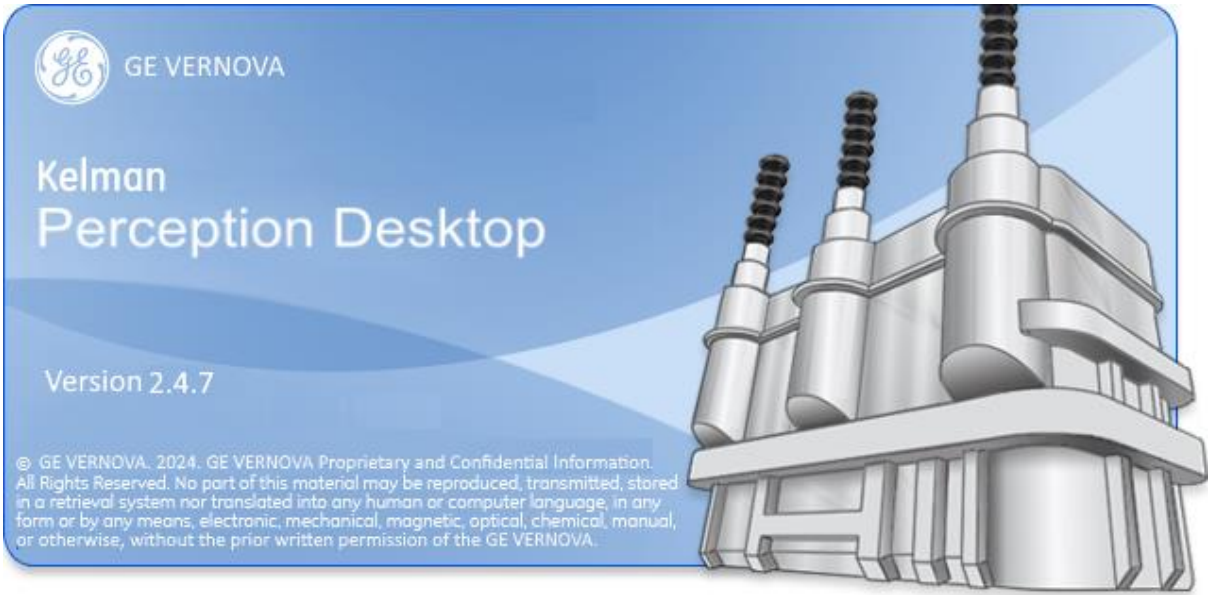
Grid Solutions
Monitoring & Diagnostics

Perception Desktop Installation & User Guide

Transformer Monitoring Software



GE VERNOVA

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Related Documents

Ref#	Title
MA-021	Perception Server - Installation & User Guide
MA-022	Perception Web - Installation & User Guide
MA-023	Perception Workflow Designer - Installation & User Guide

Abbreviations & Definitions

Abbreviation	Meaning
KPD	file suffix for a Perception Database file (stored in a SQL format)
TOA	file suffix for a device configuration file (stored in a CSV format)
DGA	Dissolved Gas Analysis
CSV	Comma Separated Variable – an industry-standard neutral data exchange format
SQL	Structured Query Language – an industry-standard database format

1 INTRODUCTION

1.1 Product Overview

Perception is a software product designed to assist power plant personnel in the maintenance and management of oil-insulated equipment used in the transmission and distribution of electrical power. It is used primarily for diagnosing fault conditions as well as trending measurements taken from transformers, circuit breakers and tap-changers.

The software accepts data from either manual or automated programs of regular sampling and condition analysis of the equipment's insulating oil as well as other performance data. Several well-established and recognized empirical diagnostic rules are used to present information to the user on the condition of the insulating oil used in the electrical equipment. This assists in the running of a maintenance program and in the identification of potential fault conditions. It allows both the maintenance engineer and asset manager to monitor and diagnose transformer data collected by GE's range of on-line monitoring units. The data includes Dissolved Gas Analysis (DGA), calculated models, bushing and other transformer measurements. By providing access to this valuable data along with powerful diagnostic tools, Perception delivers clear transformer condition information. This enables decisions to be made quickly and reliably, helping to extend the life of transformers, reduce unplanned outage, and avoid catastrophic failure.

Although Perception is an expert analysis and information system, it is only an aid and should not be regarded as a replacement for the knowledge of a subject matter expert in the analysis of insulating oil used in electrical equipment and the operation of oil filled power equipment.

1.2 Software Family

There are four members of the Perception family.

