ISSUE 0603

SCHENCK
Balancing and Diagnostic Systems

balancing news

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

Unbalance Correction: Focus on Repeatability

by Emil Wisekal

Good repeatability is often assumed to exist when it does not exist, and this can get a balancing machine operator into trouble quickly. It takes very little time to check for repeatability, and it should be checked before rotor corrections are made.

What are the types of repeatability that exist and how do they stack up in importance? Which type of repeatability should be checked first; what's next, and why? Why should repeatability be checked again, and how often should it be checked? And, perhaps most importantly, what can be done to address a repeatability issue? The answers to these questions follow immediately.

Types of Repeatability

1. Run-to-run Repeatability: How much do the unbalance readings change between measuring cycles, i.e. when the part is run up, stopped and run up again; stopped and run up again, over and over?

In every case, the effects from run-to-run repeatability must be sorted out before continuing to identify and resolve other repeatability issues. It is impossible to know if there is a problem with other types of repeatability if run-to-run repeatability remains unidentified.

Common sources of run-to-run non-repeatability include:

- Loose blades in a bladed rotor
- Windage effect from air
- Worn or loose spindle bearings
- Moving parts (cyclic, or regularly repeating, like parts connected by internal gears)
- Moving parts (non-cyclic, like fluid moving inside a coiled tube)
- Extremely low unbalance (beyond the machine's capacity)

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Diagnostic Tools For Successful Field Balancing

by George Allen & Roland Kewitsch

As anyone having experience with machinery diagnostics knows, vibration can be caused by a broad range of problems. These can include worn bearings, misalignment of components, mechanical looseness, improper or damaged foundations, hydraulic and aerodynamic forces, resonances, etc. Probably the most common problem though is unbalance.

Unbalance (an uneven distribution of mass around an axis of rotation) can result when individual components have not been properly balanced prior to assembly, from errors resulting from the assembly of these components, or both.

The high centrifugal forces generated by unbalanced rotors

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Diagnostic Tools For Successful Field Balancing

by George Allen & Roland Kewitsch (Continued from page 1)

during operation can lead to premature bearing failure, fatigue fractures, foundation deterioration, and shaft deformation, to mention just a few. Unbalanced rotors can also present a safety hazard to personnel. For these reasons, well balanced machinery is a necessity for any maintenance program.

Unlike balancing a rotor in the controlled, predictable environment of a balancing machine, field balancing presents a number of unique challenges. Not the least of these is first determining that the vibration is actually the result of an unbalance. Making the decision to balance without first verifying that an unbalance condition exists may result in wasted time and money.

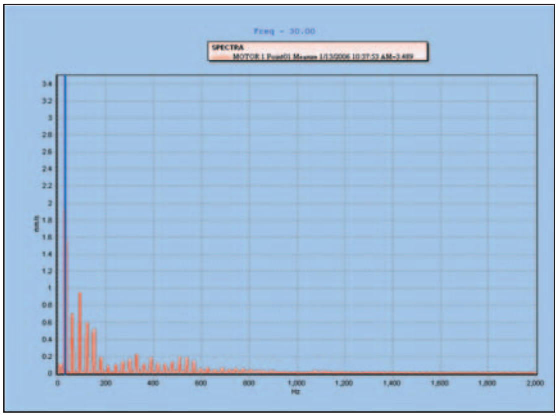
To ensure successful field balancing, today's vibration analyst needs those tools which will quickly and efficiently allow him to verify that an unbalance exists and, at what operating conditions balancing is best attempted. These diagnostic tools are outlined below.

Measurement of the Overall Vibration:
The simplest vibration measurement is the "overall" vibration. Overall vibration represents the sum of the energy content of all vibrations at all frequencies. Anyone who has worked with machinery of any kind has consciously or unconsciously measured the overall vibration. If you've ever put your hand on a machine and thought about whether the vibration is high or low, you've made a judgment of the overall vibration. Using an instrument to assign a value to that which you feel with your hand allows you to compare your machine with similar machines.

