railway locomotives in the megawatt range.
- From individual gears to complete automotive rear axle assemblies.
- From manually loaded test stands to fully automatic, networked systems.

All Schenck diagnostic test systems have one thing in common — the ability to learn. With an ever increasing number of tests to be performed, the knowledge base is expanded and errors diagnosed with greater accuracy. If a user already has the experience to know sensible measuring tolerances and the criteria to discover typical manufacturing errors, this can be incorporated and through an optimization of tolerance levels for diagnostic findings can be positively influenced. The modular concept offers solutions for measurement, evaluation and the monitoring of practically every feature and every function. This strategy furnishes an economical quality control sphere in production manufacturing and is a deciding factor in the perfect product.

Peter Boehm had his first professional experience in the test field of the department of vibration measuring and machine monitoring at CARL SCHENCK AG Darmstadt, Germany. In 1992 he transferred to the Technical Sales Department, Diagnostic Technology Group where he has worked successfully in development and sales of innovative diagnostic solutions for the world's largest electrical component manufacturers. Today he is the manager of application engineering for the Automated Systems Group at SCHENCK RoTec GmbH, in Darmstadt, Germany.

This paper was originally presented at the Electrical Manufacturing & Coil Winding Show 2001, Cincinnati, OH on October 16, 2001.

NEW from Schenck...

CS30 – THE NEW MANUAL BALANCING MACHINE FOR CRANKSHAFTS

The new CS30 dynamic balancing machine allows high-performance crankshaft manufacturers and overhaul shops to completely balance crankshafts at one convenient workstation. After one measurement cycle, corrections can be made directly on the machine with an integrated heavy-duty drilling station that can be positioned at any point along the crankshaft and easily retracted for maximum convenience.

The CS30 has an integrated heavy-duty drill correction unit with a geared drill head and six selectable operating speeds. The head stock can be rotated 360° to access the work area, or to make corrections on a separate workstation.

The CS30 comes equipped with our CAB 700 instrumentation to streamline the balancing process, provide effective operation and dependable measuring results. The CAB 700 offers powerful correction capability and a variety of advanced features. The CS30 can also be equipped with our state-of-the-art CAB 800 to



provide a vector display of unbalance measurements in a Windows NT® environment. This PC-based instrumentation makes managing balancing information easy and provides unlimited data storage capability. Bob-weight calculation software can also be included for calculating reciprocating and rotating weights for specific types of crankshafts.

Both the CAB 700 and the CAB 800 provide an automatic tolerance calculation for each plane based on ISO specifications or user defined tolerances. An electronic protractor then allows the operator to visually pinpoint the exact location to make corrections. The drill depth correction feature indicates the drill depth necessary for accurate correction based on the type of drill being used and the material being removed. If the physical characteristics of the crankshaft are not convenient for correction, the component correction feature will guide the operator to make multiple corrections at alternative locations.

For more information request the STC0201 brochure on the reply card.

110 MBRS – THE NEW BALANCING MACHINE FOR TURBOCHARGERS

The new Model 110 MBRS machine is equipped with Schenck's CAB 690 High-speed Balancing Instrumentation to accurately balance turbochargers at operational speeds of up to 200,000 rpm. The machine has a compact design with a safety-enclosed workstation that is capable of high-speed measurement and an integrated grinder to make corrections directly on the machine. The 110 MBRS is designed for use in the automotive aftermarket for the repair and overhaul of turbocharger assemblies, as well as in a manufacturing environment for high-performance applications and R&D.

The CAB 690 Instrumentation prompts the operator through the balancing process in a user-friendly environment and provides measurement indication on the first run-up so that



only one or two correction steps are necessary to accurately balance a rotor. The high-speed capability of the 110 MBRS machine allows operators to see and measure the unbalance through the entire speed range of the turbocharger. Results can then be plotted and printed as amplitude over speed, or in Nyquist diagram format.

Unbalance correction is made directly in the 110 MBRS workstation with an integrated hand grinder and transferring the assembly to a correction station is not necessary. Standardized core assembly adapters provide quick and easy changeover and offer the possibility of balancing a large range of different turbocharger assemblies.

For more information request the RE2519 brochure on the reply card.

The Schenck Help Desk...



Our Help Desk provides customers with immediate answers to application-related questions. It is designed to be a liaison between sales, service and engineering and to address technical issues about the products that we offer. If you have application-related questions for the Help Desk, call us at 1-800-873-2352, visit us online at www.schenck-usa.com/helpdesk or email helpdesk@schenck-usa.com.