- Perception Desktop — A standalone software application that provides customized access to the centrally located asset database. It provides advanced diagnostic profiles on device data, a multi-page transformer report containing key transformer information as well as the facility to launch external applications. Additionally, Perception Desktop can operate standalone or as part of a larger centralized asset management suite in conjunction with Perception Server.
- Perception Server — The pinnacle of transformer asset management software. Perception Server provides a fleet-wide network overview via a wallboard display, automatic data downloading with configurable scheduling, email notifications of device condition changes and a TOA4 data export facility. It uses a centralized data storage location based on SQL Server to which Perception Desktop links seamlessly via secure OPC UA communications.

- Perception Web — A web-based solution that provides *read-only* access to the centrally located asset database. This offers a convenient way to obtain readings and consolidated data analysis across a variety of platforms including mobile devices. This includes transformer dashboards, wallboards and an overview to the status of the entire transformer fleet.
- Perception Workflow Designer — The workflow designer uses common flowcharting techniques to express transformer diagnostic processes as a model. These models are known as workflows and in turn drive the Perception dashboard. The Designer brings easily modifiable workflow-enabled capabilities to the Perception software suite allowing control over the diagnostic process and customization of how data is presented on the Perception dashboard.

Note: Perception Express is no longer available and should be removed since Perception Desktop includes all this functionality and more.

1.3 What's New?

- Enhanced support for DGA 900 TapTrans Plus with models for cooling, thermal and OLTC data, including import and export of such data.
- Minor enhancements and bug fixes.

Note: If upgrading to Perception Desktop/Server 2.4. X from version 1.X, please contact GE Support before commencing as depending upon the size and complexity of the existing database, a service visit may be required to make the transition.

1.4 Desktop Features

Perception Desktop offers the following:

- Can be used as a stand-alone application or as a client application in a large centralized Perception Server environment
- Wallboard facility gives an overview to the entire fleet
- Trend charts for any measured parameters, including polar plots for Bushing Monitors and Partial Discharge (BMT devices & DGA 900 PLUS with bushing monitoring)
- Current status and data history displays
- Configure the data upload frequency from remote monitors
- Pre-set trend and diagnostic graphs for dissolved gases
- User-configurable trend graphs for any monitored parameters
- Gas Ratio trend charts
- Preset fault monitoring displays utilising Gas ratios (IEC60599 & IEEE C57.104, Transformer Condition, Rogers Ratio and Doernenburg Ratio), Duval's diagnostics and Japanese ETRA standards
- Models for Intellix MO150 & Hydran M2 / M2-X devices (see Section 4.16)
- Transformer Report for an overview to key information on a transformer's condition based on the dissolved gas measurement analysis and user input (see Section 5.5)
- Facility to launch external applications from within Perception Desktop (see Section 5.7)

1.5 System Requirements

The minimum PC and system requirements for Perception Desktop are:

Operating System:	Windows 7 with .NET Framework 4.7
CPU:	2 GHz Processor
Memory:	2 GB RAM
HDD:	10 GB free
Graphics Card:	64 MB graphics, update to the latest driver for your hardware to ensure that it can provide all the facilities of NET Framework 4.7

Note: Windows 8 does not enable Microsoft .NET 3.5 features by default. However, all Perception installers require .NET 3.5, so you will be prompted to enable it.

1.6 Software Licensing

Perception Desktop uses a tier-licensing model when used with Perception Server. This provides greater flexibility to add devices and manage license expiry. There are six tiers in the model, as listed in Table 1-1, with each tier supporting an increasing number of devices according to a range of accumulated device weightings.

Table 1-1: Tier scores

Tier	Accumulated weightings
1	0-50
2	51-100
3	101-150
4	151-250
5	251-500
6	501+

The weighting scores for each type of device are listed in Table 1-2.

Table 1-2: Device scores

Device	Weighting Score
Offline	1
201Ti	2
Hydran M2 / M2-X	3
8 series relays	3
MO150	4
MINITRANS	4
CB Watch3	4
Transfix	5
DGA 500	5
DGA 900	5
BMT 300	5
BMT 430	5
DUALTRANS	6
TAPTRANS / DGA 900 TAPTRANS	6
MULTITRANS / DGA 900 MULTITRANS	6
Transfix PLUS	6
DGA 900 PLUS	6
TMS	7
MS 3000	7

You can add any number of devices and assets within the limits set by the Perception fleet license tier. To add further devices or assets requires a license upgrade — contact Customer Support.

