



Brüel & Kjær Vibro

Product Data

COMPASS™ Performance Monitoring Software
Part of the Type 3540 COMPASS™ — Version 6.x or higher

Application Software Types 7109, 7110, 7116, 7120-X

COMPASS “X-Plot” Enhanced Scalar Plot Software – Type 7110

The **Type 7110 COMPASS “X-Plot” Enhanced Scalar Plot Software** is an ‘add-on’ which can be used with most of the other application packages for plotting scalar data. The displayed data can be intermittently or continuously monitored from any machine state. The program is primarily aimed at performance monitoring but may also be used in many other applications. Extensive and versatile plot display features are available such as graphical zoom, editing functions, scaling, advanced reporting, plot annotations, and more!

Data validation and operating conditions

For intermittent measurement data, a permissible, user-defined time difference between the data sets is used for plotting data. Thus, only valid data is plotted.

The measurement data can also be constrained to one or more scalar measurements, i.e. operating conditions, and displayed together in a plot. For example, if it is desired to display polytropic efficiency and compressor capacity values only for a constant RPM value for analysis purposes, the RPM measurement can be set up as a constraining operating condition. That means the data will not be plotted if the RPM value is outside the pre-defined limits. Any parameter can be used as constrained operating conditions (e.g. load, inlet turbine temperature, etc.), and since the operating conditions are global within the same database, each operating condition may be re-used in connection with several setups. Any number of these pre-setups can be stored.

Cursors

Each data pair is indexed by a number, which indicates the time relationship between the plotted data sets and the time of the measurement. The data sets are displayed together with the operating condition values as the cursor is moved.

Plot comments

It is possible to write short comments that are visible in the plot at any user selected instance of time. More comprehensive user comments can be displayed by clicking in the plot at that instance of time. These comments are visible no matter which plot is open.

Scalar vs. scalar plot

Any scalar value in the COMPASS database can be plotted against another scalar value in X-Y axis coordinates.

In addition to measured data it is also possible to construct one or more reference baseline curves, such as a compressor map, which can be displayed together with the X, Y values to graphically show deviations. The interpolated deviations are shown in the plot, and of course are automatically monitored by COMPASS to alarm limits as a separate process. A Baseline curve may be generated by using the mouse, i.e. point-and-click in the plot area, or by reading values from a disk file.

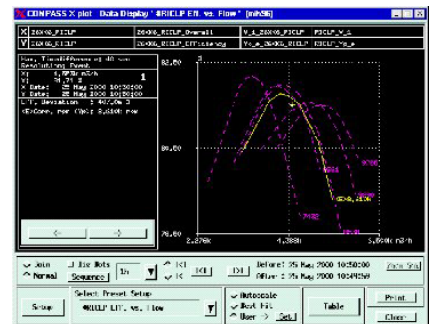


Fig. 14 Scalar vs. Scalar plot

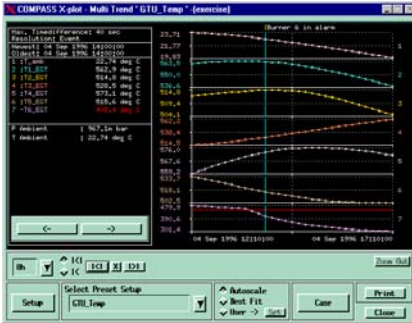


Fig. 15 Multiple Trend plot

Multiple Trend plot

Several history plots may be simultaneously displayed for correlation diagnostics. All cursor values for each plot are simultaneously displayed. The time axis can be scrolled or stretched by a click of the mouse.

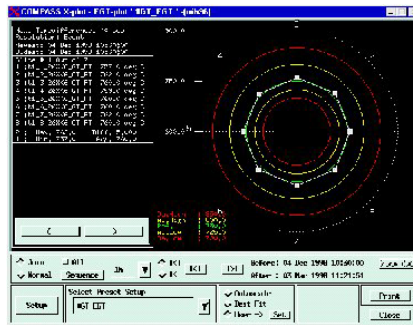


Fig. 16 EGT plot

EGT plot

This plot can simultaneously display more than 15 scalars configured by user -defined angles in a single plot and still give excellent overview. Alarm limits are also shown. The EGT (exhaust gas temperature) plot plays an important role in the Performance Monitoring Application Database 7120-GT.