Most often the decision to conduct a vibration analysis begins with someone questioning the severity of a machine's overall vibration. Measuring the overall vibration at various points on the machine allows for comparison with local and international standards (ISO, API, DIN, etc.). If this comparison then concludes that the levels are excessive and further analysis shows that field balancing is required, the first step should always be to document the overall vibration. As a matter of fact, regardless of what methods are employed to resolve a vibration issue, documenting the overall vibration is always the initial step.

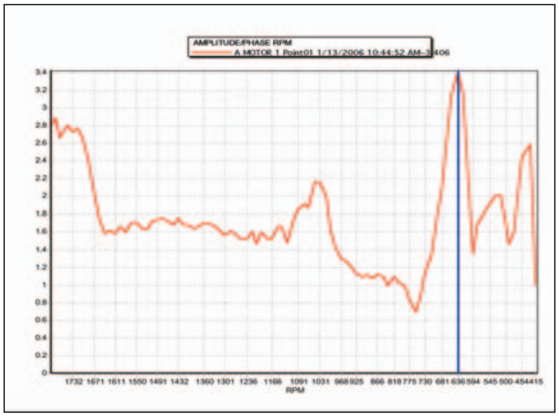
Frequency Analysis (the FFT function):
Arguably the most valuable tool in the vibration analyst's arsenal is the ability to separate a measured overall vibration into its individual components. This is most commonly done using an instrument's "FFT" (Fast Fourier Transform) function. Employing the FFT function results in a spectrum showing the individual vibration amplitudes and their associated frequencies. The beauty of an "FFT spectrum" is that it allows the vibration analyst to see the frequencies that represent the most severe vibration. Correlating these frequencies with a machine's components, or the interaction between components, makes it possible to pinpoint the problem.

While high overall vibration can result from a multitude of problems, each having its own signature on a spectrum, high vibration due to unbalance occurs at the rotational frequency of that component which is out of balance. It goes without saying that balancing without there being an unbalance problem is a waste of time and effort. Therefore, an FFT spectrum is essential in determining whether balancing is the proper course of action as opposed to drive alignment, bearing replacement, foundation repair, etc.



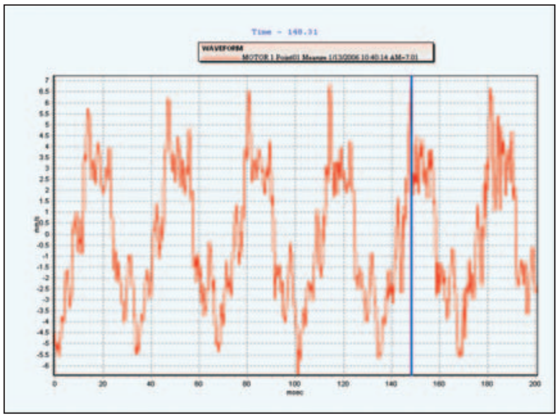
Frequency spectrum showing a rotor's unbalance at the running speed of approx. 30 Hz (1,800 Rpm).

Tracking Function
Using a reference sensor, such as a photocell, the Tracking Function's bandpass filter locks onto that vibration frequency corresponding to the running speed of a rotating machine, following it as it changes. Tracking this vibration component (i.e. amplitude and phase) during run-up or coast-down helps one to see how the rotor responds at various speeds. In addition to being a necessity for Bode and polar plots, the Tracking Function makes it possible to determine where, for example, a system resonance might be, thereby helping the analyst to avoid this speed when balancing.



Typical plot of a rotor's amplitude and phase during coastdown.

Time Waveform Function (Oscilloscope Function): The FFT capabilities of today's analyzers often cause the value of the oscilloscope function to be overlooked. Where the oscilloscope has an advantage is that, unlike the FFT function, the oscilloscope provides an almost un-damped, instantaneous response to the vibration signal. This makes it useful in the identification of transient, short duration, events such as shocks and impacts. Influence from unstable, irregular vibrations caused by such things as mechanical looseness, transient impacts, etc., can negatively affect the outcome of a field balancing job. Their identification and resolution is therefore very important prior to balancing. The oscilloscope function is also useful for identifying sensor problems.



Time waveform (Oscilloscope) plot.

