Nanoprecise

Prediction with Precision

DASHBOARD USER MANUAL

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Introduction

Welcome to the comprehensive manual of the Nanoprecise Dashboard, designed to provide a complete understanding of the platform's functionalities and features. As a dynamic maintenance professional, your journey through this manual will familiarize you with the intricacies and capabilities of the cutting-edge platform developed by Nanoprecise Sci Corp.

This manual will offer a clear and detailed explanation of each element and feature present on the dashboard. By thoroughly exploring the contents within, you will gain a deep insight into the diverse functionalities available, empowering you to leverage the platform's full potential.

Whether you are a seasoned professional or a novice user, this guide will serve as your key companion, enabling you to navigate through the dashboard with confidence and efficiency. We are confident that this manual will provide you with the necessary tools and knowledge to maximize your experience and drive your productivity to new heights.

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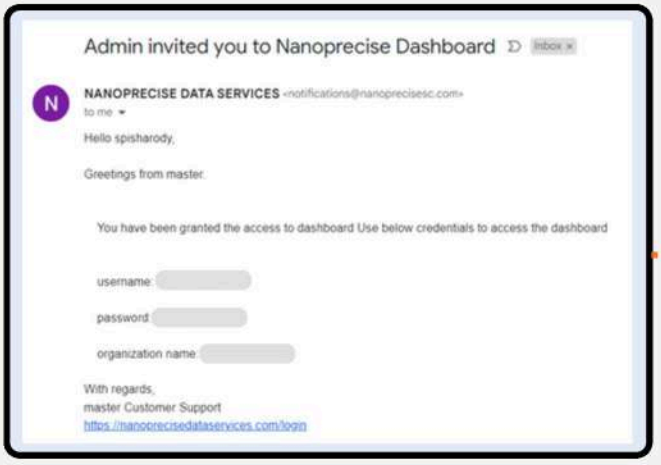
Login

Nanoprecise Users

Access the website through the following link:
https://nds.nanoprecisedataservices.com/login

Enter the Username, Password, and Organization Name, received via email from notifications@nanoprecisesc.com, then click on "Sign In."

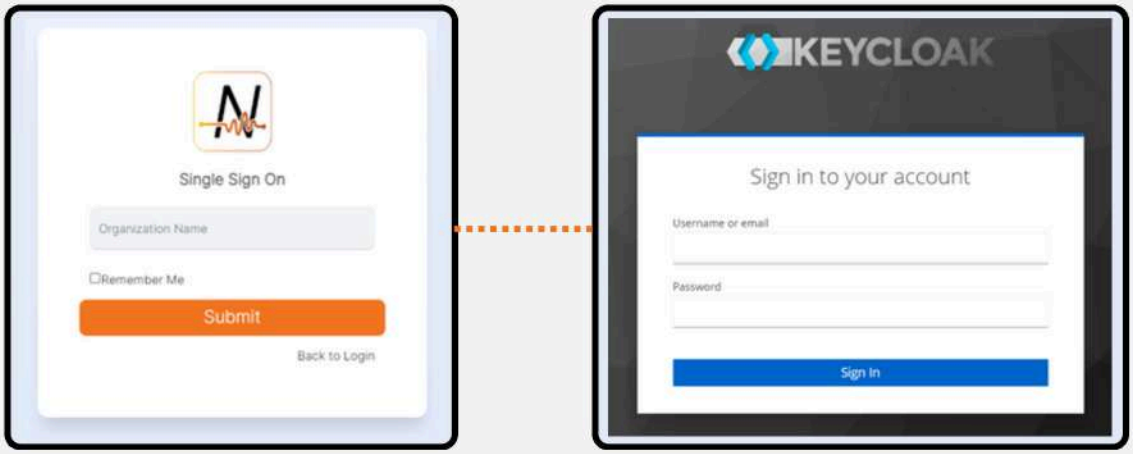


Sample email with Credentials

Login

SSO Users

Enter the “Organization Name” of the Company you are trying to access. If Organization is setup for SSO, it will redirect you to the “Sign In” page of your company SSO



Upon successful sign-in, you will be automatically redirected to the Nanoprecise Homepage. If you would like to setup SSO for your company, please contact your Nanoprecise representative or customer-success@nanoprecise.io

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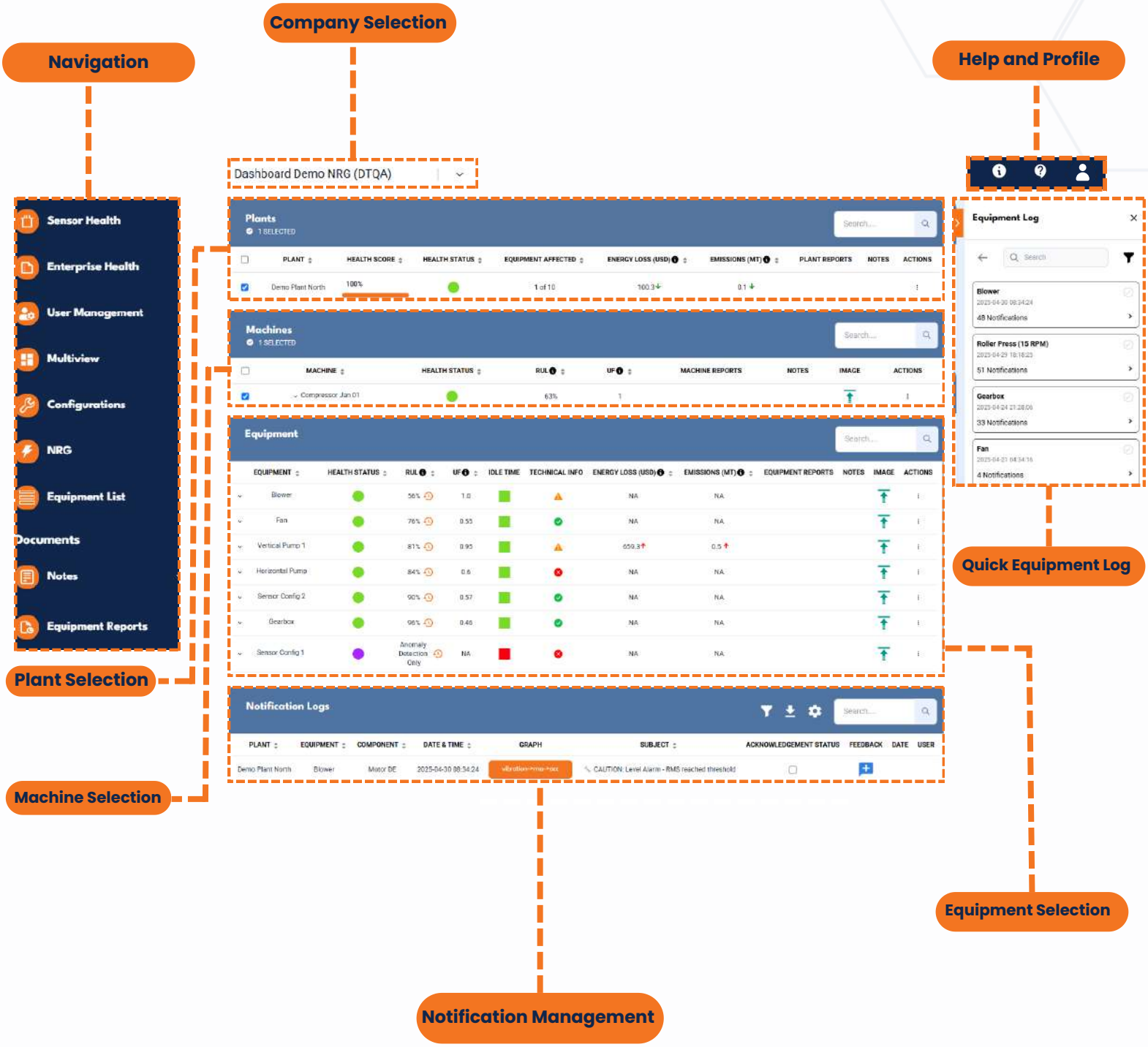
Homepage



Navigation

Facilitates rapid access to various sections of the dashboard, with available options contingent upon user privileges and activated features.

Company Selection

Enables users with access to multiple companies to make selections from a dropdown menu.

Plant

This section furnishes an inclusive health assessment and status overview for each of the company's plants. The presentation is structured based on the health score, with the lowest scores taking precedence. By default, the first plant on the list is automatically selected, although the option to select multiple plants is available. The chosen plant's details will be displayed in the machine/equipment tab below, along with a concise "Plant Health Summary" on the right-hand side.

Features

- **Plant list** : Displays a comprehensive listing of all company plants, each accompanied by a checkbox for selecting the desired plant(s) to populate the equipment view.
- **Health Score:** Represents a computed value reflecting the overall health of a specific plant, derived from the collective health status of the equipment within that plant.
- **Health Status:** Indicates the current health status of the most compromised equipment within the selected plant.
- **Equipment Affected:** Displays the count of machines exhibiting degraded health conditions within the plant.
- **Energy Loss (USD):** Reflects the estimated financial impact of energy inefficiencies resulting from underperforming equipment in the plant.
- **Emissions (MT):** Indicates the increase in carbon emissions (measured in metric tons) due to inefficient equipment performance, aiding sustainability tracking.
- **Plant Reports:** Serves as a centralized repository for storing detailed findings, insights, and reports related to individual plants.
- **Notes:** Facilitates the addition of remarks and contextual observations at the plant level.
- **Action:** Enables users to rename both plant and equipment entries and manage related operations as needed.

Machine

This section provides a detailed overview of individual machines within the selected plant(s), focusing on their operational health and performance metrics. Each machine is listed with key indicators such as Health Status, Remaining Useful Life (RUL), and Utilization Factor (UF), enabling teams to prioritize maintenance and operational decisions effectively. The list is sorted by Health Status by default, ensuring that the most critical machines are highlighted first. Selecting a machine reveals associated reports, notes, and available actions, facilitating comprehensive equipment management.

Features

- **Machine List:** Displays a comprehensive listing of all machines under the selected plant(s), each accompanied by a checkbox for selecting specific equipment for focused review.
- **Health Status:** Indicates the current operational condition of each machine using a color-coded status marker.
- **RUL (Remaining Useful Life):** Reflects the estimated usable life remaining for each machine, expressed as a percentage based on current and historical performance data.
- **UF (Utilization Factor):** Represents the operational intensity of the equipment, helping identify underused or overused machines within the plant.
- **Machine Reports:** Serves as a centralized repository for storing diagnostic summaries, historical data, and specific recommendations related to individual machines.
- **Notes:** Facilitates the addition of comments, observations, or instructions linked to specific machines within the plant.
- **Image:** Allows viewing or uploading of images related to the machine for identification or issue documentation.
- **Action:** Enables users to rename individual machines

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Equipment

Based on the selected plant(s) (which can be multiple), the equipment will be listed in order of priority, with the lowest health score ranked first.

Features

Equipment List: Displays all equipment corresponding to the selected plant(s) from the Plant section, each accompanied by a checkbox for multi-selection and prioritization.

Health Status: Determined by the active Fault Severity/stage (2/3/4) and the Remaining Useful Life (RUL). (Refer to Appendix C for detailed information)

Remaining Useful Life (RUL): Represents the remaining useful life of the most critical or degraded component in the equipment. Shown as a percentage.

Utilization Factor: Indicates the percentage of running measurement points relative to the total measurement points, helping assess operational consistency.

Idle Time: Provides an indication if the equipment has not operated for a defined number of days. (Refer to notification settings for customization)

Technical Info: Links to technical specifications and documentation relevant to the equipment, aiding troubleshooting and maintenance planning.

Energy Loss (USD): Estimates the cost of energy waste attributed to the performance decline of individual equipment units.

Emissions (MT): Indicates the additional CO_2 emissions, measured in metric tons, generated due to inefficient equipment operation.

Equipment Report: Serves as a central repository for storing equipment-specific analysis reports and additional findings.

Notes: Facilitates the addition of observations, comments, or follow-ups for individual equipment entries.

Image: Displays a visual reference of the equipment to support identification and tracking.

Actions: Enables users to rename equipment entries

Notification

Notifications from the selected plant(s) (accessible to the user) will be exhibited for the previous 2 weeks, with the most recent appearing first.

Features

- **Plant/Equipment/Component:** Indicates the specific location—plant, equipment, and component—where the notification was triggered.
- **Date & Time:** Displays the exact moment the notification was generated, enabling timely investigation and action.
- **Graph:** Provides a hyperlink that redirects to the graph of the parameter that crossed the threshold, offering visual insight into the condition anomaly.
- **Subject:** Specifies the subject and summary of the notification, typically indicating the type and severity of the alert.
- **Acknowledgement Status:** Allows users to acknowledge the alert, indicating it has been reviewed. Users can hover over the field to see who acknowledged it and when.
- **Feedback:** Enables users to log follow-up actions in response to the notification. Feedback can include maintenance types, descriptions, time ranges, and assigned personnel. Once submitted, feedback becomes part of the notification history to ensure full traceability.
- **Date:** Records the date of acknowledgment or feedback entry, where applicable.
- **User:** Identifies the user who acknowledged or commented on the notification.