Specifications 7110

Special Plot Features Available with this Package *)

Feature	Comments
Annotations	Comments at a specific point in time, saved with the plot
Constrained data display	Data sets plotted only if the user-defined constraining measurement is within limits
Data validation	Data sets plotted only if the time between values is within limits
Zoom	Zoom in a part of the plot using mouse clicks
Reports	User comments can be generated together with plots

Performance Plots Available with this Package *)

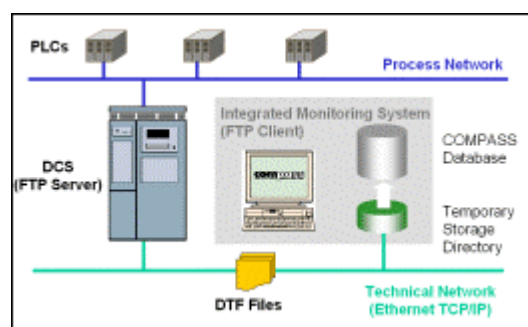
Plot Name	Comments
Scalar vs. scalar	X, Y data display with reference baseline curves
EGT	Exhaust gas temperature spread polar plot with alarm limits.
Multiple trend	Several scalar history plots can be simultaneously displayed, each with its own y-axis scale.

*) These plots are normally pre-defined for a specific machine in the relevant Performance Monitoring Application Database product Type 7120-X

Imported and Calculated Measurement Software – Type 7109

The Type 7109 Imported Process and Calculated Measurement Software is also an 'add-on' that can be used with most of the other application software packages. Although it is a primary building block to the performance monitoring application, it can also be used in other applications. This package consists of two types of measurements:

- Imported process measurements
- User-defined calculated measurements



Imported Measurements

The Type 7109 allows process data to be automatically imported from existing control, monitoring and information systems, where it can be monitored and stored by COMPASS just like any other COMPASS process measurement.

Integrated monitoring strategy

The 7109 allows COMPASS to be used as an integrated monitoring system platform, where data from several other control, monitoring and information systems can be monitored and stored in COMPASS. This means there is a unique method for automatic alarm handling, a unique database, and a unique measurement plot user-interface for diagnostic analysis and trending. This has several benefits:

- Both dedicated monitoring systems with specialized measurement techniques can utilize COMPASS's advanced monitoring and diagnostic capabilities - no need to throw these out!
- Specialized monitoring data can be easily correlated using COMPASS's multi-trend plots and advanced scalar vs. scalar plot facilities, thus improving the reliability and accuracy of early fault detection and diagnosis
- Reduce COMPASS monitoring system hardware and transducers by importing process data from the existing distributed control system (DCS) - perfect for performance monitoring, residual life assessment calculations or statistical analysis

Performance monitoring applications

Imported measurements (as well as the Calculated measurements) play an important role in COMPASS's performance monitoring strategy, and is thus an integral part in COMPASS's Performance Monitoring Software package. This is because the DCS systems of many petrochemical and power industries provide most of the necessary process data needed for proper thermodynamic calculations used for performance monitoring.

Data transfer technique

Overall value measurements (scalars) can be imported by several means –

- Text file sent over a TCP/IP LAN/WAN network using file transport format (FTP)

- Keyboard input
- Text file on diskettes or tape

A special purpose program is provided that opens the imported measurement text files when they are received, reads the measurement values, compares them to alarm limits and then stores the measurements in the database.

Calculated Measurements

The Type 7109 also allows you to create customized measurements for specific monitoring applications, based on user-defined formulas that use constants, measured data or other calculated measurements as variables. Process measurements such as temperature, pressure, load, etc., can give a limited indication on the condition and/or performance of a machine. In many cases, however, calculated parameters which are not directly measurable give the best results, as in the case of thermodynamic parameters used in performance monitoring. This is also true for parameters used in residual life assessment calculations or statistical analysis in general.

Like the Imported measurement or any other COMPASS scalar measurement (i.e. overall value measurement), the Calculated measurement is treated in the same way - same automatic monitoring and alarm handling capability, stored in the same database, and displayed in the same measurement plot user-interface for diagnostic analysis and trending.