Balancing: The "art" of balancing has come a long way from the days when vectors were plotted by hand on polar graph paper. Whether static (single plane) or dynamic (dual plane) balancing is needed, today's instrumentations provide the analyst with an array of powerful user-friendly tools, all designed to get the job done as quickly and efficiently as possible. Some of the more useful field balancing software features include:

- Some instruments allow the analyst to obtain up to four measurement points. A variety of combinations are possible, such as simultaneous horizontal and vertical measurements, or two horizontal and two vertical measurements. This unique "optimization" feature allows unbalance vibrations to be recorded at up to four locations and reduced to a minimum by balancing in one or two planes. This feature is ideal when an operator needs to simultaneously measure the effect of field balancing efforts at other locations on the system.

- Displaying data in both polar or component form.

- The freedom to define a rotor's available correction locations whether equally or unequally spaced.

- The ability to store a rotor's influence coefficients in the instrumentation's memory, thereby negating the need to re-calibrate when future balancing is required.

- The ability to store the description of the machine, sensor positions, date and time and, to upload all data to a PC.

PC Upload Capability: Whether for your own records or those of your customer, the ability to upload all recorded data to a PC is vital. The PC environment affords the user further data analysis and management capacity. Using PC-based software the analyst can, for example, create expert balancing reports. These reports might incorporate such tools as Bode and Nyquist plots, cascade / waterfall spectra, etc. Naturally, compatibility with Windows Office Suite programs such as Word and Excel are important features as well.

Schenck's line of portable vibration analysis and field balancing instrumentations provide all of the above features as well as many not specific to the task of field balancing. For additional information and advice on which instrumentation is best suited to your needs you can contact George Allen by e-mail at allen@schenck-usa.com.

Unbalance Correction: Focus on Repeatability

by Emil Wisekal *(Continued from page 1)*

The last few instances may be correctable with Schenck's averaging features, depending on their severity and the rotor's unbalance tolerance.

2. In-Out Repeatability: How much do the unbalance readings change when the part is removed from the balancing machine and put back in the "same" place? This can be a concern when the part must be removed from the balancing machine to make corrections (such as drilling, milling, riveting, or welding), so if you know that the part must be taken out of the machine repeatedly, this must be checked before continuing.

3. Assembly, or "fit" Repeatability: Rotors with this problem exhibit readings that change when the rotor is stopped, the constituent parts are disassembled and reassembled in the "same" relationship to one another, and the rotor is run again. (This is NOT a problem if the constituent parts are going to be kept assembled continuously after balancing. In fact, for these purposes, if two parts are going to kept assembled, do not take them apart.)

Assembly repeatability is sometimes called "break-and-remake" repeatability. Depending upon how much angle and/or amount change occurs when the parts are re-assembled, this may have to be addressed before continuing. The non-repeatability can sometimes be corrected by making physical changes to the tooling mating surfaces, such as filing burrs or cleaning mating pilots.

Repeatability: check it more than once
If your rotors show good repeatability when you first check them, do not assume that they will stay that way forever. Conditions change. For example, machine parts wear or become mis-aligned, and rotors are not all manufactured identically, so non-repeatability can become an issue later. It is important to periodically audit for run-to-run (and the other types of non-repeatability) so that your rotors are balanced to the tolerances that you believe they are.

What Can Be Done

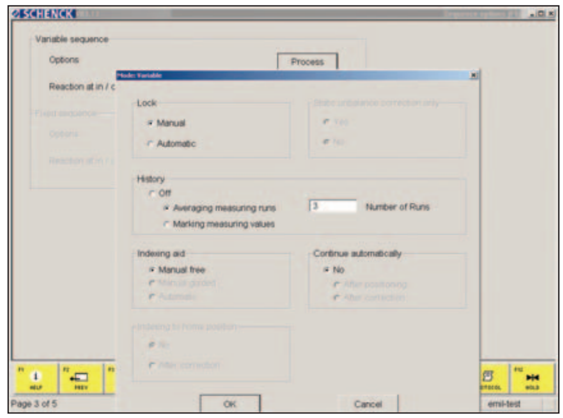
Two important features available on Schenck Balancing Instruments are the two averaging features, "averaging over time" and "averaging over runs". With the help of these features, a balancing machine operator can more effectively deal with measuring non-repeatability.