Info

The info button shows details on different notification types, about health statuses, NRG Monitor details, definitions of running condition parameters, and what triggers each and also how we define health status based on Fault Severity and RUL

Help Information

Notification | Health Status | NRG Monitor | Running Condition

Summary on notification type and notification email subject:

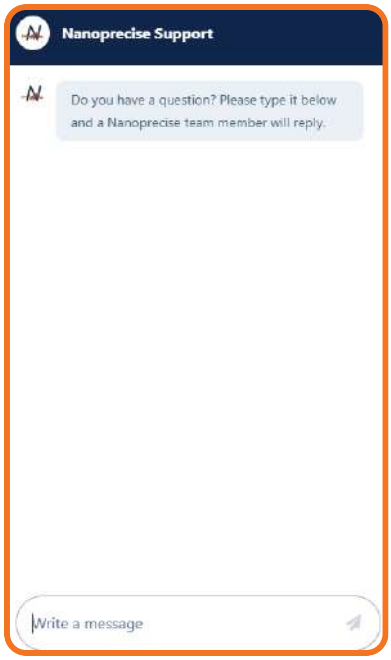
Source	Notification Type	Notification Email Subject	Notification - Priority - Action
Notifications from Cloud Computation	Notifications on Health Status Summary and Remaining Useful Life (RUL)	⚠ LATE-STAGE FAULT: Attention is required for your equipment Fault mode trend stage alarm	Action priority based on Health Status Needs Immediate Attention – HIGH – Suggested actions Maintenance Review – MEDIUM – Suggested actions Needs Immediate Attention – MEDIUM – Suggested actions
	Notification by Condition Intelligence	**Critical Multivariable Condition Intelligence**	**Critical Multivariable Condition Intelligence – HIGH** **Review data and inspect equipment**
	Notification by NanoAI Alarm	EARLY-STAGE FAULT: NanoAI Amplitude Alarm ANOMALY DETECTED: NanoAI RMS Alarm ANOMALY DETECTED: NanoAI Peak Alarm ANOMALY DETECTED: NanoAI Sound RMS Alarm	MEDIUM → Review data monitor LOW → Review data to validate changes LOW → Review data to validate changes LOW → Review data to validate changes
	Notification by Email alarm	CAUTION: Level Alarm–User Set Alarm threshold on different trends	Alarm – HIGH – User defined Warning – MEDIUM – User Defined Pre-warning – LOW – User Defined
	Grouped Notification	Daily Alarm Notification	LOW → Review data to validate changes
Saturated Sensor Detected, Acc Peak within 5% of max level of sensor range Last Running Difference > 24h	Sensor Operational Status Notification	Please conduct connectivity/battery check for the following sensors Sensor Saturated → MEDIUM → Troubleshoot sensors MEDIUM → Check sensors installation or running not running setup	Sensor offline > 4days → MEDIUM → Troubleshoot sensors
Notifications from Sensor Edge	Notification on Real-Time Anomaly Detection by Edge Computing	CAUTION: Sensor Notification	Anomaly from sensor edge → MEDIUM → Review data to validate changes

Note: If feedback is provided to the specific notification through the notification log and the selected maintenance type has 'Reset Fault Detection' activated, then all data till that time will be discarded and learning will be restarted.

Help

The Help button provides quick access to Nanoprecise Support for any questions, and offers a library of comprehensive training resources designed to help you get the most out of the platform.

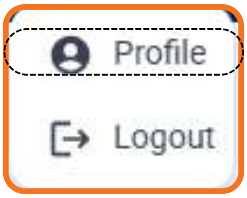
Instantly chat with Nanoprecise Support Team

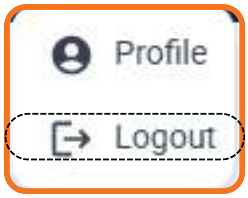


Access our resources to help you make the most of Nanoprecise

User Settings

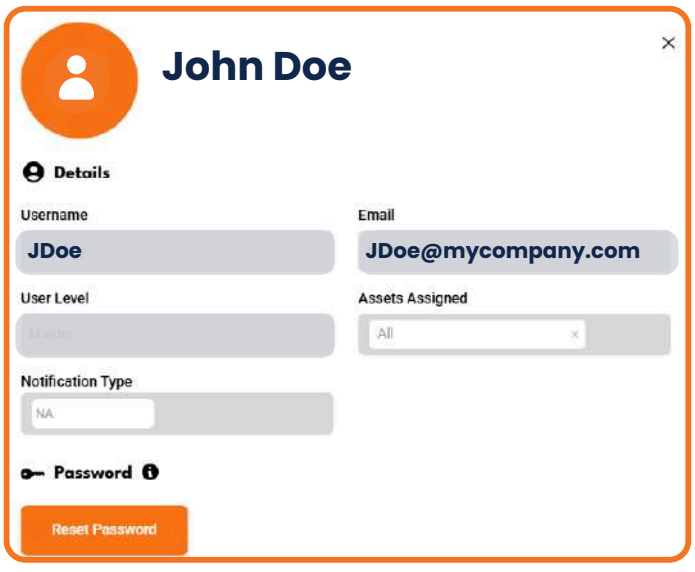
Access password modification and logout functionalities