Note: Customers on an existing annual fleet licensing agreement can add assets and devices beyond the limits set by the new license tier. However, once the annual fleet license agreement expires, the license tier is recalculated and may require an upgrade to service all devices.

Note: When connected to Perception Server, the Fleet Summary window becomes available in Perception Desktop and provides details on the

Perception license tier including expiry date and a summary of the devices and assets that have been added to the database.

1.6.1 License Expiry

A License Expiry message appears in Perception Desktop 90 days before the Perception fleet license is due to expire as shown in Figure 1-1. Reminder messages are automatically scheduled to reappear at 60 days, 30 days, 15 days and 5 days, or on each first launch of the application within the set days of the expiration period.

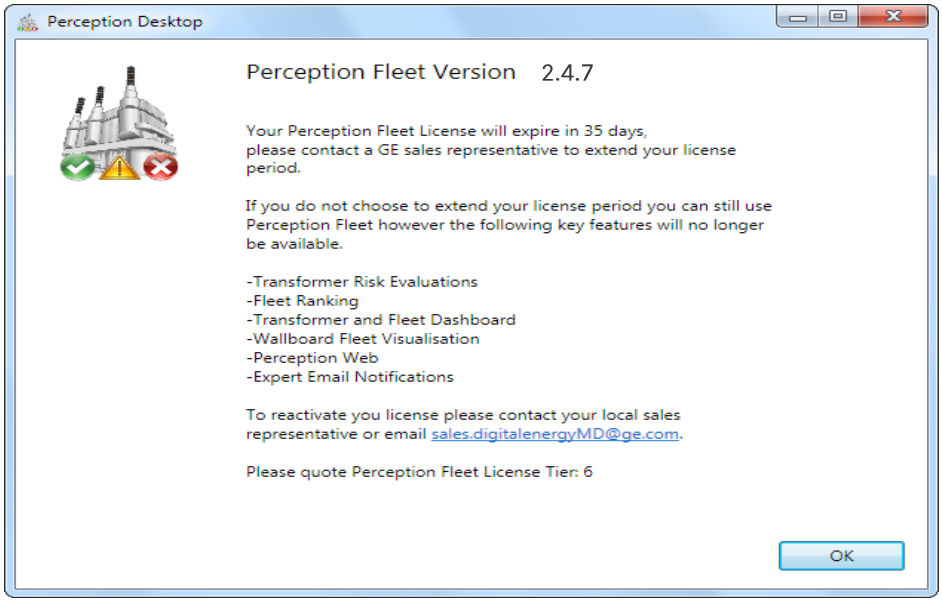


Figure 1-1: License expiry notification

A yellow warning icon also appears in the lower right corner of the application window with a tooltip when you rest the mouse pointer over it as shown in Figure 1-2.

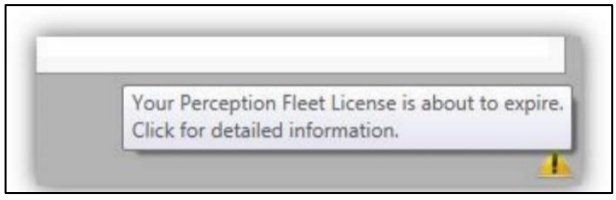


Figure 1-2: License warning indicator

Perception Server restricts functionality after license expiration. The following features are disabled:

- Transformer Risk Evaluations
- Fleet Ranking
- Transformer and Fleet Dashboard
- Wallboard Fleet Visualisation
- Perception Web
- Expert Email Notifications

1.6.2 Fleet Summary

Perception provides a useful summary dialog with license tier details and all assets and devices that comprise the Perception Fleet. Select **Help > Fleet Summary** as shown in Figure 1-3.

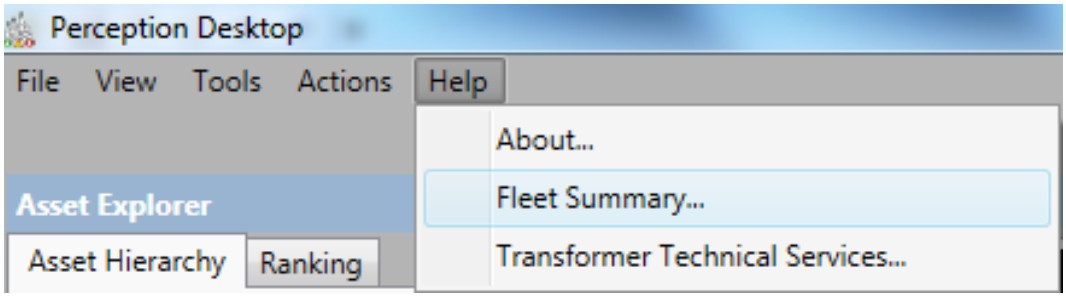


Figure 1-3: Help menu

The Fleet Summary dialog displays as shown in Figure 1-4.