Averaging Over Time
This feature will reduce or eliminate unbalance errors that are created by other influences, such as:

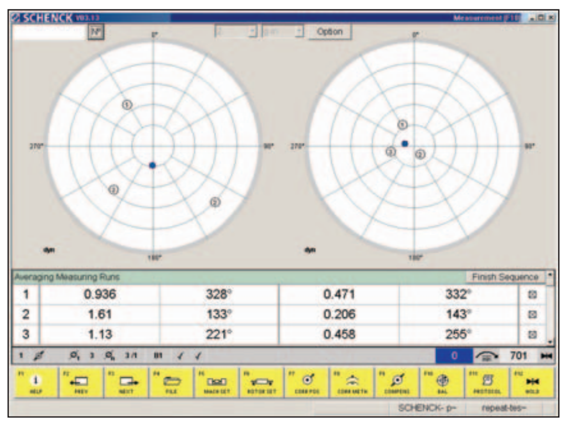
- Loose blades/parts
- Low unbalance
- Unstable rotor
- Light windage, which causes blades to move around slightly during rotation

This feature is enabled at the start of the balancing run, and as time passes during a measuring run, the averaging feature stabilizes the indications. The longer the part is measured, the more averages are taken and the less change is seen on-screen.

Averaging Over Runs



CAB803 setup screen for the Averaging Over Runs feature (3 runs entered).



Indicates 3 runs averaged; note that all three runs are checked in the bottom of the table.

This feature reduces unbalance indication errors that are caused by a variety of common problems that can't be corrected using "Averaging Over Time" by itself. These problems include:

- Rotors with loose blades that take a different set each time they are stopped and started
- Rotors designed with moving parts
- Rotor temperature fluctuations caused by sunlight or other radiant heat
- Small changes in rotor lubrication conditions

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Regional Workshops Scheduled for 2006

Beginning in March, our regional service centers in Chicago, Los Angeles, Houston and Atlanta will host a series of four one-day balancing workshops. These workshops will provide an opportunity to review basic balancing concepts and will then focus on specific elements that are critical to the balancing process. Interactive participation will be encouraged and students will also have the opportunity to address their specific application challenges. Scheduled focus modules include:

Balancing Workshop I - Understanding Tolerances & Speed
Balancing Workshop II - Improving Measurement Results
Balancing Workshop III - Addressing Rotor Configurations
Balancing Workshop IV - Improving Correction Techniques

In addition, Schenck Trebel will continue to offer our three-tiered Balancing Certification Program which has been established in order to provide a standard benchmark for excellence and productivity within a company, as well as individual recognition for technical skill and aptitude. Candidates may take the Level I Balancing Operator Exam after completing our Fundamentals, Pump & Impeller or Jet Engine Balancing seminars and can return to take the test as often as is necessary. Students that have previously attended one of these three courses can also take the exam.

For complete information on our workshops, seminars and certification programs, visit our website at http://www.schenck-usa.com/serv_schedule.html

2006 Balancing Workshops, Seminars & Certifications

March		
Balancing Workshop I- Understanding Tolerances & Speed	March 10	Chicago, IL
Balancing Workshop II- Improving Measuring Results	March 24	Houston, TX
Balancing Workshop III- Addressing Rotor Configurations	March 30	Santa Ana, CA
Balancing Workshop IV- Improving Correction Techniques	March 31	Atlanta, GA
April		
Balancing Theory & Applications / BOC, BTC*	April 4-6	Deer Park, NY
June		
Balancing Workshop IV- Improving Correction Techniques	June 9	Chicago, IL
Fundamentals of Balancing / BOC*	June 13-15	Deer Park, NY
Balancing Workshop I- Understanding Tolerances & Speed	June 16	Houston, TX
Balancing Workshop II- Improving Measuring Results	June 22	Santa Ana, CA
Balancing Workshop III- Addressing Rotor Configurations	June 30	Atlanta, GA
July		
Pump & Impeller Balancing / BOC*	July 18-20	Deer Park, NY
August		
Balancing Workshop III- Addressing Rotor Configurations	August 4	Chicago, IL
Balancing Workshop IV- Improving Correction Techniques	August 11	Houston, TX
Balancing Workshop I- Understanding Tolerances & Speed	August 17	Santa Ana, CA
Balancing Workshop II- Improving Measuring Results	August 25	Atlanta, GA
September		
Balancing Jet Engines & Industrial Turbines / BOC*	Sept. 19-21	Deer Park, NY
October		
Balancing Workshop II- Improving Measuring Results	October 6	Chicago, IL
Balancing Workshop III- Addressing Rotor Configurations	October 13	Houston, TX
Balancing Workshop IV- Improving Correction Techniques	October 19	Santa Ana, CA
Balancing Workshop I- Understanding Tolerances & Speed	October 27	Atlanta, GA
November		
Balancing Theory & Applications/ BOC, BTC*	Nov. 14-16	Santa Ana, CA
December		
Advanced Balancing Theory & Applications / BSC*	Dec. 5-7	Deer Park, NY