Powerful toolbox

The 7109 includes a number of built-in functions (i.e. pre-defined formulas) that can be used as building blocks in a complete Calculated measurement formula for a specific user-defined application. The 7109 also includes a wide range of operators - similar in syntax to that used in popular spread sheet programs - that can be used in creating or editing your own Calculated measurement formulas:

- Arithmetic operators (+, -, ×, /, ^, ())
- Comparative operators (>, <, =, >=, <=, <>)
- Logical operators (.AND, .OR.)
- Conditional operators (If ... then, else)

Performance monitoring applications

As with the Imported measurements, Calculated measurements play an important role in COMPASS's performance monitoring strategy, and is thus one of the necessary building blocks to COMPASS's Performance Monitoring Software a package. The 7109 is well suited to this application since thermodynamic calculations have to be flexible. They often have to be customized or 'fine-tuned' to optimise the performance monitoring of the individual machines.

Time-based Maintenance Scheduler

This monitoring function allows you to keep track of running hours between maintenance intervals using Calculated measurements with alarm limits. When an alarm is activated, this indicates it may be necessary to do an inspection, perform greasing, or replace certain machine components.

Specifications 7109

Measurements Available with this Package

Meas. Name	Comments
Calculated Measurement	Formula syntax is similar to the MS Excel®. There are over 50 mathematical functions available. A list of these can be provided on request.
Imported Measurement	<p>Data transmission rate Single data, max. 30 scalars/min. Data block of data, max. 300 scalars</p> <p>File requirements for data transfer See your Brüel & Kjær, Schenck Sales Representative for more information</p>

Built-in Functions Available with this Package

Built-in Function	Meaning
abs(x)	Absolute value of x.
acos(x)	Arc-cosine of x.
alert(n)	Alert alarm status of symbol n. Returns a "1" if measurement violates alert limit, else "0".
alog(x)	Base 10 antilogarithm (10x).
asin(x)	Arc-sine of x.
atan(x)	Arc-tangent of x.
avg(x1, x2, ... xn)	Arithmetic average value of x1, x2, ... and xn.
avg_value(n, t1, t2)	Average value of symbol n from time t1 to t2. The result receives time stamp t2.
cos(x)	Cosine of x.
cosh(x)	Hyperbolic cosine of x.
danger(n)	Danger alarm status of symbol n. Returns a "1" if measurement violates Danger limit, else "0".
date_conv("yyyy-mm-dd hh:mm:ss.s")	Converts time (only GMT time can be used) in a standard format (i.e. "yyyy-mm-dd hh:mm:ss.s") to UNIX time (seconds counting from 1 January, 1970, 00:00:0.0).
day()	Number of seconds in one day.
default(x1, x2)	Default value. Returns default value x2 if x1 is invalid, else x1.
e()	Base of natural logarithm (e).
exp(x)	Natural antilogarithm (ex).
former(n)	Returns the next to last value for the given Symbol n.
FormerT(n,t,x)	Returns the most recent value of Symbol n for the time period going back x values from timestamp t.
geo(x1, x2, ..., xn)	Geometric mean of x1, x2, ... and xn, i.e. nth root of the product x1*x2* ...xn.
hour()	Number of seconds in one hour.
in_range(x1, x2, x3)	In range value test. Returns 1 if x2 < x1 < x3, otherwise returns 0.
int(x)	Value of x truncated to an integer. Same as trunc(x).

Built-in Function	Meaning
inv()	Invalid value.
ln(x)	Natural logarithm of x.
log(x)	Base 10 logarithm of x.
max(x1, x2, ..., xn)	Maximum value of x1, x2, ... xn.
max_value(n, t1, t2)	Maximum value of symbol n from time t1 to t2. The result receives time stamp t2.
min(x1, x2, ..., xn)	Minimum value of x1, x2, ... xn.
min_value(n, t1, t2)	Minimum value of symbol n from time t1 to t2. The result receives time stamp t2.
minute()	Number of seconds in one minute.
mod(x1, x2)	Floating point remainder of x1/x2.
month()	Number of seconds in one month.
mstate	Returns the current machine state as a value for a given Symbol n.
now()	Current UNIX time in seconds counting from 1 January, 1970, 00:00:0.0.
pi()	π
rand()	Random real number value between 0 and 1.
round(x)	Value of x rounded to the nearest integer.
seq(x1, x2, ..., xn)	List of values in a sequence.
sin(x)	Sine of x.
sinh(x)	Hyperbolic sine of x.
sleep(x)	Pause function for x seconds.
spread(x1, x2, ..., xn)	List of normalized values in a sequence.
sqrt(x)	Square root of x
stamp(x, t)	The latest values of all variables are used in the function x and the result stored in the database for the Calculated Measurement at time t.
std(x1, x2, ..., xn)	Standard deviation of x1, x2, ... xn.
tan(x)	Tangent of x.
tanh(x)	Hyperbolic tangent of x.
time(n)	Return time stamp associated to last value of n.
trunc(x)	Truncate value of x to an integer.
valid(x1, x2, x3)	In range value test. Returns x1 if $x2 < x1 < x3$, otherwise returns invalid value.
value(n, t)	Return value of symbol n at time t with time stamp t.
void()	The result of a formula is ignored regardless of which result has been returned.
week()	Number of seconds in one week.
year()	Number of seconds in one year.