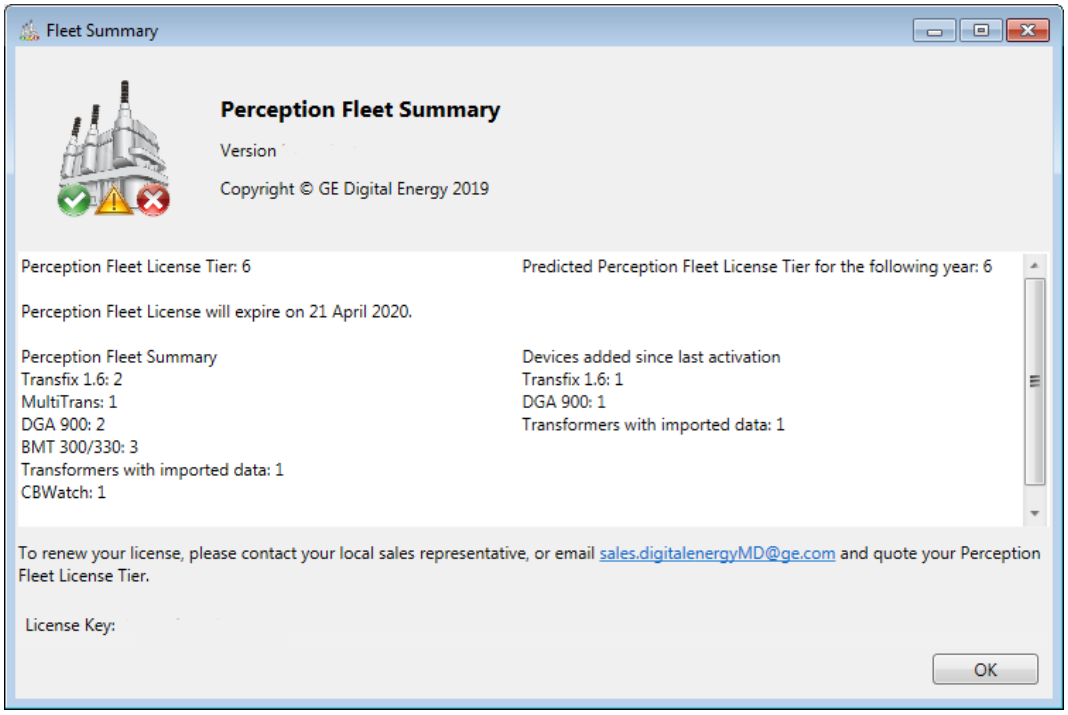


Figure 1-4: Fleet Summary dialog

1.7 Customer Support

E-mail:	ga.support@ge.com
North America:	1-877-605-5777
Worldwide:	+44 1785-250-070

2 INSTALLING & CONFIGURING

2.1 Overview

There are two main steps to installing and setting up Perception Desktop:

- Install the Perception Desktop software on your PC.

Note: It is advisable to use Windows Update to check that your PC is running an up-to-date version of the '.NET Framework' before launching the Perception Desktop installer.

- Set up the connections to the Perception databases or Perception Server.

Note: If you install Transport X software on your PC, you can also incorporate data from the Transport X portable range.

2.2 Run the Perception Desktop Installer

2.2.1 To install Perception Desktop, double click the **Perception.Desktop.Setup.exe** file. The Setup / Upgrade Wizard opens to guide you through the process as shown in Figure 2-1. Click **Next** to proceed.

Note: The Perception.Desktop.Setup.msi file must also be available in the same location.