* BOC - Balancing Operator Certification I Exam, BTC - Balancing Technician Certification II Exam
BSC - Balancing Specialist Certification III Exam

Evernham Achieves Winning Performance

by Rich Idtensohn

In October of 1999, after nearly 23 years of NASCAR absence, Dodge turned to motor sport legend Ray Evernham to bring them back into racing prominence. The deal lead to the formation of Evernham Motorsports and the beginning of an historic 500-day countdown to field two teams for the 2001 Daytona 500.

Evernham Motorsports' Statesville, N.C. complex has three facilities for engineering, administration, fabrication and R&D as well as an adjacent airstrip for their three corporate airplanes.

The building of a dream

Evernham began building the foundation that would eventually become one of NASCAR's premier racing organizations. In March of 2000, Evernham announced that the team would be anchored by driver Bill Elliott in the No. 9 Dodge Dealers/UAW Dodge. Shortly thereafter it was revealed that Casey Atwood would be behind the wheel of the No. 19 car. A major turning point for the team then came 330 days into the countdown when NASCAR approved the Evernham Dodge, followed by the Dodge engine 85 days later.

Then on February 11, 2001, history was made as Elliott earned the pole position at the 2001 Daytona 500 - the first for Evernham Motorsports and the first for Dodge in nearly 23 years.

Now in its sixth year, the Evernham empire continues to grow with nearly 300 employees and fielding vehicles in the Nextel Cup, Busch and Truck Series, as well as a part-time program in ARCA. In 2002 Jeremy Mayfield joined the team as the new driver for the No. 19 car. In 2004, Bill Elliott retired from full time competition and became more involved in the research and development program for Evernham. He then turned the wheel of the No. 9 car to Kasey Kahne, who went on to become the 2004 Raysbestos Rookie-of-the-Year. In five years of competition on the NASCAR circuit, Evernham teams have visited victory lane at the NEXTEL Cup level each year.

Building better performance

Led by Evernham's passion for performance and his renowned "20 Points to Success," the team has steadily posted incremental achievements to become the major competitor Evernham envisioned. In 2003, engine builder Mark McArdle joined the team as General Manager of the Evernham Engines Division. McArdle carried an impressive resume having posted victories with legends such as Michael Andretti, Emerson Fittipaldi and Al Unser Jr. His experience with Formula I also meant that he shared Evernham's engineering-oriented philosophy to go further, faster, with better technology.

As soon as you step close to the team during its 36 week chase for the Nextel Cup, it is clear that the competition extends far beyond the track. Every week the Engine Group in the Concord, N.C. facility meticulously prepares six R5-P7 Dodge Magnum Engines for the three Nextel Cup Cars. In 2006 the driver line-up includes Kasey Kahne in the No. 9 Dodge Dealers Dodge, Scott Riggs in the No. 10 Valvoline/Stanley Tools Dodge, and Jeremy Mayfield in the No. 19 Dodge Dealers Dodge. Evernham Motorsports also fields the No. 9 Ultimate Chargers Dodge in the NASCAR Busch Series and the No. 98 Cheerios/Betty Crocker Dodge Ram in the NASCAR Truck Series. In addition, McArdle's group provides the engines for two Nextel Cup cars for Petty Enterprises and ten other Busch and Truck teams. On average, the group produces approximately four Dodge Engines a day with an operating speed of 10,000 r.p.m. and capable of delivering close to 800 horsepower. Every engine is custom built based on the type of track, the ambient environment, data from past experience and improvements from the R&D group.