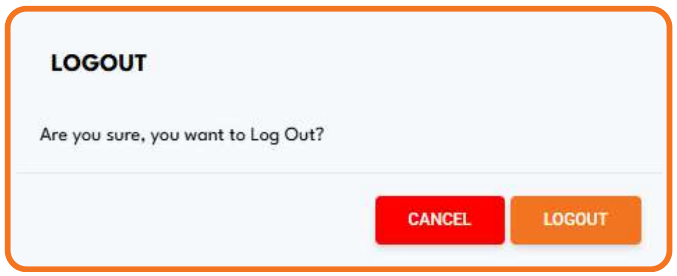




Reset your password and check access level

Access our resources to help you make the most of Nanoprecise



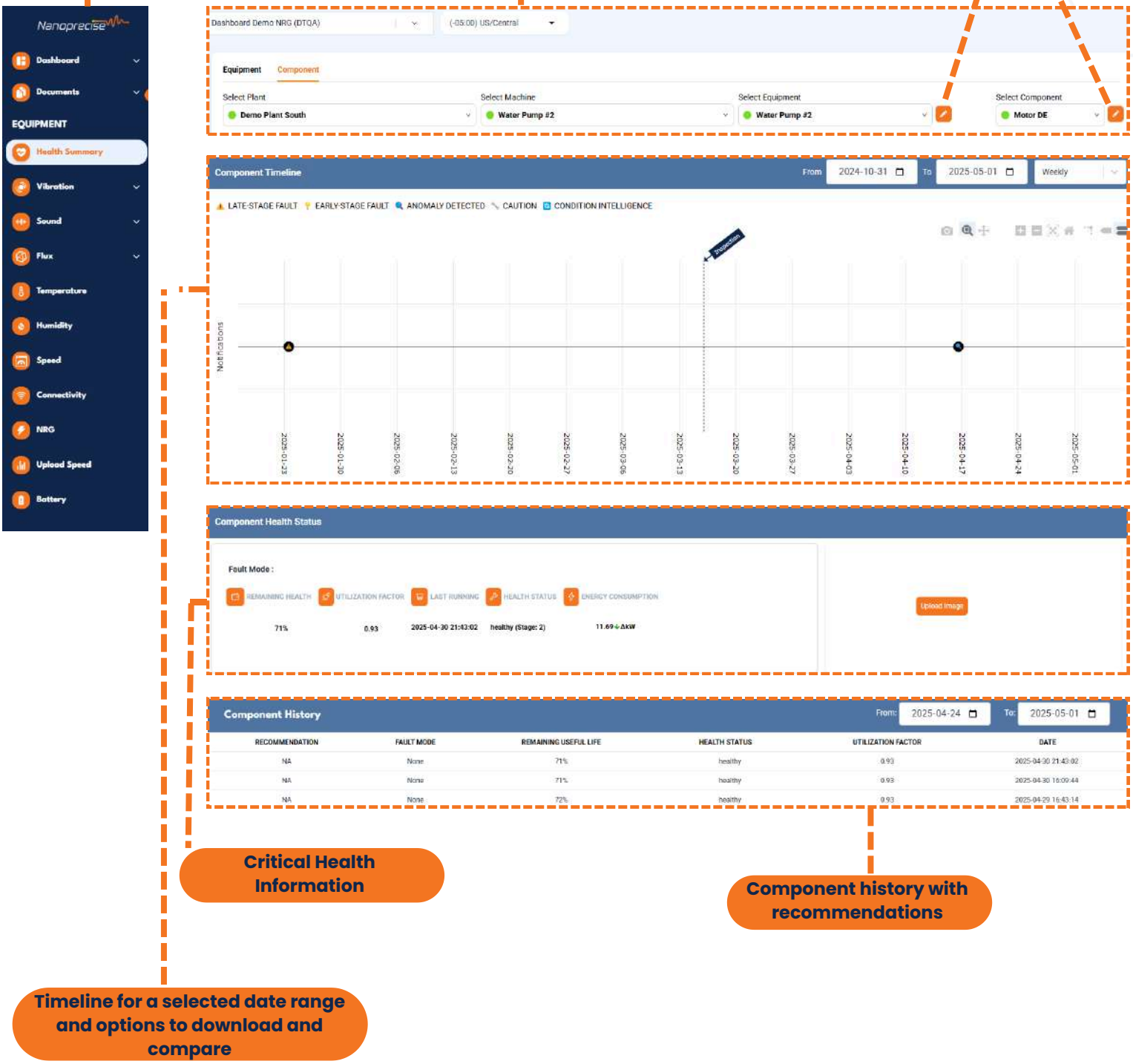


Equipment / Component Health Summary

Easy navigation to the various data sources

Equipment/Component Navigation Bar for a Single Plant

Modify Component / Equipment name and other technical info



Critical Health Information

Component history with recommendations

Timeline for a selected date range and options to download and compare

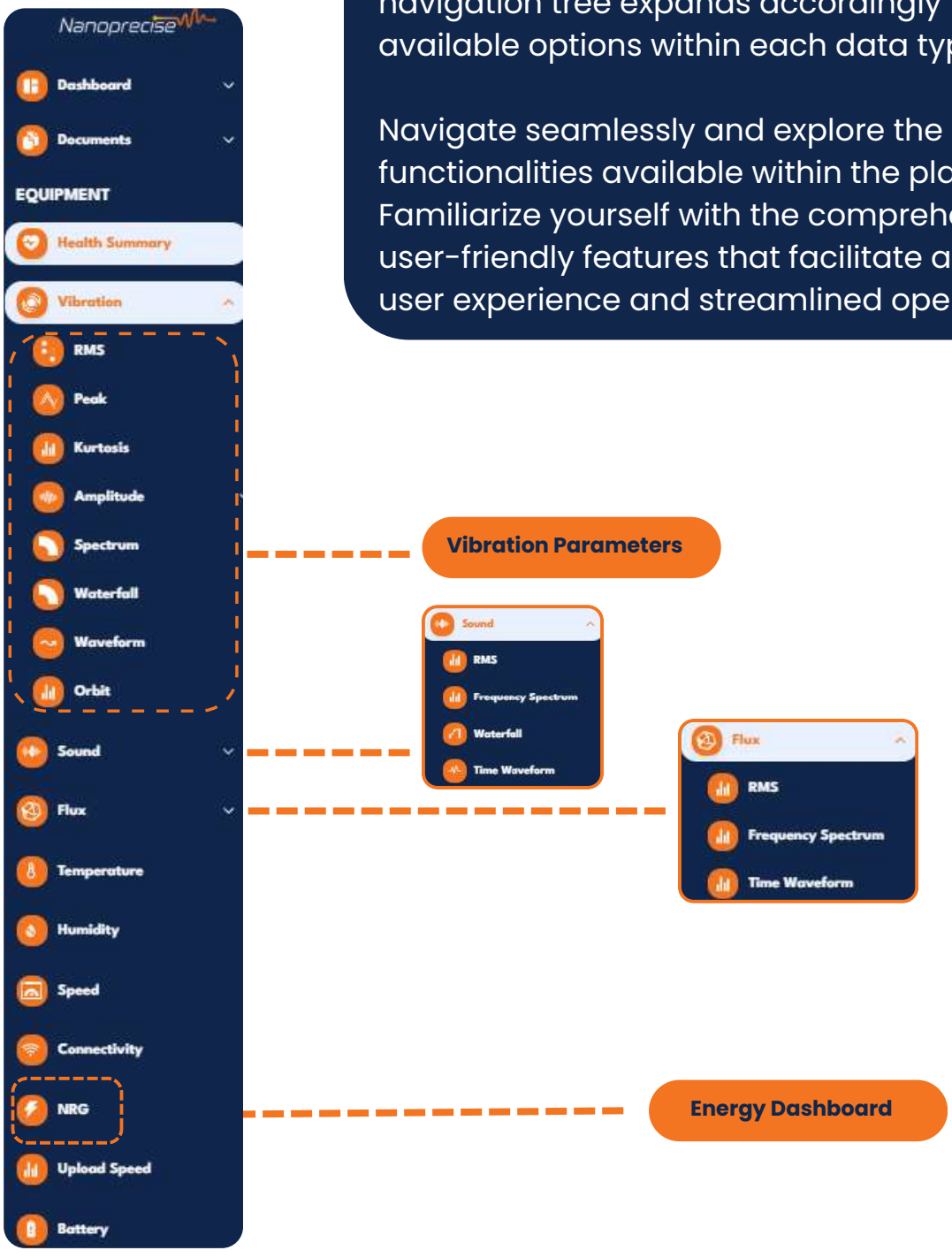
Navigation and General Functionality

Navigation

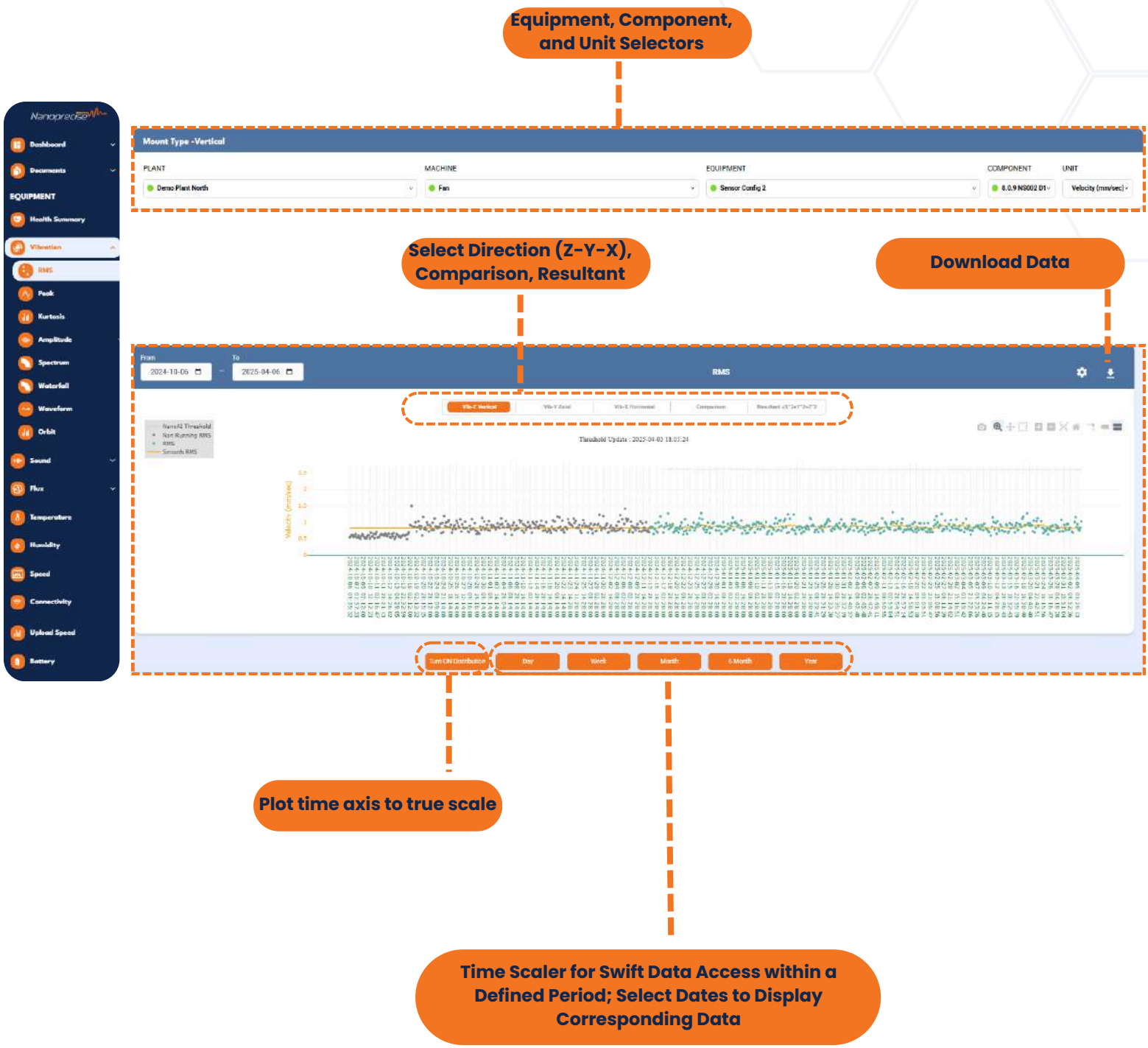
The data sources are individually selectable, and the navigation tree expands accordingly to display all available options within each data type.

The data sources are individually selectable, and the navigation tree expands accordingly to display all available options within each data type.

Navigate seamlessly and explore the diverse functionalities available within the platform. Familiarize yourself with the comprehensive and user-friendly features that facilitate an enhanced user experience and streamlined operations.

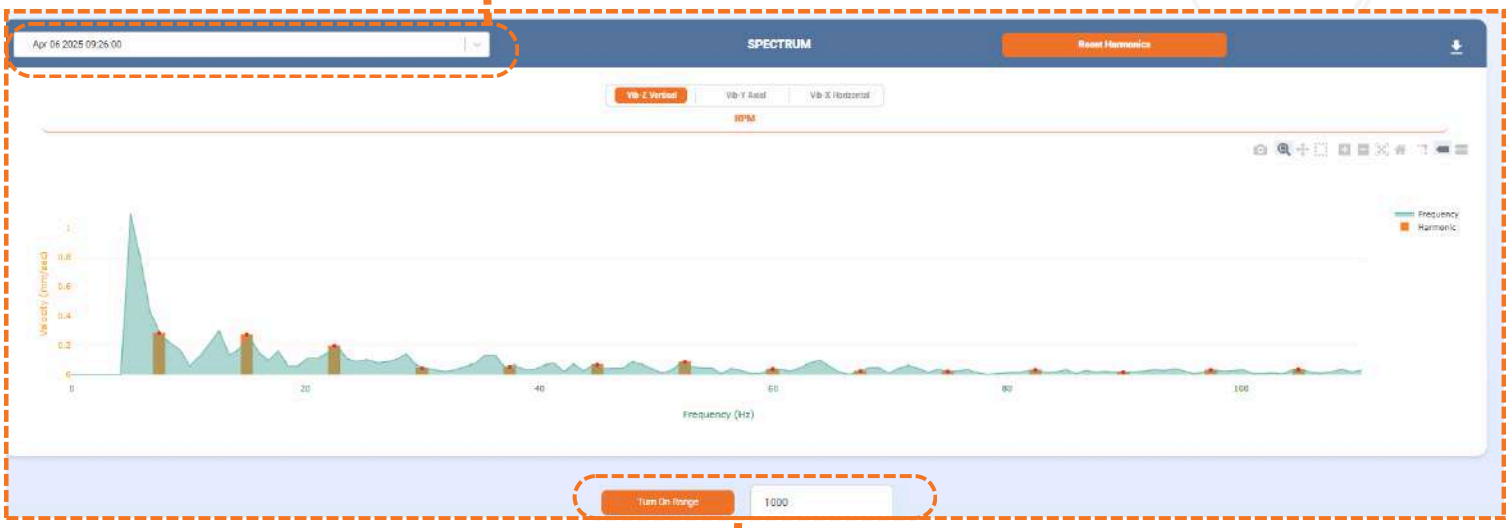


Trending Graph Functionality



Spectrum & Time Waveform Graph

Last 30 days data (Grey = Not Running) Last running speed is selected by Default



Turn on Frequency Axis Zoom Range

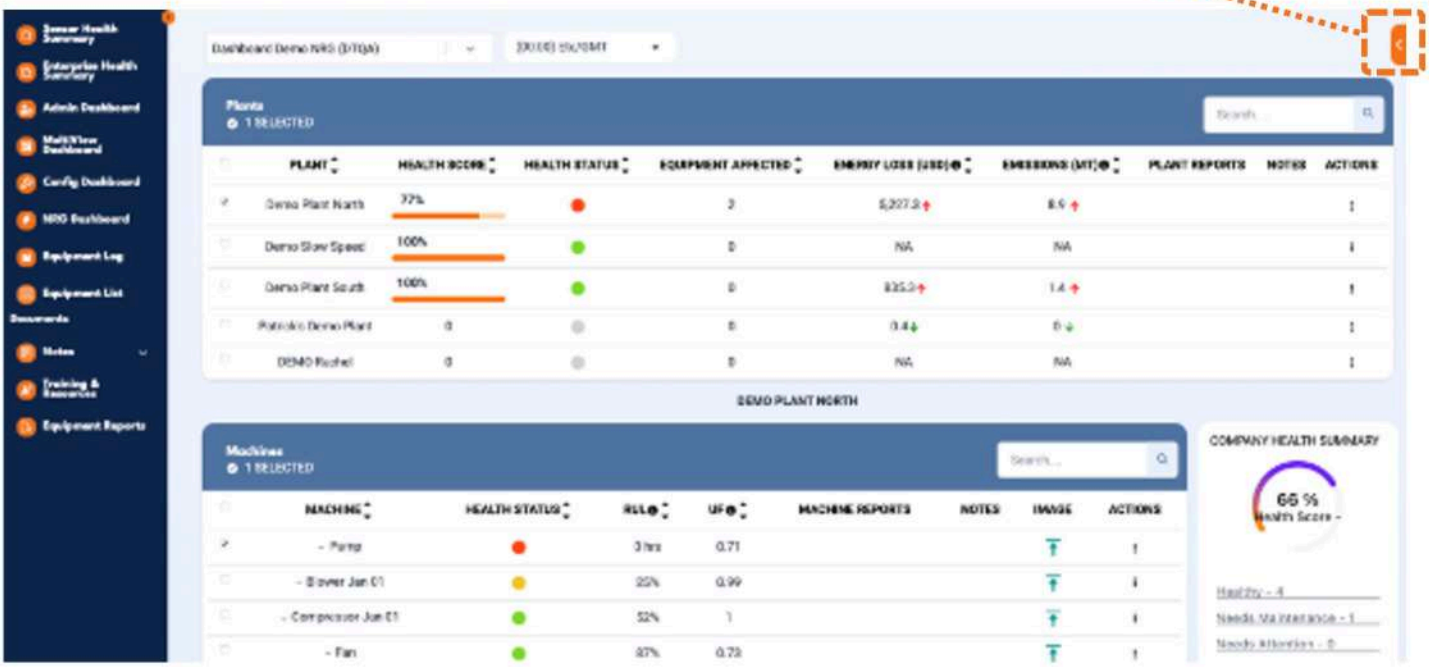
Select Direction (Z-Y-X), Comparison, Resultant

Equipment Log & Feedback

Where to find?

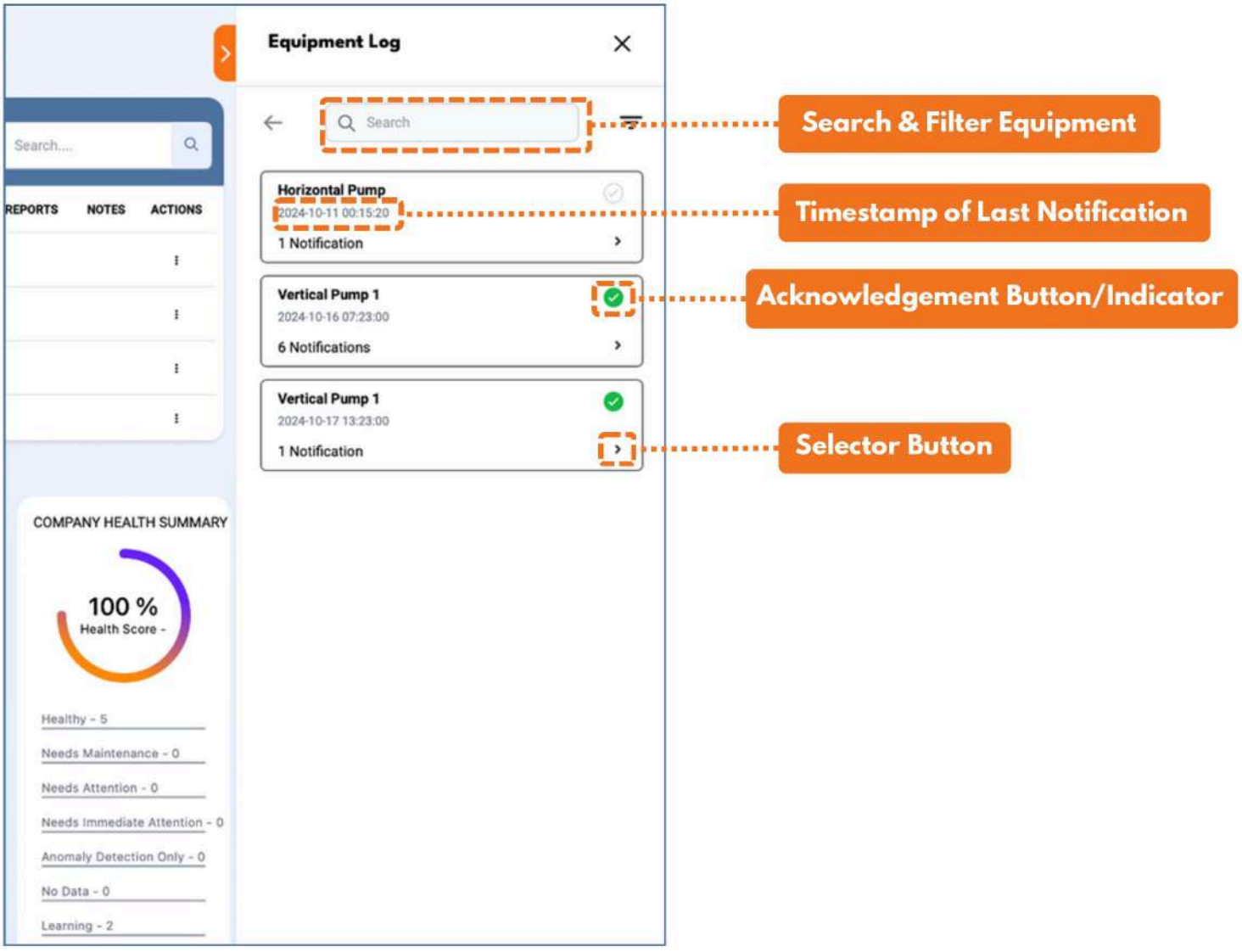
A quick access side panel can be found on the right-hand side of the Nanoprecise web platform.