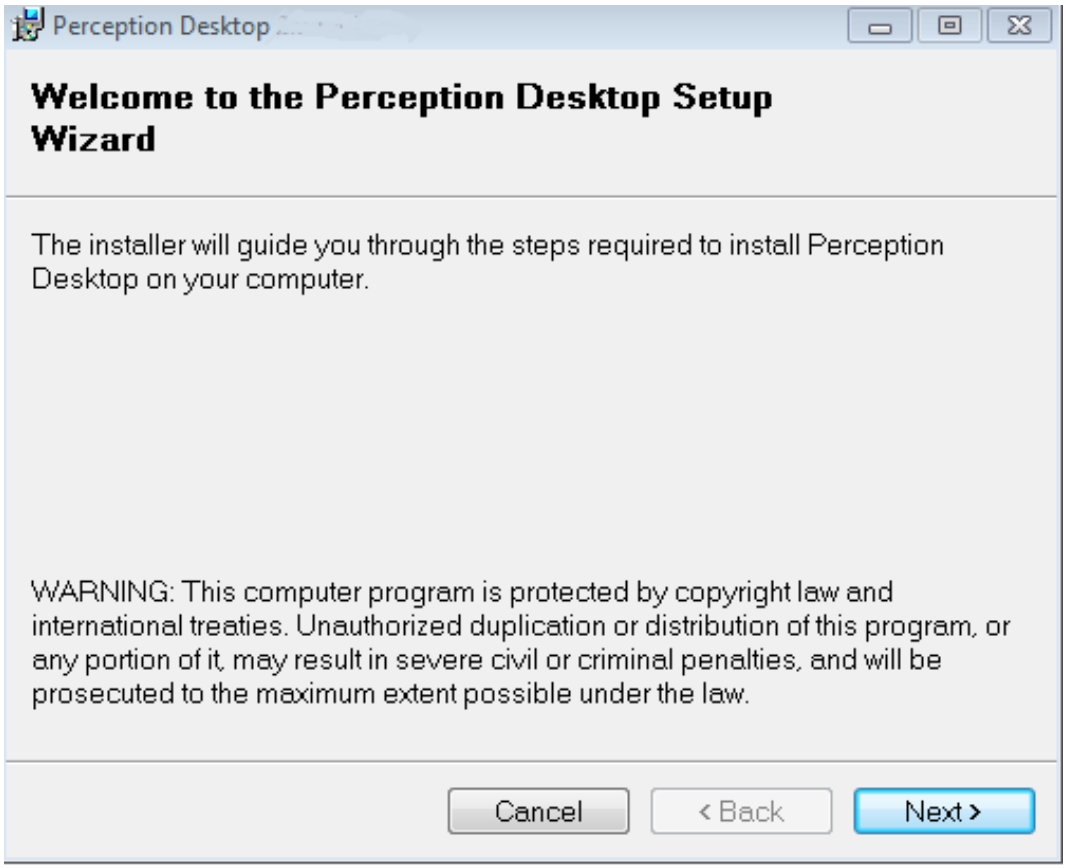


Figure 2-1: Welcome to the Perception Desktop Setup Wizard

2.2.2 If the License Agreement is acceptable, select **I accept the terms in the License Agreement** and click **Next** as shown in Figure 2-2.

Figure 2-2: License Agreement

2.2.3 Browse to select the installation folder or accept the default folder and click **Next** to continue as shown in Figure 2-3.

Note: If your PC is shared with other users, you can choose to install Perception Desktop for use under your login account only, or for all user accounts of the PC.