A number of people have contacted us about *electronic compensation*, and the difference between *biasing* and *key compensation*. We thought you might find this explanation helpful.

Improving Your Balance Quality with Electronic Compensation

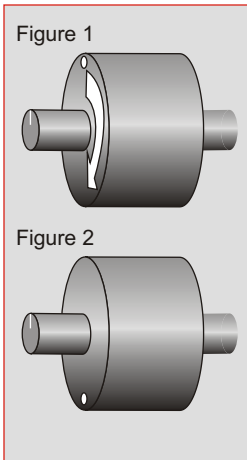
What is Electronic Compensation?

Electronic compensation is an instrumentation feature wherein an electronic signal is generated and summed with a rotor's unbalance signal. This virtual unbalance (vector) is generated through a special procedure depending upon the type of compensation required.

What are the types of Electronic Compensations?

Index Balancing or Double Compensation: used mainly to compensate for measured unbalance error caused by the tooling (i.e. arbor, end-drive's universal joint). This error is normally attributed to both tooling unbalance and mounting eccentricity.

To create the compensating vector requires at least two unbalance measurement runs. The first measurement run is with the rotor mounted at any arbitrary position (Figure 1). The second is performed with the rotor indexed relative to the tooling. Indexing of the rotor is generally done at 180°, though other angular positions are also possible (Figure 2).



Biasing or Single Compensation: a single run process used to "zero" or "null" out the measured unbalance.

This feature is generally used for balancing of multi-stage pumps. With this type of pump, the balancing procedure requires individual impellers to be balanced progressively in stages (stacked). As the residual unbalance from an earlier stage can be inadvertently projected to a succeeding stage, the assembly unbalance is electronically compensated prior to the installation of the impeller. This feature is also used as a diagnostic tool. By effectively nulling out a rotor unbalance, the effect of a test mass added to the rotor can be accurately observed with reference to "zero." This enables the operator to readily identify possible machine problems such as plane separation or angle error.

Key Compensation: used to simulate the effect of a key during normal unbalance measurement. This is a two-run process requiring one run without a

key, and another with a key installed. Designed for production balancing, eliminating the key installation from the procedure can significantly enhance the balancing process efficiency.

Would balancing the tooling yield the same result as Index Balancing?

No. The tooling unbalance is only a component of the overall tooling error. The other possible source of error is mounting eccentricity. The tooling manufacturing tolerances will always cause the rotor to spin at an axis that is different from its rotational axis in service.

Although "index balancing" can be duplicated through manual biasing (not to be confused with "Biasing Compensation"), the process can be very tedious and time consuming. Once a tooling is biased it becomes dedicated specifically for one rotor type. For rotors to be of the same type, they must be of the same weight and physical configuration (mass distribution).



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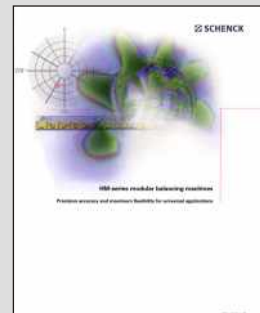
	Dates	Location
Balancing Theory & Applications 1	January 29-31, 2002	Deer Park, NY
Fundamentals of Balancing	February 12-14, 2002	Anderson, SC
Vibration Analysis & Field Balancing	February 19-21, 2002	Indianapolis, IN
Pump & Impeller Balancing	March 26-28, 2002	New Orleans, LA
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Performance Testing for Motor & Blowers Assy's	April 30-May 1, 2002	Orion, MI
Flexible Paper Roll Balancing	May 7-9, 2002	Vancouver, CN
Balancing Theory & Applications 1	May 21-23, 2002	Deer Park, NY
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Driveshaft Balancing	August 27-29, 2002	Orion, MI
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Vibration Analysis & Field Balancing	October 1-3, 2002	Los Angeles, CA
Fundamentals of Balancing	October 22-24, 2002	Deer Park, NY
Vibration Analysis & Field Balancing	November 12-14, 2002	Anderson, SC
Crankshaft Balancing	November 19-21, 2002	Orion, MI
Fundamentals of Balancing	December 3-5, 2002	San Diego, CA

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New Literature



Turbocharger Balancer 110 MBRS # RE2519
Provides features and specs for our high-speed balancer operating at speeds of 200,000 rpm.



HM Modular Balancing Machines # RM1016
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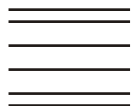
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SCHENCK TREBEL CORP.
535 Acorn Street
Deer Park, NY 11729 USA
Tel: (631) 242-4010

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