Performance Monitoring Software – Type 7116

The **Type 7116 Performance Monitoring Software** is used together with the Type 7120-X Application Database packages to allow your COMPASS system to automatically detect the slightest changes in process performance parameters for a wide range of specific machines. The 7116 is a complete software package that includes the 7109 and 7110.

This performance monitoring product can be used in a wide range of industries, but it is specially defined for the petrochemical and power industries. Here it is used for both performance assessment (e.g. optimising efficiency, reducing fuel consumption and emissions, etc.), as well as for detecting machine faults (e.g. leakage, erosion, fouling, worn or faulty components, etc.) which manifest themselves as degraded performance parameters. The 7116 is well suited to these applications since the 7120-X application database packages are based on the actual design data for specific machines (e.g. LM6000, gas turbine, etc.). This gives a high level of reliability and accuracy.



Integrated Monitoring

One of the major advantages of using the 7116 with COMPASS is that all vibration, process, performance and other data is stored in the same database, viewed in the same user interface, and treated with the same alarm handling strategy. Moreover, the 7116 is designed to accept the process measurements used in calculating the performance parameters from the client's distributed control system (DCS), so no COMPASS monitoring hardware is needed!

Special plotting tools are also available in the 7116 to easily correlate the data to more accurately diagnose and analyse developing machine faults.

Effective thermodynamic analysis

Much consideration has been given to ensuring the optimal thermodynamic calculation accuracy. For example, the Lee-Kessler method is used for calculating the properties of the gas mixture, and the Schultz factor is used in the polytropic compressor analysis.

The calculated performance parameters are also corrected to reference conditions. For gas turbines, the actual performance monitoring parameters are corrected to reference inlet conditions (e.g. ISO conditions), lower fuel heating value and load (for part load operation, correction curves are used). For compressors, the performance monitoring parameters are corrected to inlet gas conditions and composition.

Machine and gas/fluid properties

To ensure accurate performance parameters are calculated, much effort has been made to use machine manufacturer reference data concerning design baseload and part load performance, seal and thermal losses. These values are updated on-site as a 6809 service using data from testing.

The type of gas and fluid properties used in the thermodynamic calculations has a significant affect on the accuracy of the resulting performance parameters. The 7116 has an extensive library of gas and fluid properties:

- Natural gas properties

- Flue gas properties
- Air composition calculations
- Combustion calculations
- Steam and water properties

The Gas Composition Editor in the 7116 allows you to set up and manage a wide range of user-defined gas compositions.

Full monitoring capability

Performance parameters are monitored to alarm limits and trended just as the individual process parameters. Baseline data representing “new and clean” machine condition at on-site conditions can be manually input or read in as a file. This data is not only displayed in the aero-thermal and EGT plots to graphically show deviations from actual operating conditions, but the calculated, interpolated deviations are also compared to alarm limits.

Support service

A complete support service package is available for 7116 users to start monitoring right away. These services range from a turnkey solution to the specialized ‘Performance Monitoring Implementation Service – Type 6809’. This latter service not only ensures the performance monitoring databases are properly installed into COMPASS, but also improve the performance monitoring accuracy and reliability even further by fine tuning the databases to site conditions! See the respective product data sheet for more details.

Specifications 7116

Special Features Available with this Package *)

Feature	Comments
Gas property functions	Extensive library of gas and fluid properties.
Gas Composition Editor	Manage a range of process gas compositions for performance parameter calculations.
Interfacing	DTF formatted text files are imported to COMPASS as Imported Measurements (see below) via FTP or other means.