Click here to access the Equipment Log to add feedback and view notifications



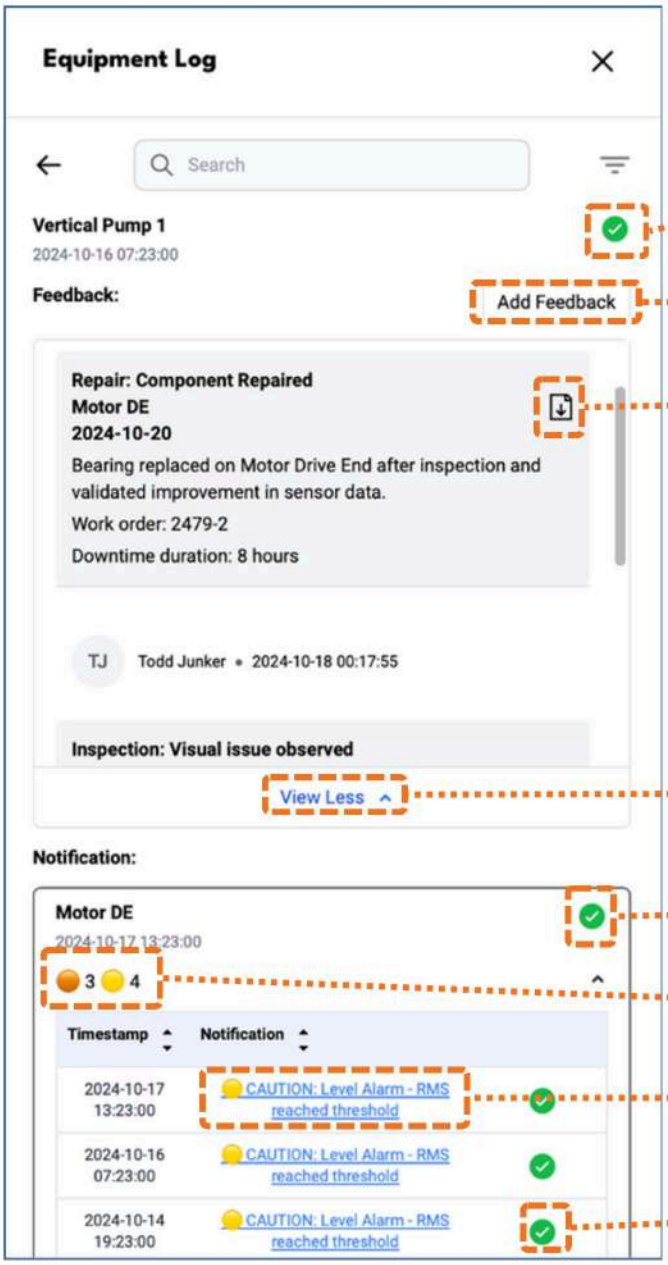
Equipment Log – Equipment List

View equipment that have observed notifications, sorted by acknowledgement status and recency. Use the search or filter functions to narrow down equipment.
Click on an equipment of concern to investigate further.



Equipment Log – Equipment Details

Selecting an equipment then provides quick access to track and log maintenance activity, and a temporal view of notifications grouped by components that have observed any alerts/notifications.



Acknowledge All Equipment's Notifications

Add Feedback Opens the Feedback Form

Download Attachment from Feedback

Expand/Collapse Feedback Thread

Acknowledge All Component's Notifications

Notification Level & Count

View Alarm Graphs & Data

Acknowledge Individual Notifications

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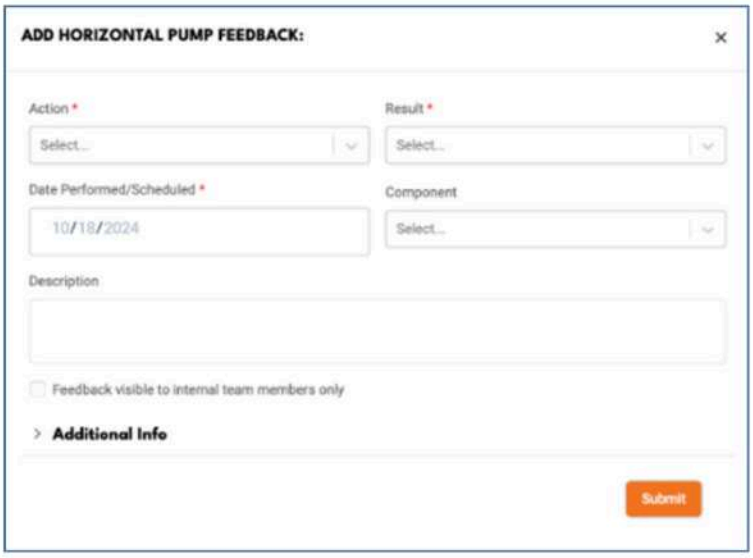
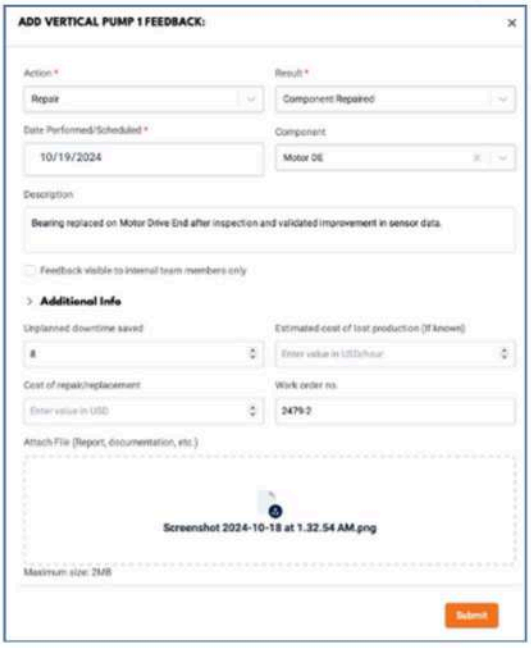
Feedback Form

Clicking the "Add Feedback" button opens the feedback form where users can share details on ongoing maintenance activity. The submitted feedback is posted on the feedback thread for the corresponding equipment – viewable by all users.





Form Features

Action: Select between a variety of maintenance activities from inspections to repairs and more. This provides a high-level view of the maintenance state.

Result: Select between different outcomes depending on the type of maintenance activity selected, such as a visual observation or equipment failure. This feeds into the platform's automation and analytics capabilities.

Date Performed/Scheduled: Provide an estimate on when this maintenance activity was performed or will be performed.

Description: Provide context on the maintenance outcome being discussed. Feel free to add as much detail as possible to boost collaboration within the maintenance team.

Additional Info: Provide more details on the maintenance activity, such as Work order number, downtime/cost figures (for ROI calculations) and file attachments which could include reports or other relevant information.

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Vibration

RMS, Peak, Kurtosis

RMS

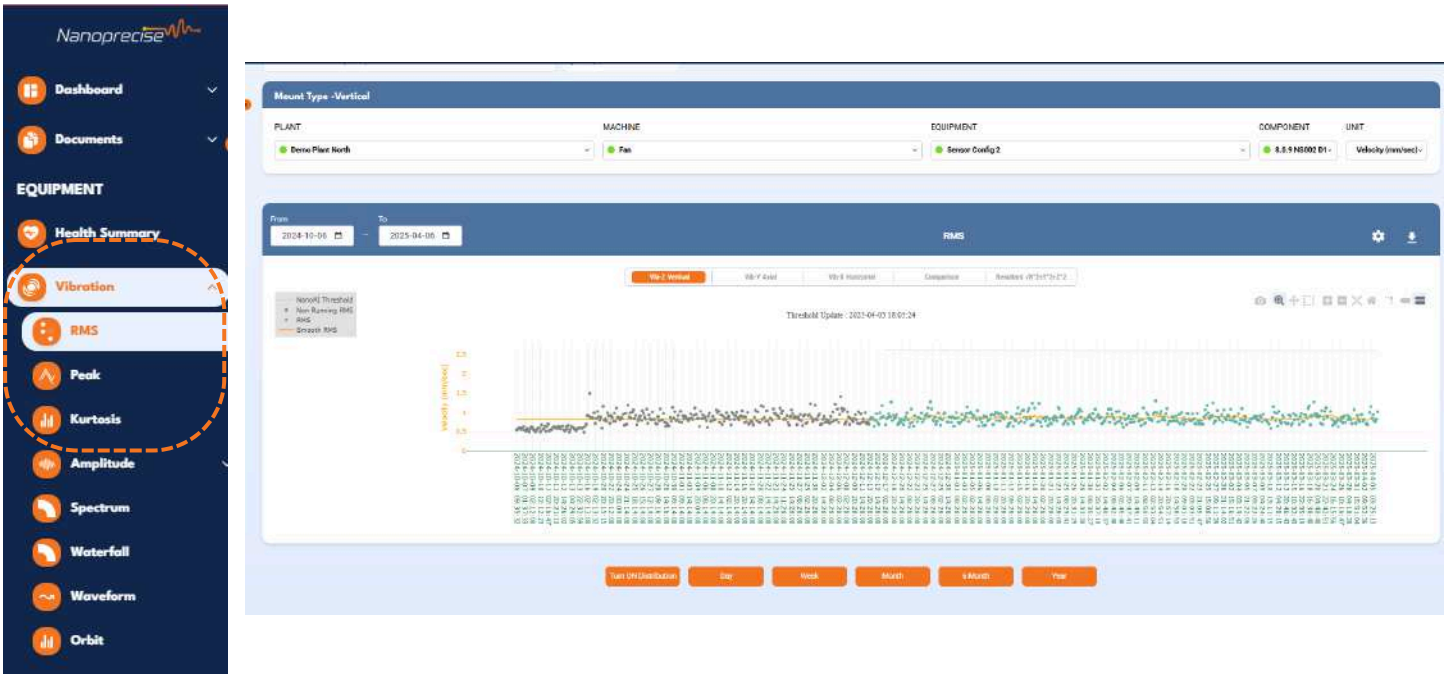
RMS is the root mean square of the vibration waveform from 2-1000 Hz as of ISO10816. It describes the energy emitted by the machine, the higher the energy, the higher the RMS value is.

PEAK

Vibration peak refers to the maximum excursion of the time wave from the zero point. The amplitude describes the severity of a specific fault mode.

KURTOSIS

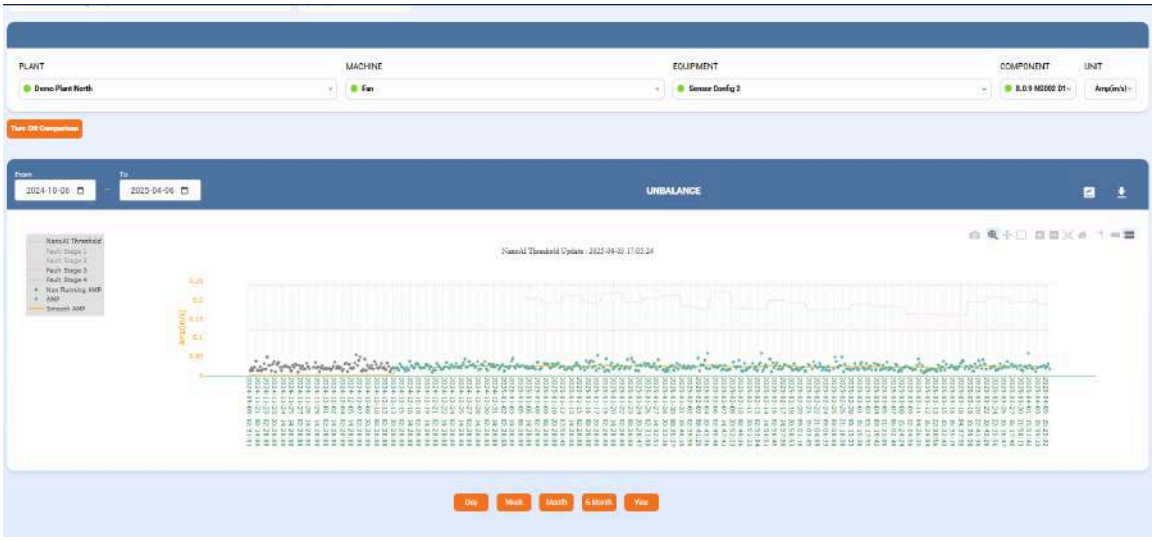
Kurtosis provides a measure of the peak intensity within a vibration signal. Signals that have a higher kurtosis value have more peaks that are greater than three times the RMS value.



Amplitude

The amplitude graphs correspond to the monitored component, with each sensor configured to cover relevant fault modes based on its specific location. For instance, antifriction bearing faults are addressed through graphs for Bearing Inner Race, Bearing Outer Race, and Bearing Ball, while options for shaft faults encompass unbalance, misalignment, and looseness.

These graphs play a crucial role in determining the Remaining Useful Life (RUL) of a component, with each fault categorized into four stages. RUL is calculated as the time taken to reach Fault Stage 4, with the equipment deemed unstable upon crossing the Fault Stage 4 threshold. Appendix D provides additional insights into the initial setting of the Stage 4 threshold during the learning phase and its subsequent self-adaptive behavior.