Every week the Concord facility also receives the motors used from the previous week, which are completely disassembled. Every single component is completely evaluated and analyzed for unusual wear, archived and sent to their respective departments to be rebuilt or discarded.

Quest for perfect balance

It was in 2003 that Evernham turned to Schenck to help with some frustrating issues within their balancing department and what was becoming a quality problem.

Evernham's Concord, N.C. facility is home for Evernham Engines, LLC. and Evernham Performance Parts.

"We were having a lot of problems with repeatability on our crankshafts," says Oliver." We were getting inconsistent measurements and conflicting data from our vendors. It also became clear that we needed better sensitivity if we were going to make any improvements to the crankshafts. We really needed something better that we could have some confidence with."

Oliver estimates the life of a crankshaft to be about 10 million cycles, or 6-7 races. Based on the gear ratio, the tire diameter, the track length and the length of the event, the crank is good for about 1.5 to 2 million cycles per weekend. They constantly ran check balances on the cranks and the inconsistent readings were a problem.

New rotors are custom made to Evernham specifications and later modified at the engine shop. The data from the vendors were sometimes as much as 10 g-in out, and the rejection rate on the modified components was about 30%.

The balancing solution

With over 25 years of high performance engine experience and operating a variety of different balancing machines, Steve Oliver knew there was a better way. In December of 2004 Evernham installed a Schenck CS30 Crankshaft Machine with CAB 803 Instrumentation.

Evernham's machine shop and engine fabrication department.

Since installing the machine, the engine shop has developed a new level of confidence in their balancing program. The rejection rate on their modified cranks has gone from 30% to virtually zero. Disputes with vendors have also gone down considerably." At least now when they do happen we know we can stand behind our measurements," says Oliver." We even had one vendor concede when he saw that we were using a Schenck." In addition, the expanded speed range has given them greater versatility. The Engine Group has since been able to expand their balancing program to include clutch components, flywheels, fans, water pump impellers and pulleys.

Precision accuracy means precision performance

As GM Mark McArdle points out, in a world where NASCAR regulations limit the options for modifications, the battle is won by knowing where you can compromise.

McArdle is especially pleased with the improved sensitivity. After an incident where Mayfield grounded out and caused damage to his flywheel, they were able to work the rotor on the balancing machine and develop a new tolerance threshold that substantially improved its performance.

Balancing technician Jim Luce on the CS30 Crankshaft Balancing Machine.

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☐ CAB 700	RC1007e
☐ CAB 803	RC1026e
☐ CAB 690	RC1006e
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☐ Spin test systems	RT1117e
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Unbalance Correction: Focus on Repeatability

by Emil Wisekal *(Continued from page 4)*

This feature is enabled at the start of a set of balancing runs. At least two runs (preferably three) are used to come up with a "running average" of indications. The instrument will show the readings on-screen as they are taken, and will then display one trustworthy unbalance reading for each plane representing the average over the previous runs.

Tolerance Issues

It is important to keep things in perspective. Modern balancing machines are often capable of measuring unbalance far below the rotor's unbalance tolerance (how much residual unbalance is allowed to remain in the rotor after balancing). A non-repeatability amount or angle below a properly set unbalance tolerance is normal and not a malfunction.

There is also an optional feature available in Schenck balancing machine instrumentations called "ISO Tolerance" which will select the proper unbalance tolerance. The ISO Tolerance that is calculated is based upon the following:

1) Class of rotor (from gyroscopes to large steam turbines)
2) Maximum service speed of the rotor (in RPM)
3) Rotating mass (in pounds or kilograms)
4) Mass distribution along the rotor (is it symmetric [50/50] or other)

Upon entering the above information on the screen, the calculated unbalance is placed into the tolerance fields, and after running the rotor, the instrument automatically tells the operator whether the part is in or out of tolerance, and by how much the unbalance tolerance is exceeded (1.5 X tolerance, for instance).

In the end, solid repeatability is a fundamental element in order to obtain dependable measurement results. With the help of these features, a balancing machine operator can more effectively deal with measuring non-repeatability.

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