Measurements Available with this Package *)

Measurement Name	Comments
Calculated Measurement	The setup type and number of these measurements which are already pre-defined, are dependent on the specific machine database ordered (see Product Data for the Type 7120-X Performance Monitoring Application Database).
Imported Measurement	

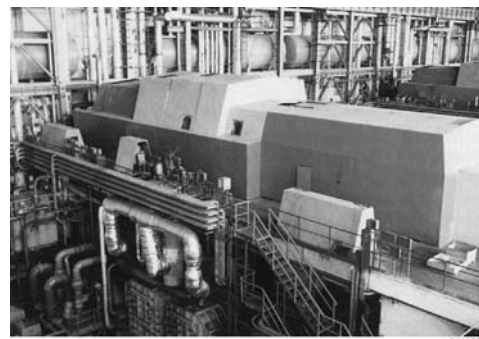
Plots Available with this Package *)

Plot Name	Comments
Various Type 7110 Plots	The specific plots used depend on the specific machine database ordered (see Product Data for the Type 7120-X Performance Monitoring Application Database).

* A description of the measurements and plots is given in the sections 'Measurements/Plots Used in the Application Software', and in the product data descriptions for the Type 7109 and 7110 in this product data sheet, respectively.

Performance Monitoring Application Databases – Type 7120-X

The **Type 7120-X Performance Monitoring Application Database** packages are used together with the Type 7116 Performance Monitoring Software for automatically detecting the slightest changes in process performance parameters for a wide range of specific machines. Each Application Database, complete with all performance monitoring calculations needed for a specific machine, can be easily merged into the standard COMPASS database for an integrated monitoring strategy.



Machines Monitored

There are seven different Performance Monitoring Application Database packages available, each corresponding to a specific group of machines.

Type No.	Machine Group	7116 Req.	Std. Services 6809 - X	Non-std. Service 6809 - NS
7120-GT	Gas Turbines (aero derivative and industrial)	Yes	Yes	
7120-ST	Steam Turbines ¹⁾	Yes	No	Yes
7120-C	Compressors (centrifugal and axial)	Yes	Yes	
7120-TE	Turbo Expanders	Yes	Yes	
7120-LE	Liquid Expanders	Yes	Yes	
7120-P	Pumps	Yes	Yes	
7120-HT	Hydro Turbines	Yes	Yes	
7120-NS	Other machines		No	Yes

In principle, each machine group database is “generic” for all types of gas turbines, compressors, etc., but these database packages are “fine-tuned” with the required Type 6809 Performance Monitoring Implementation Service to your specific machine and process characteristics at on-site conditions.

Thermodynamic parameters

The exact parameters calculated depend on the particular machine database, but in general, the following apply:

- Actual process values and performance parameters
- Correction of actual performance parameters to reference conditions (e.g. ISO conditions) for gas turbines (e.g. power, heat rate, efficiency, head, flow, pressure ratio, exhaust temperature, inlet filter pressure drop, etc.)
- Comparison of corrected performance parameters to part load reference curves
- Correction of actual performance parameters to reference gas properties for compressors
- Expected machine performance according to machine design data (base and part load)

¹⁾ This is a non-standard product since there are so many different configurations.

- Expected compressor performance according to machine design
- Expected losses (friction, leaks, and heat)
- Deviations from expected values

Complete Database

Each machine database is complete and ready to be used for performance monitoring (see specifications below).

The default values in the “generic” machine group are replaced with those values which are specific to your particular machine, using the required the Type 6809 Performance Monitoring Implementation Service.

Vendor Requirement Specifications to Customer

This document, available from your Brüel & Kjær, Schenck Sales Representative, describes in detail what is required from the customer for a standard performance monitoring implementation. Although the requirements to the customer are minimal, it makes it easier for all parties since everything is clearly specified. Of course part or all that is normally supplied by the customer can be done as a service.

In brief, this is:

- DCS measurements required with value range, time interval, timestamps, etc., are available from a database on the network
- Process and instrument drawing (P&ID) of measurement types and locations
- Tag names
- Gas composition
- LHV of fuel
- Machine design data from the manufacturer (e.g. losses)
- On-site machine test data
- Compressor maps
- Correction curves

Specifications 7120-X

Special Features Available with this Package

Feature	Comments
Standard View	Status alarm lights positioned and Machine drawings made for entire database
Custom View	Custom view screen(s) with drawings and values indicated
Tag Names	Default tag names created
Measurements	All Calculated and Imported measurements set up and enabled with default alarm limits
Formulas	All thermodynamic calculations set up together with Symbol definitions
Plots	All applicable performance plots set up