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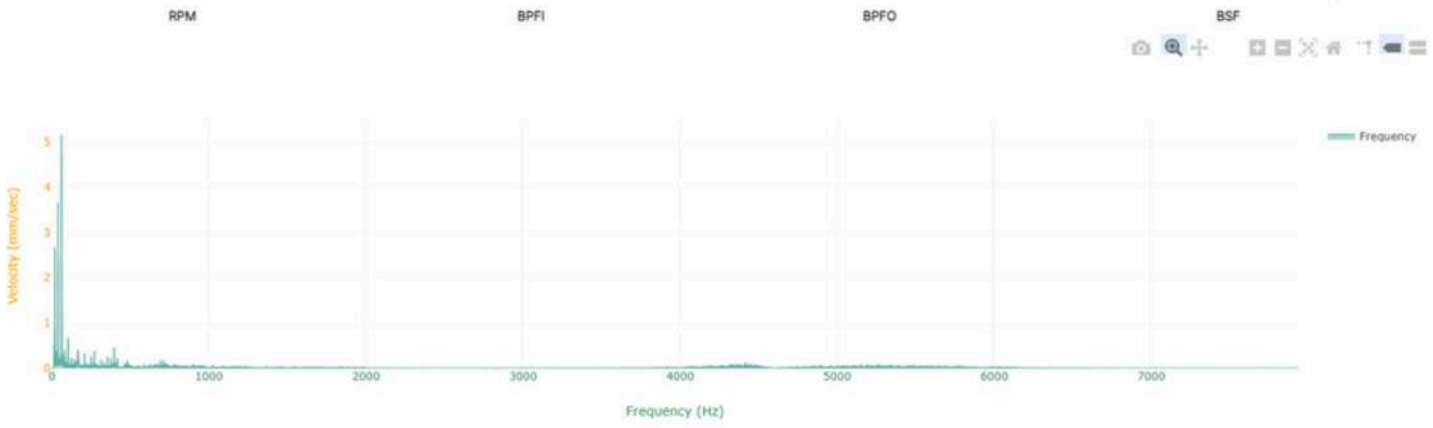
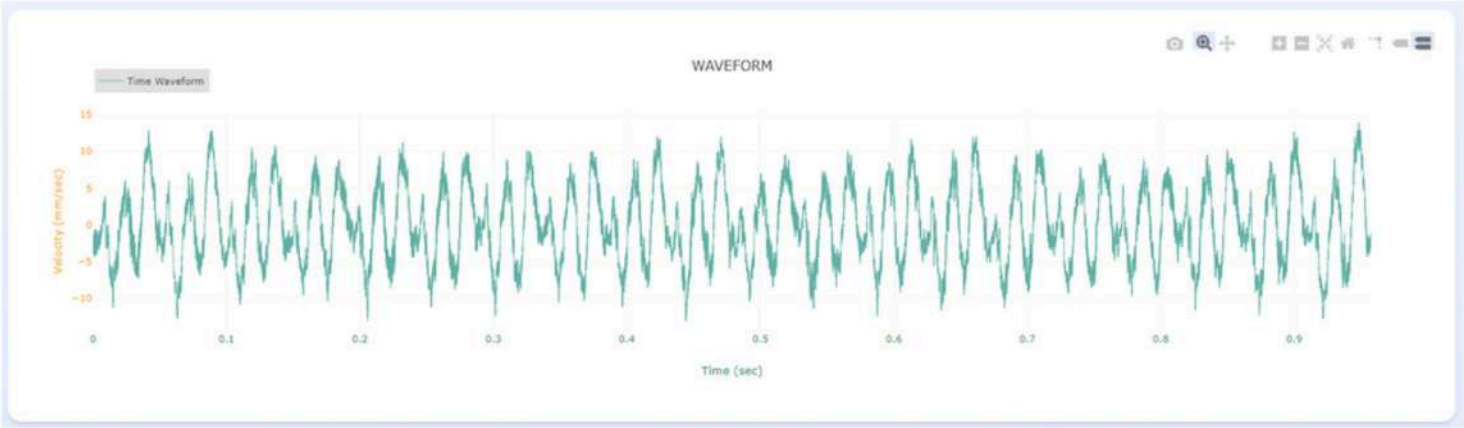
Spectrum



Waveform

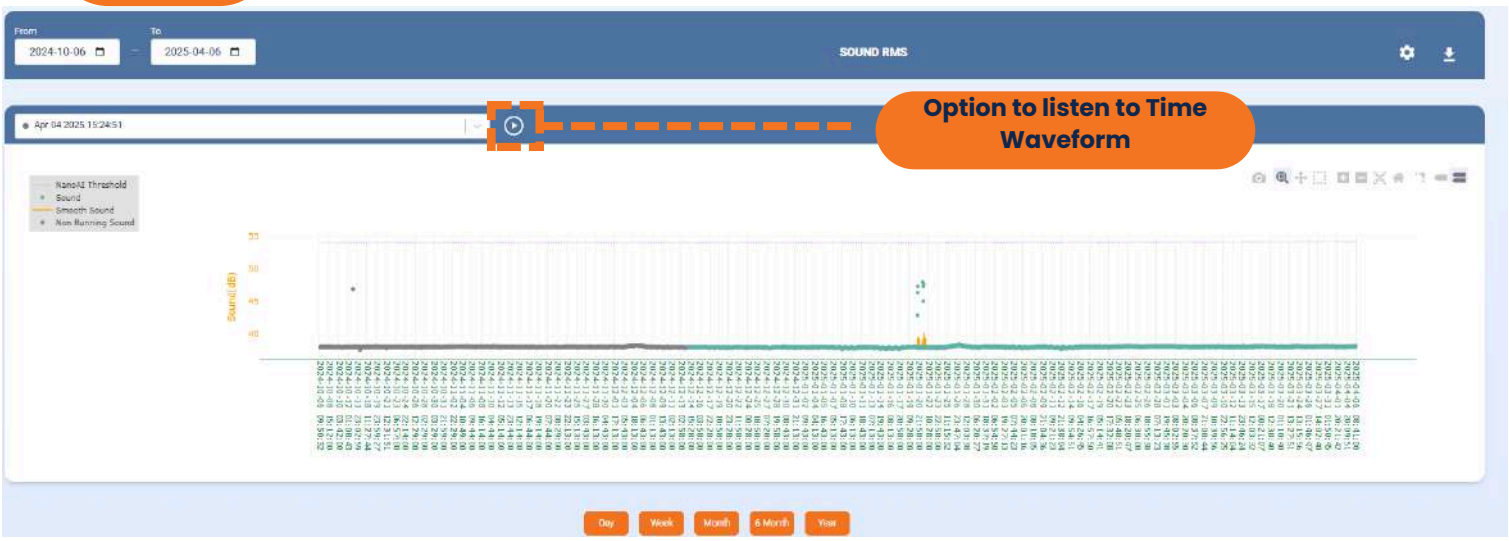


Waterfall Spectrum

Sound

The acoustic emission data has a set frequency range of 20kHz - 40 or 80 kHz to capture the maximum amount of useful data, which is beyond human hearing range.

RMS



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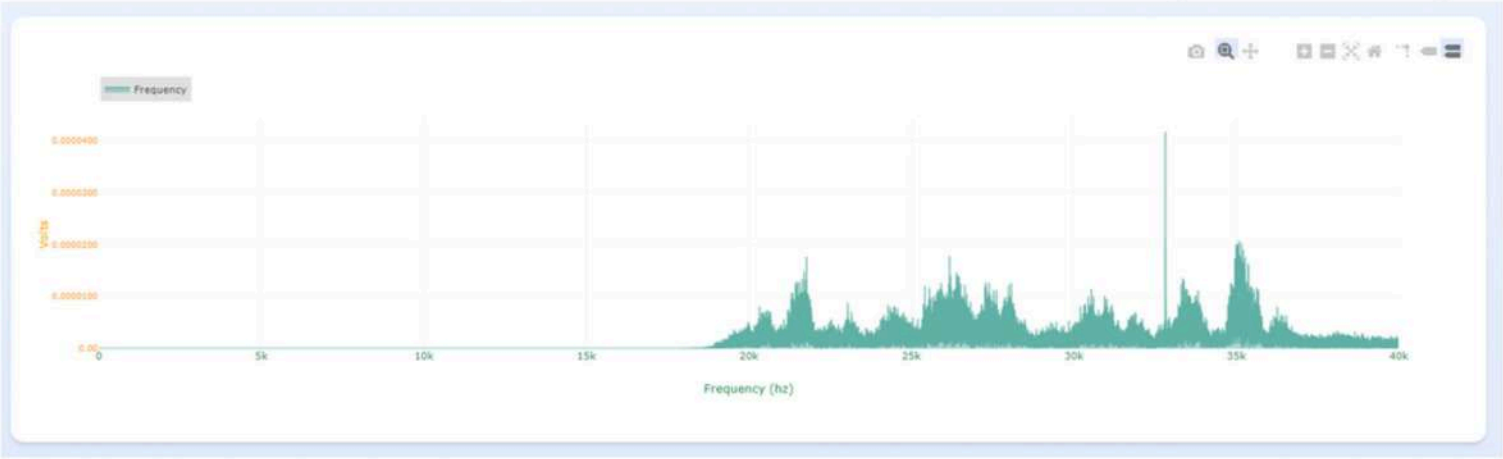
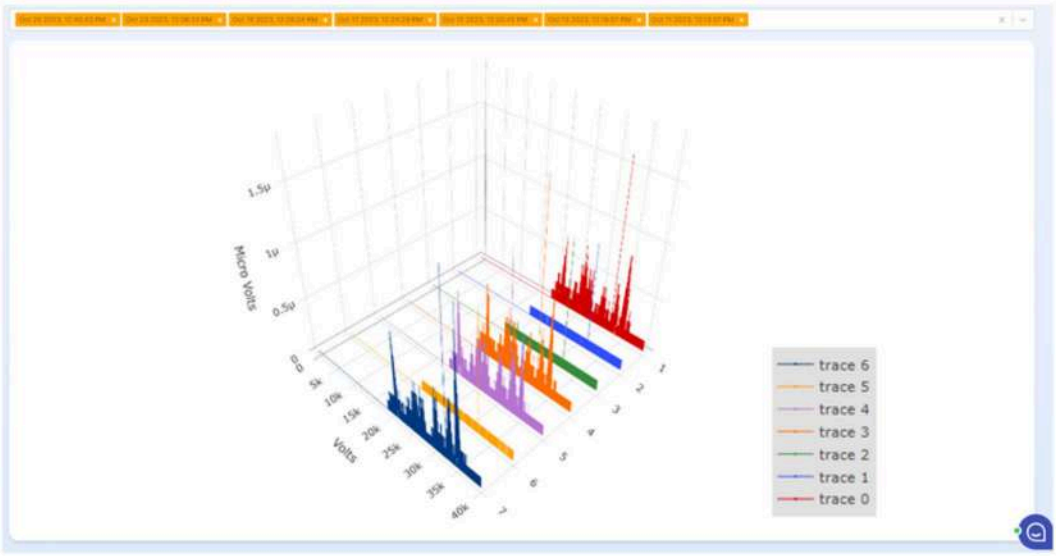
Spectrum



Waterfall Spectrum



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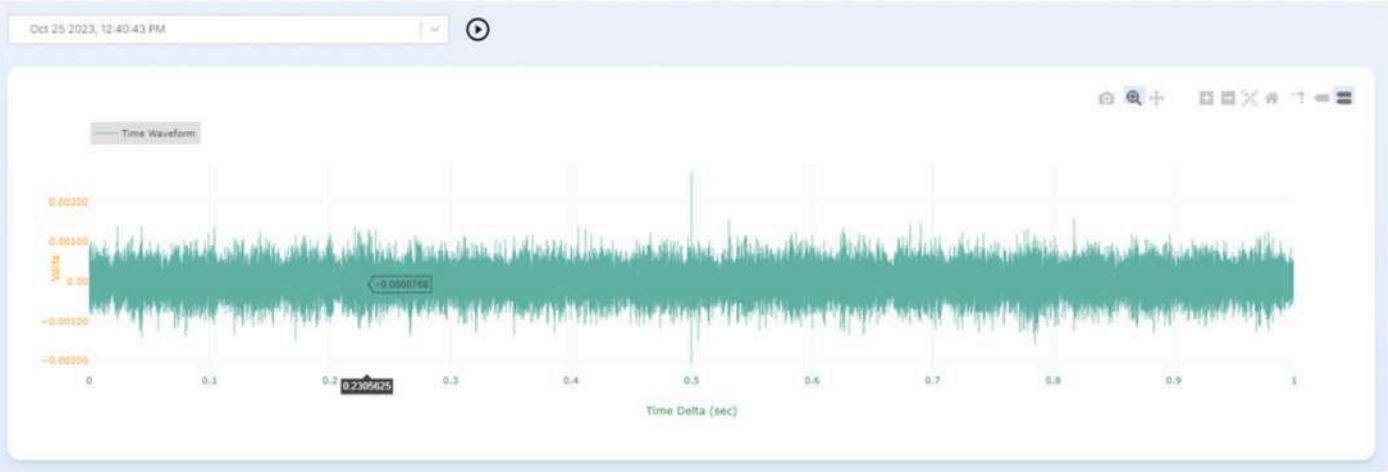
Time Waveform



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Magnetic Flux

The graph represents magnetic flux near the sensor mounting position. It displayed in RMS, Spectrum and Time Waveform.

Temperature

Temperature graph represents surface temperature of each location on which the sensor is mounted.

Humidity

The humidity graph represents the atmospheric humidity value near the sensor.

Speed

The speed graph provides RPM of the equipment, which is extracted from the vibration or flux signal.

Device Metrics

The connectivity graph provides the strength of the network. Higher values (greater than -70dBm) represent good connectivity.

Upload speed is measured and displayed in trend with every data upload.

The battery graph indicates the current status of battery life.

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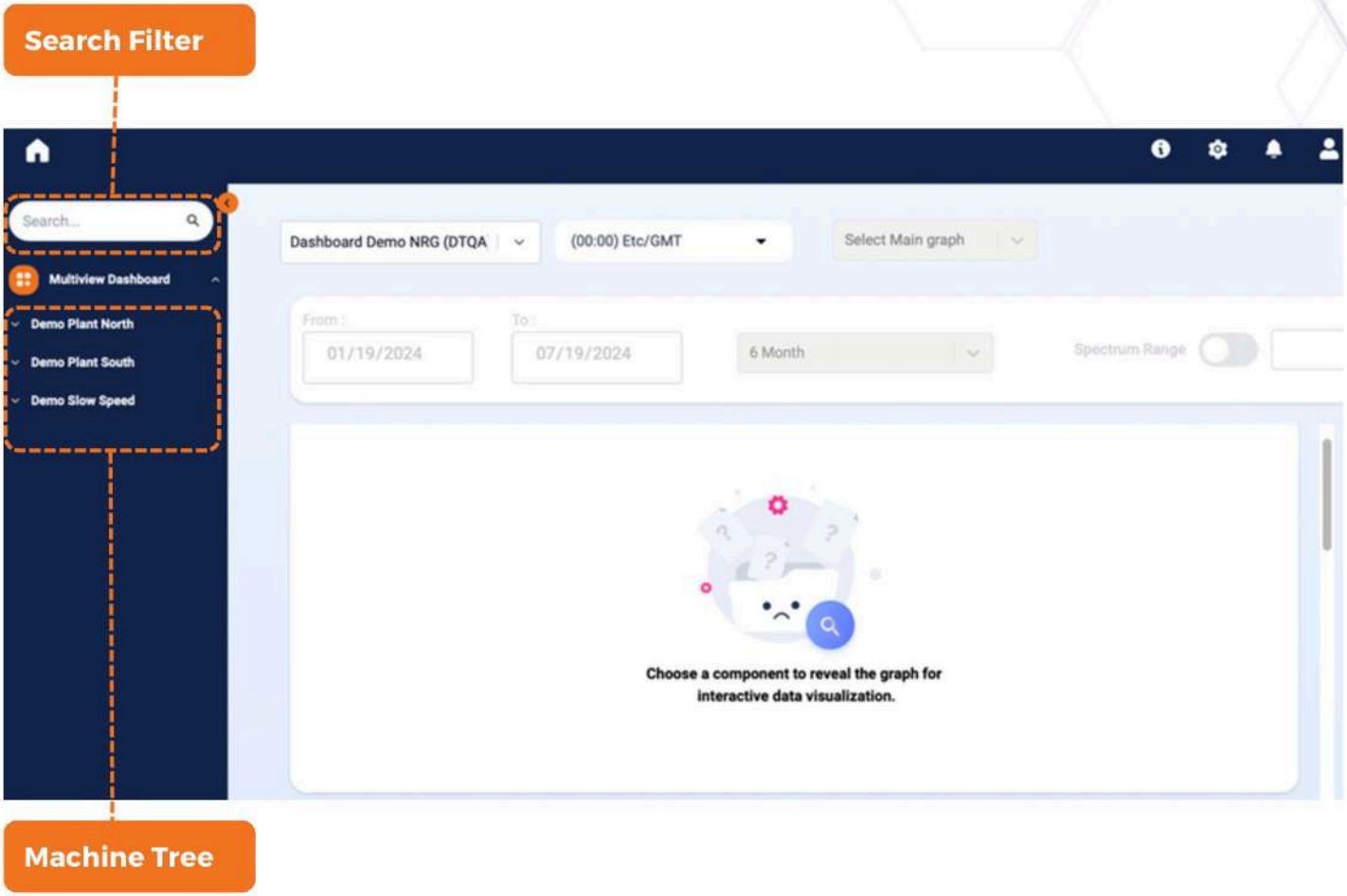
Multi View



Getting Started

To populate Multiview dashboard, use the Machine Tree in the navigation pane to view the graphs for those component(s). Use the Search Filter to quickly identify plants, equipment, and components.

Select and compare charts across different components and data types.

If only one component is selected, RMS & Peak vibration, sound, and temperature charts will be shown. Vibration RMS will be the default chart for more than one component selected. Default chart is changed via the selector.

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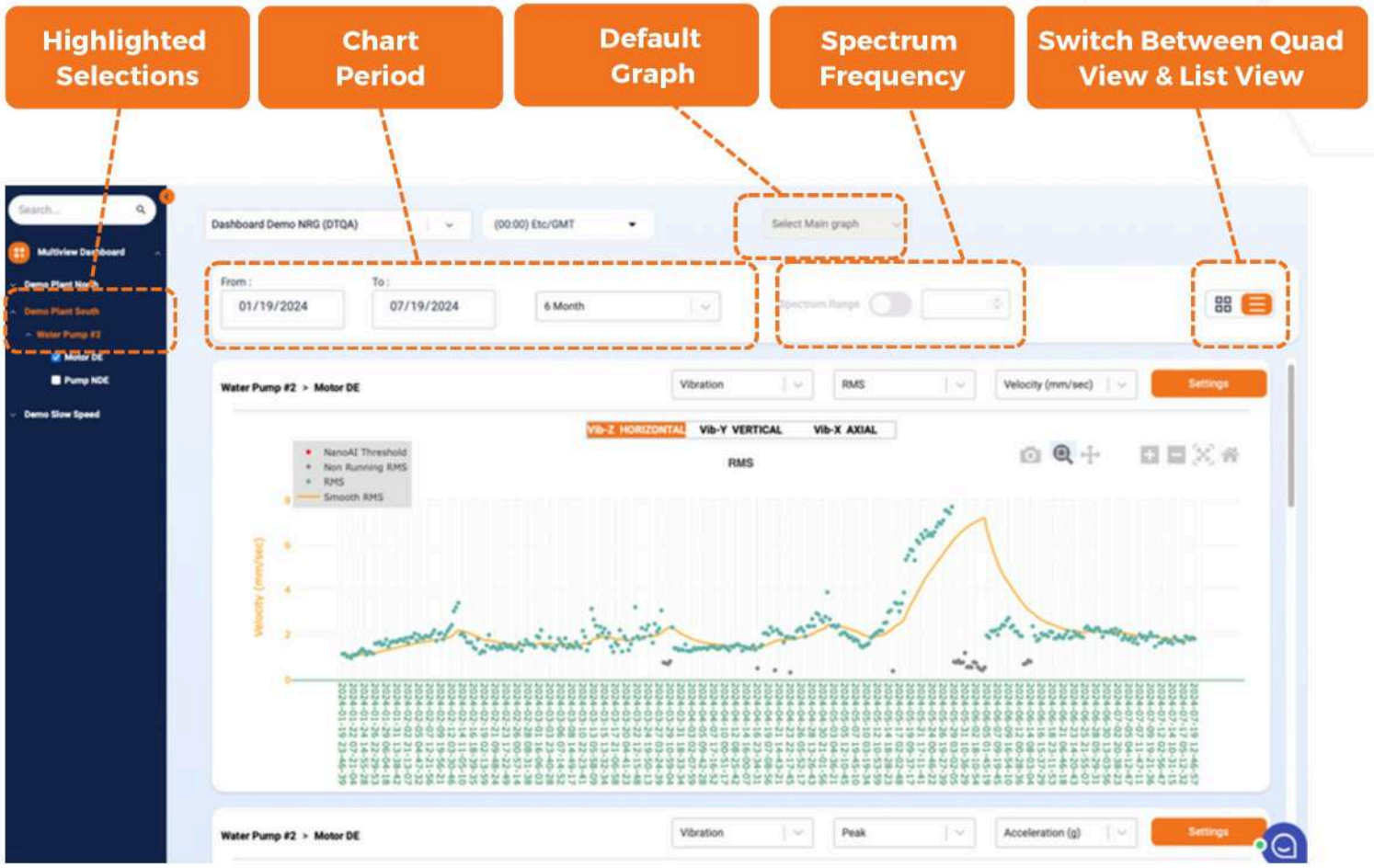
Multi View Settings



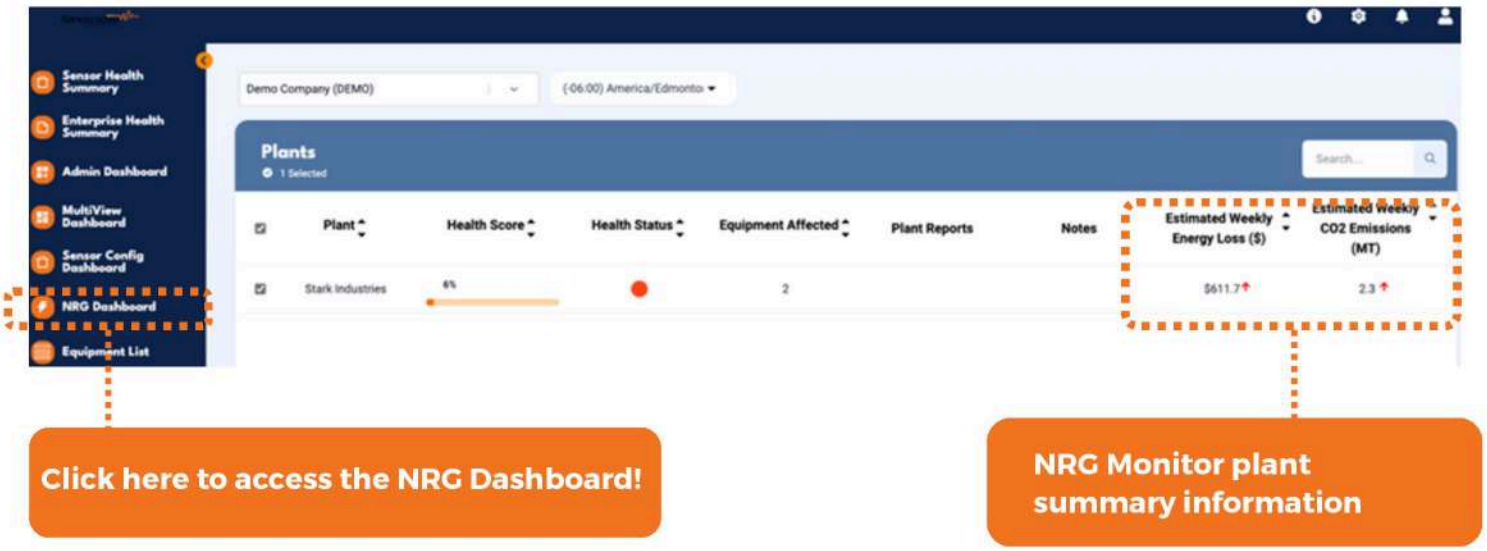
NRG Dashboard

Nanoprecise's NRG Dashboard revolutionizes maintenance strategies by focusing on energy optimization and sustainability. Through predictive analytics, it anticipates energy consumption changes and enables early fault detection to reduce energy waste and lower operating expenses.

Where to find

Access your NRG Dashboard via the left navigation pane upon logging into the Nanoprecise platform.

Login:



Click here to access the NRG Dashboard!

NRG Monitor plant summary information

Settings

Company Selection

If applicable, and with the appropriate user credentials, users may view the NRG Dashboards for individual organizations and companies.
Note: Click home to return to the main landing page.

Chart Period

Use the “From” and “To” date selectors to set the time window when viewing the Historical Increased Energy Consumption chart. This helps observe the change over time. Toggle between: Daily, Weekly, Monthly and Quarterly intervals.

Chart Units

Toggle between units across ΔEnergy Consumed (kWh), ΔEmissions Generated (MTCO2) and Cost of ΔEnergy Consumed (Using currency based on user’s region).
Note: This setting affects both the Total Change in Energy Consumption and Historical Change in Energy Consumption charts.

Total Change in Energy Consumption

Here is the aggregate change in power consumption across all equipment type classes. This delta (change) in power consumption is indicated as it relates to the baseline performance of individual equipment.

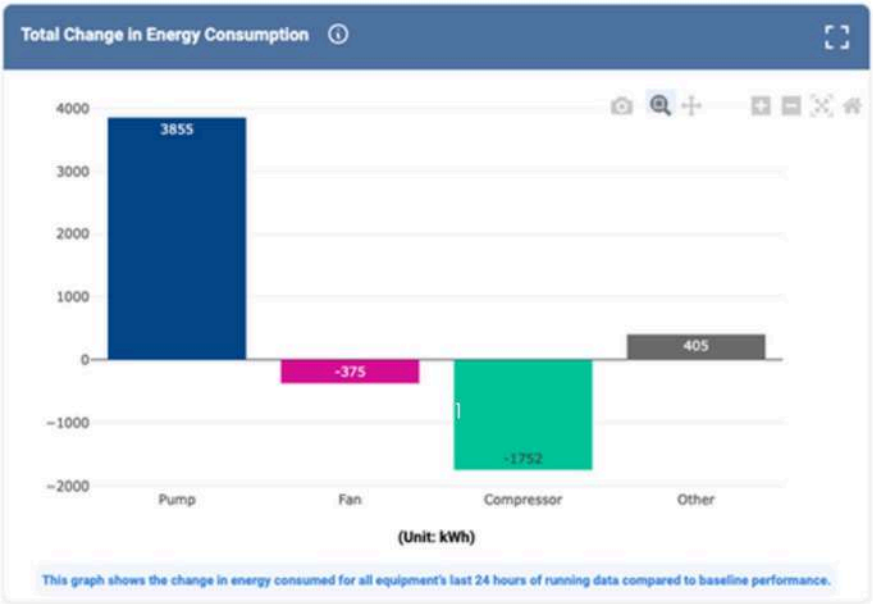


Chart Features

Equipment Type: Depending on the different types of equipment being monitored, they will show up as individual color-coded columns in this chart.

Total kWh Increase (or Decrease): For each equipment type column, the numerical value indicates the total kWh increase (negative value for decrease) of power consumption for all equipment of that equipment type.

Chart Viewer Controls: On top of the chart are the viewer controls. Users can download (screenshot), zoom, pan, and autoscale (reset zoom). Users can also enlarge the chart via the maximize icon on the top right.

Units Adjustment: The units selector on the top right of NRG Dashboard toggles Δenergy consumption metrics in the form of energy (kWh), emissions (MT CO2), or currency (region-based). All metrics are equivalent estimates.

Total Power Rating for All Monitored Equipment

Here is the distribution of a plant/organization's equipment types and the total power rating across all their equipment (in Horsepower). This is for latest data shown today.

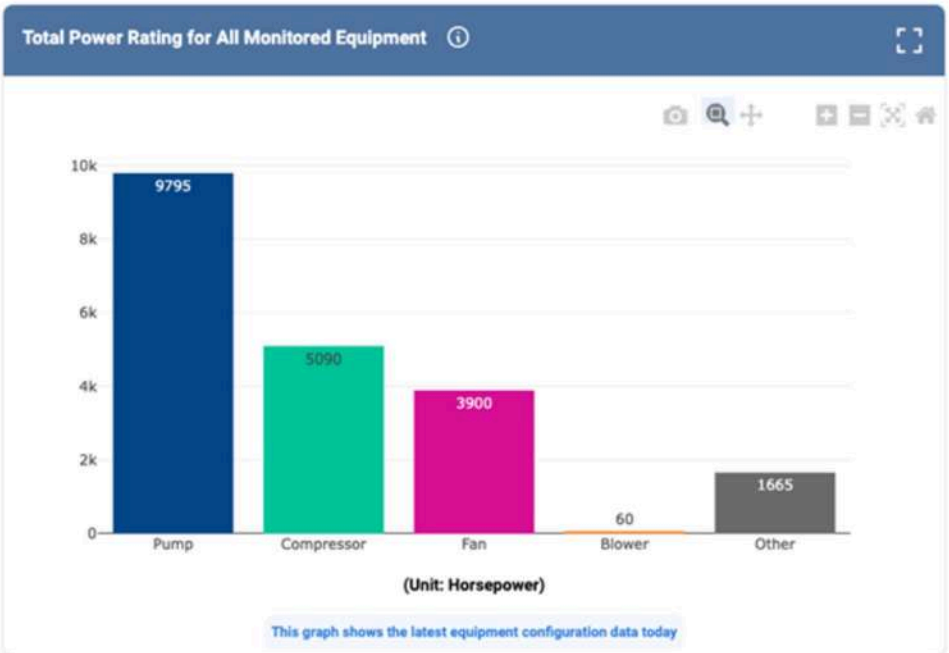


Chart Features

Equipment Type: Depending on the different types of equipment being monitored, they will show up as individual color-coded columns in this chart.

Total Horsepower Rating: For each equipment type column, the numerical value indicates the total horsepower of all equipment of that type. This data is static and unaffected by NRG Dashboard period or unit settings.

Chart Viewer Controls: On top of the chart are the viewer controls. Users can download (screenshot), zoom, pan, and autoscale (reset zoom). Users can also enlarge the chart via the maximize icon on the top right.

1Baseline performance as analyzed by Nanoprecise NRGMonitorTM

Historical Change in Energy Consumption

Here is a pareto chart on the trend for changes in power consumption for all an organization's equipment. This delta (change) in power consumption is indicated as it relates to the baseline performance1 of individual equipment.

Chart Features

Total kWh Increase (or Decrease): For timestamp columns, the numerical value indicates the total kWh increase (negative value for decrease) of power consumption compared to baseline[1] This is for all the company's equipment.

Cumulative Energy Losses (or Savings): The cumulative line shows the aggregate energy losses (negative value for savings)as time has passed.

Chart Viewer Controls: On top of the chart are the viewer controls. Users can download (screenshot), zoom, pan, and autoscale (reset zoom). Users can also enlarge the chart via the maximize icon on the top right.

Units Adjustment: The units selector on the top right of NRG Dashboard toggles Δenergy consumption metrics in the form of energy (kWh), emissions (MT CO2), or currency (region-based). All metrics are equivalent estimates.

Period Adjustment: The period selector on the top right of NRG Dashboard can change the time interval (select window between two dates) and frequency (daily, weekly, monthly or quarterly) of the trend data.

[1] Baseline performance as analyzed by Nanoprecise NRGMonitorTM

Energy Intensity Last 24h

Here is the measured energy intensity for all a company's plants over the past 24 hours. This is a ratio of the change in power consumption for all equipment to the total rated power for all equipment. Higher values indicate more inefficiency when compared to baseline.[1]

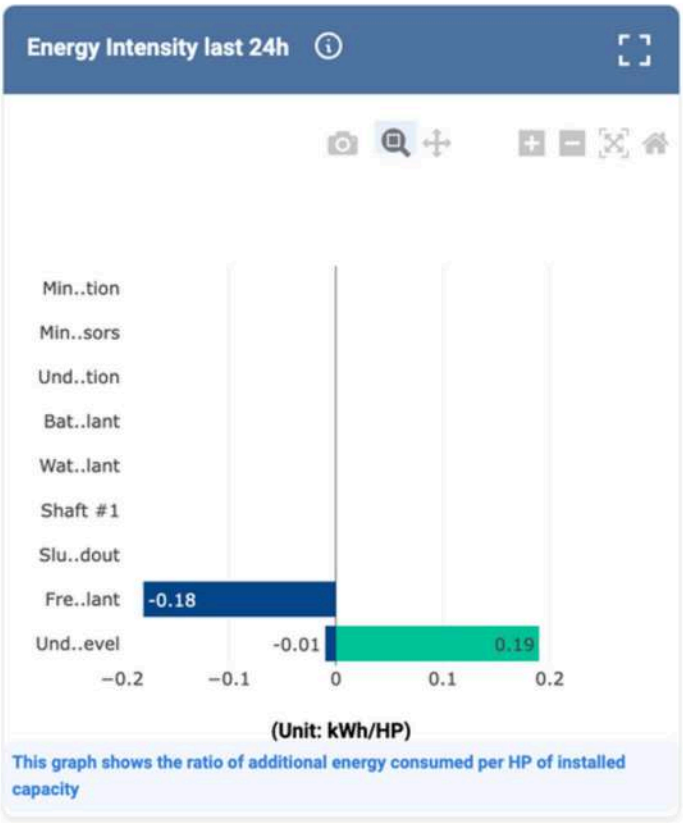


Chart Features

Plant: Depending on the user's access credentials, the rows of this chart will show the various companies/plants of the organization.

Energy Intensity: For each row, the numerical value indicates the energy intensity across all a plant's equipment for the past 24 hours. Higher values indicate increasing inefficiency while negative values suggest improvements.

Chart Chart Viewer Controls: On top of the chart are the viewer controls. Users can download (screenshot), zoom, pan, and autoscale (reset zoom). Users can also enlarge the chart via the maximize icon on the top right.

[1] Baseline performance as analyzed by Nanoprecise NRGMonitorTM

Config Dashboard

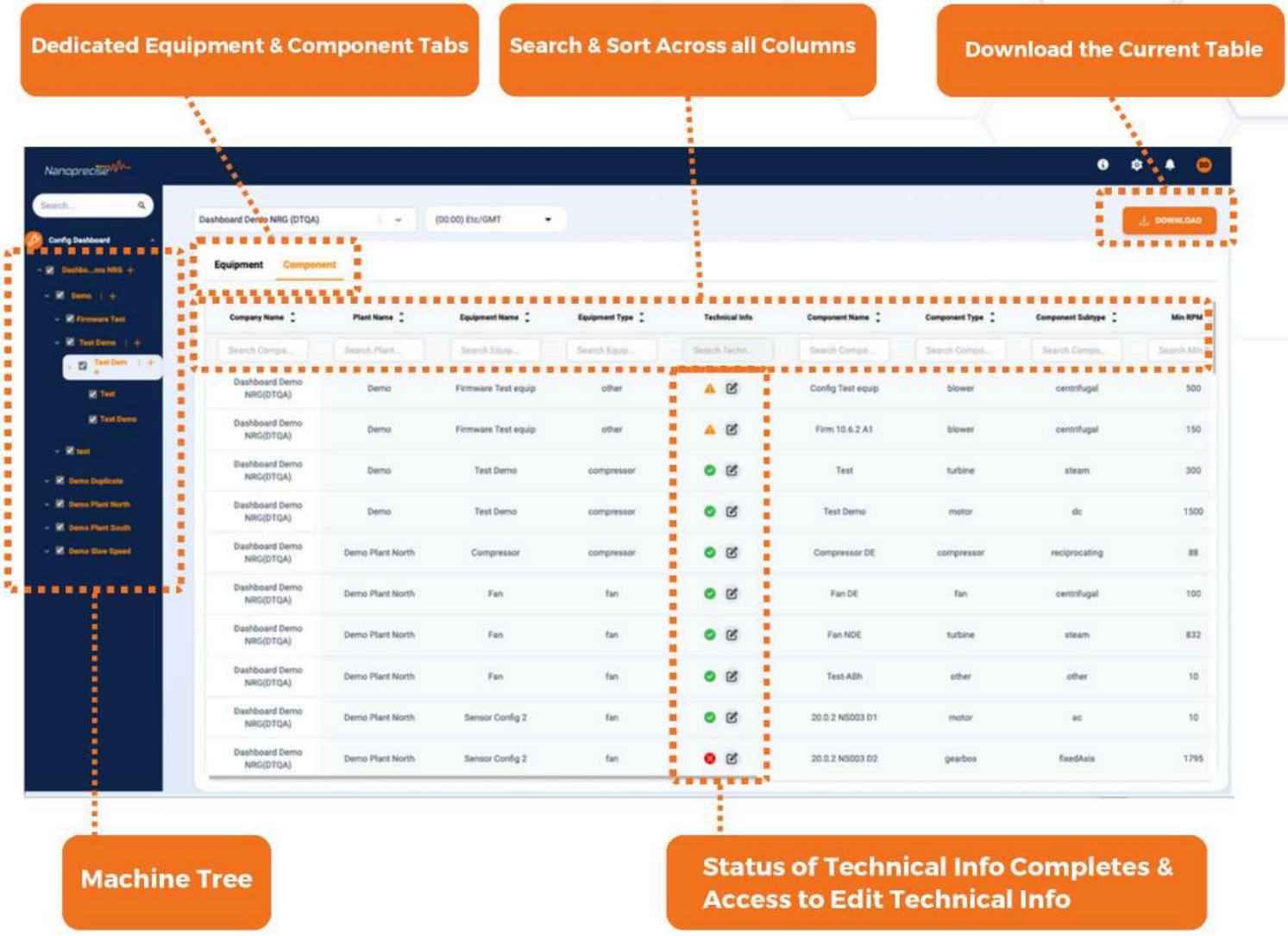
Nanoprecise's new Config Dashboard is designed to enhance usability and speed up the configuration process, by taking the configuration functionality of the DIY mobile app and adding it directly to the dashboard itself.

Where to find

Admins/Super Admins can find the "Config Dashboard" in the side menu upon logging into the Nanoprecise platform.

Login:

Click here to access the Config Dashboard!

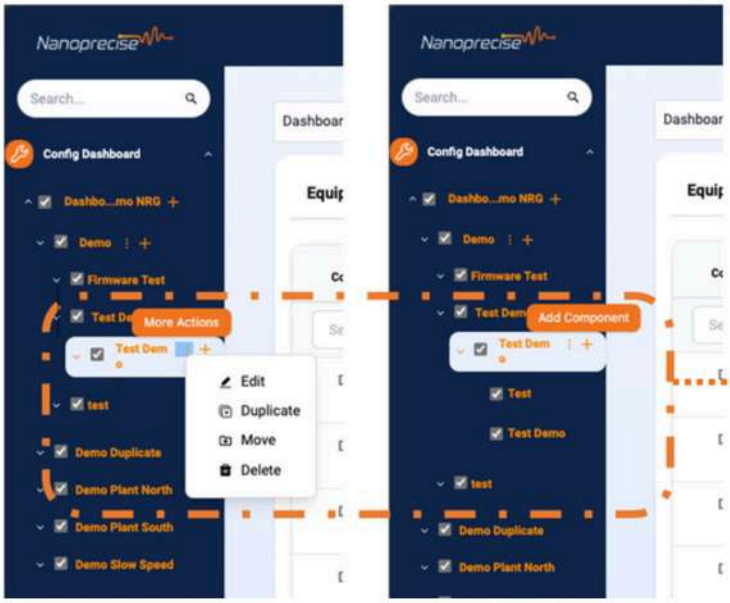


Getting Started:

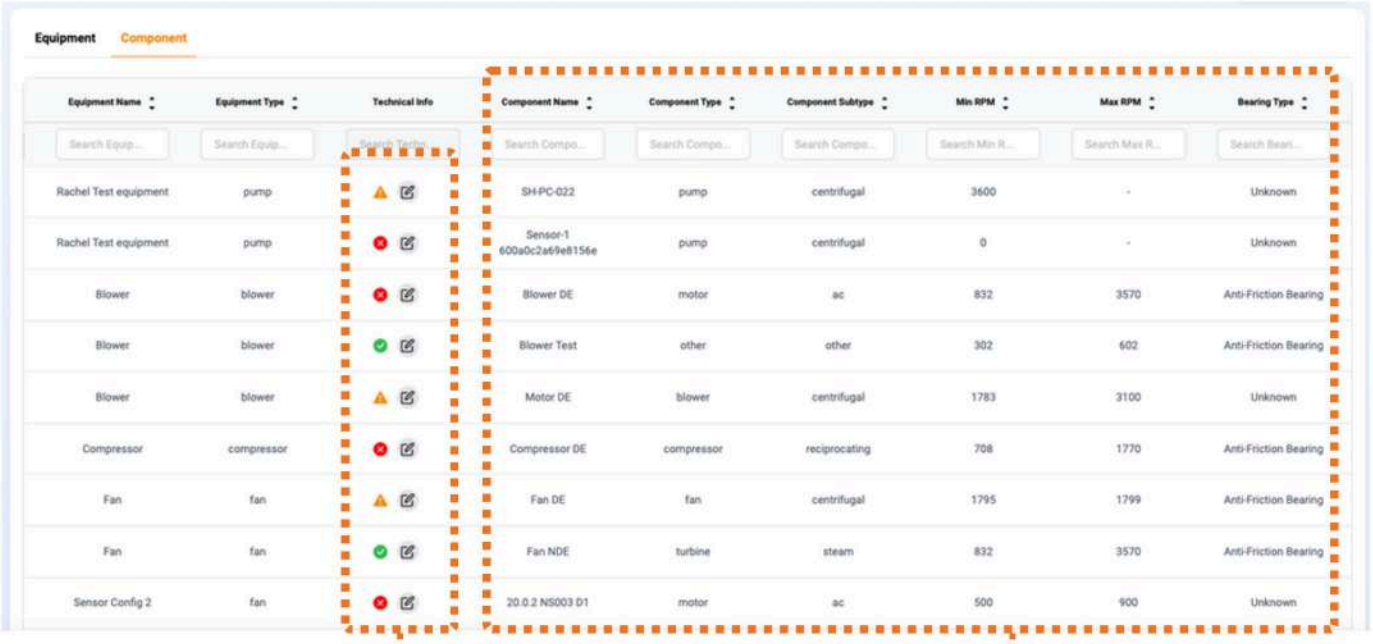
- Navigate through the Machine Tree or Tabular view with "equipment" and "Component" tabs.

Key Features:

- **Hierarchical Management:** Easily add, configure, and manage equipment at different levels.
- **Asset Editing:** Edit, duplicate, move, or delete assets directly from the machine tree. Technical Info: Ensure data completeness with indicators for missing or complete info.
- **Quick Config:** Edit details like speed, horsepower, RPM, and bearing types via a popup.
- **Search:** Quickly find equipment or components by name or type.



Assets can be added, edited, duplicated, moved or deleted directly from the Machine tree.



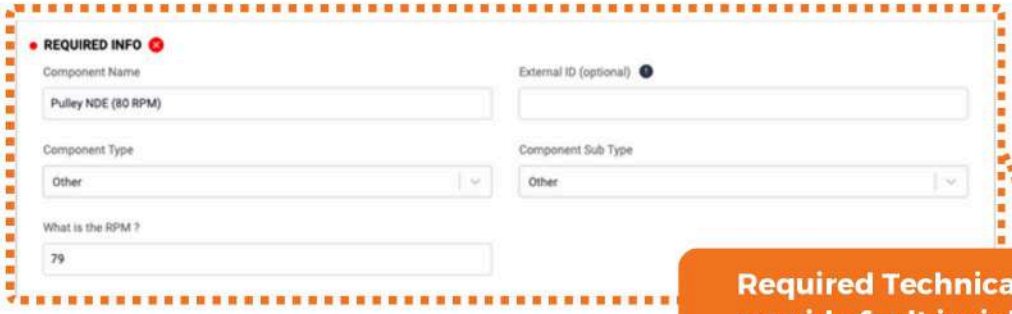
Equipment | Component

Equipment Name	Equipment Type	Technical Info	Component Name	Component Type	Component Subtype	Min RPM	Max RPM	Bearing Type
Rachel Test equipment	pump		SH-PC-022	pump	centrifugal	3600	-	Unknown
Rachel Test equipment	pump		Sensor-1 600a0c2a69e8156e	pump	centrifugal	0	-	Unknown
Blower	blower		Blower DE	motor	ac	832	3570	Anti-Friction Bearing
Blower	blower		Blower Test	other	other	302	602	Anti-Friction Bearing
Blower	blower		Motor DE	blower	centrifugal	1783	3100	Unknown
Compressor	compressor		Compressor DE	compressor	reciprocating	708	1770	Anti-Friction Bearing
Fan	fan		Fan DE	fan	centrifugal	1795	1799	Anti-Friction Bearing
Fan	fan		Fan NDE	turbine	steam	832	3570	Anti-Friction Bearing
Sensor Config 2	fan		20.0.2 NS003 D1	motor	ac	500	900	Unknown

Review Technical Info Completeness Status & select edit to add or update info

Find all relevant technical info in easy to navigate columns

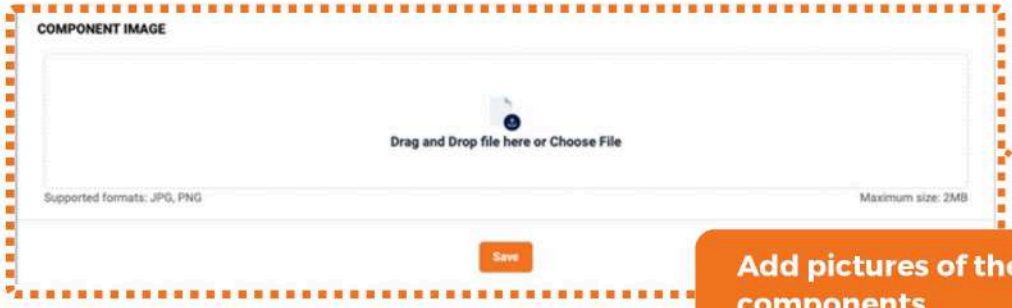
Component Configuration:



Required Technical Info, is needed to provide fault insights. Requested info will vary based on component type.

Recommended Technical Info, will assure optimal monitoring of all possible fault modes for the component type.

Easily Assign/Reassign the SensorID and mounting config



Add pictures of the equipment and components

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Appendix A

NanoAI Alarm & Adaptive Fault Amplitude Threshold

- Threshold is automatically updated every 30 days based on the data of the last 30 days
- AI trained model is used to capture the features of data
- Threshold is set/modified to adapt to the features
- No prior knowledge is required from customer
- Alarms will be automatically sent to customer if RMS/Peak hits the threshold
- Applies to RMS/Peak of vibration signals (acceleration & velocity) and RMS of ultrasonic signals
- It can also be applied to Amplitude fault trends

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Prediction with Precision

Appendix B

Vibration

Waveform

A plot of amplitude versus time. The waveform illustrates how the vibration signal (i.e., acc., vel., and dis.) appears when graphed as amplitude over time.

Spectrum

- A plot of amplitude versus frequency.
- The Spectrum is obtained by applying a Fast Fourier Transform (FFT) on Waveform, which breaks the signal down into specific amplitudes at various component frequencies
- If a machinery problem exists, FFT Spectrum provides information to help determine the location of the problem, the cause of the problem, and, with trending, how long until the problem becomes critical
- Because we know that certain machinery problems occur at certain frequencies, we analyze the FFT spectrum by looking for amplitude changes in certain frequency ranges

Frequency Spectrum Waterfall

- A three-dimensional plot in which multiple vibration spectra curves are displayed simultaneously
- On the Nanoprecise Dashboard, vibration frequency spectrum waterfall plot covers multiple spectra for the last 7 days
- By using the frequency spectrum waterfall plot, it can show how the frequency spectral structure changes over time

Amplitude

The maximum amplitude for the fault characteristic frequencies and its harmonics up to 10th order. This amplitude describes the severity of a specific fault mode. Nanoprecise uses such amplitudes for RUL calculation.

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Vibration

Peak

Peak value in time domain. The maximum excursion of the time wave from the zero or equilibrium point in the time domain.

Kurtosis

Kurtosis is a statistical parameter used to characterize a signal. Kurtosis provides a measure of the peak of a vibration signal. Signals that have a higher kurtosis value have more peaks that are greater than three times the RMS value, which are, for mechanical vibration signals, the impulses introduced by the mechanical impacts, indicating the potential mechanical fault.

RMS

Root Mean Square is the square root of the average of the squared values of the vibration waveform. RMS describes the vibration energy in the machine. The higher the vibration energy, the higher the vibration RMS is.

Magnetic Flux

Time Waveform

The time waveform illustrates how the magnetic flux appears when graphed as amplitude over time.

Frequency Spectrum

A plot of amplitude in micro voltage versus frequency. The Flux spectrum describes the amplitude at each frequency component.

RMS

Root Mean Square is computed from the spectrum to quantify the magnetic flux energy emitted by the machine.

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Sound

Time Waveform

The Acoustic Emission (AE) waveform illustrates how the AE signal appears when graphed as amplitude over time.

Frequency Spectrum

A plot of amplitude in micro voltage versus frequency. The AE spectrum describes the amplitude at each frequency component.

Frequency Spectrum Waterfall

- A three-dimensional plot in which multiple AE spectra curves are displayed simultaneously
- On Nanoprecise Dashboard, AE frequency spectrum waterfall plot covers multiple spectra for the last 7 days
- By using the frequency spectrum waterfall plot, it can show how the frequency spectral structure changes over time

RMS

Root Mean Square (RMS) is the square root of the average of squared values within the AE waveform. RMS characterizes the acoustic emission (AE) energy emitted by the machine. A higher AE energy level corresponds to an elevated AE RMS value.

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Appendix C

Health Status

Health Status is defined by a combination of Fault Severity of the worst condition Fault Amplitude of that component and the Remaining Useful Life.

HELP INFORMATION

Based on the comprehensive signal processing and transfer learning techniques, fault severity is analyzed and trended subject to ASNT standards with proper severity stage categorization by our algorithm. Various health summary metrics in the dashboard are linked to the fault severity as mentioned in the following table:

Fault Severity	Remaining Useful Life	Health Status	Fault	Suggestion
lower than stage 2	>75%	Healthy	Not Available	None
stage 2	>50%	Healthy	Not Available	None
stage 2 & fault anomaly detected*	>50%	Needs maintenance review	Applicable fault	Review maintenance plan and parts availability
stage 3	>750 hours	Needs maintenance review	Applicable fault	Review maintenance plan and parts availability
stage 3	251-750 hours	Needs attention	Applicable fault	Schedule maintenance activity
stage 3	<250 hours	Needs immediate attention	Applicable fault	Repair immediately
stage 4	0	Needs immediate attention	Applicable fault	Repair immediately

*fault anomaly detected: fault amplitude data exceeds NanoAI Amplitude threshold

Health Score

Health score on Plant level is the average rating of each equipment health status under the plant. Assuming Plant A has 4 different equipment in it. Each equipment has 4 health modes with following health modes and associated score of ranking.

- **Healthy - 3**
- **Needs Maintenance Review - 2**
- **Needs Attention - 1**
- **Needs Immediate Attention - 0**

If two equipment are in the Healthy mode, 1 is in Needs Maintenance Review mode and 1 is in Needs Attention mode then he health score will be calculated by averaging the total score. In this case, it will be calculated as 3 + 3 + 2 + 1 / 12 = 0.75 = 75 is the health score

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Remaining Useful Life

The Remaining Useful Life (RUL) in the notification is given either in percentage or in hours, by considering both the absolute amplitude values and the relative amplitude trend.

- **Absolute Amplitude Values: Determining whether it is above or below Stage 3**
- **Relative Amplitude Trend: Determining whether it is increasing or not**

  - **If the trend is flat, even though its absolute value is beyond Stage 3, the predicted RUL to reach Stage 4 would still be very large**
  - **Otherwise, the increasing trend would lead to a short-predicted RUL to reach Stage 4.**

Fault Stage	Predicted RUL in hours	RUL Representation on Dashboard
Stage 1	NA	Percentage
Stage 2	NA	Percentage
Stage 3	>750	Hours
	<750	Hours
Stage 4	>750	Hours
	<750	Hours
Note 2	Two factors are taken into consideration for RUL calculation: Absolute Amplitude and Relative Amplitude Increasing Trend.	
Note 1	By NA for Stage 1 and Stage 2, it means the RUL will be represented in percentage regardless of the value of predicted RUL in hours.	
Note 3	750 hours is around one month, being treated as the boundary to have RUL in percentage or in hours.	
Note 4	When the Remaining Useful Life (RUL) is expressed in hours, immediate action accompanied by a field check is necessary, as the escalating trend in detected fault amplitude would be substantial.	
Note 5	When the Remaining Useful Life (RUL) is presented as a percentage, continuous monitoring is required without immediate action, as the detected fault amplitude would likely remain relatively consistent.	

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