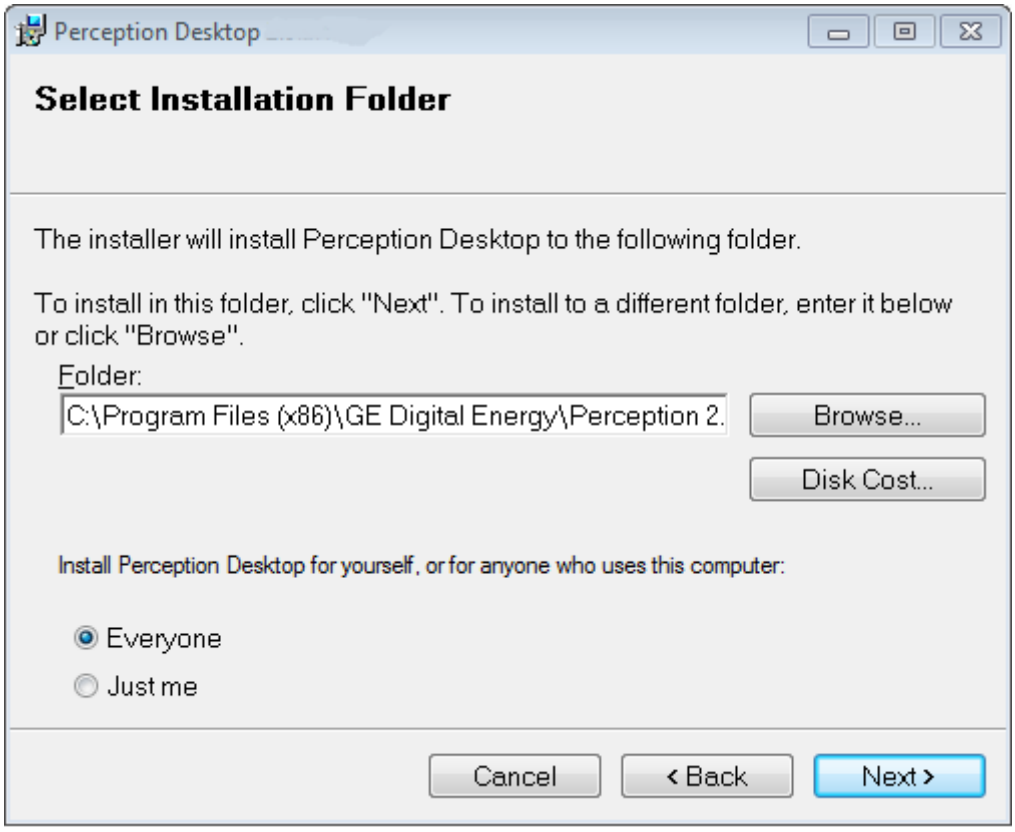


Figure 2-3: Select Installation Folder

2.2.4 Click **Next** to start the installation, **Back** to backtrack and change some of the selections, or **Cancel** to quit the process entirely, as shown in Figure 2-4.

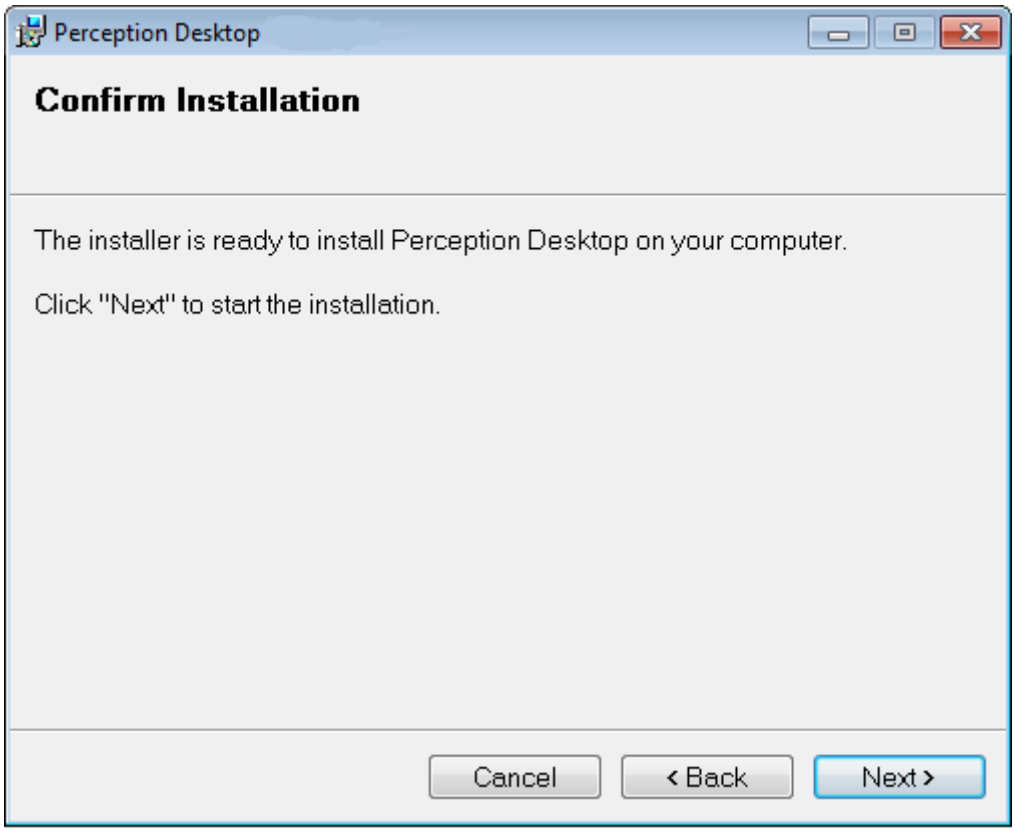


Figure 2-4: Confirm Installation

2.2.5 If you click **Next**, then the installation commences and a progress bar indicates the progress so far as shown in Figure 2-5. The installation may take some minutes.

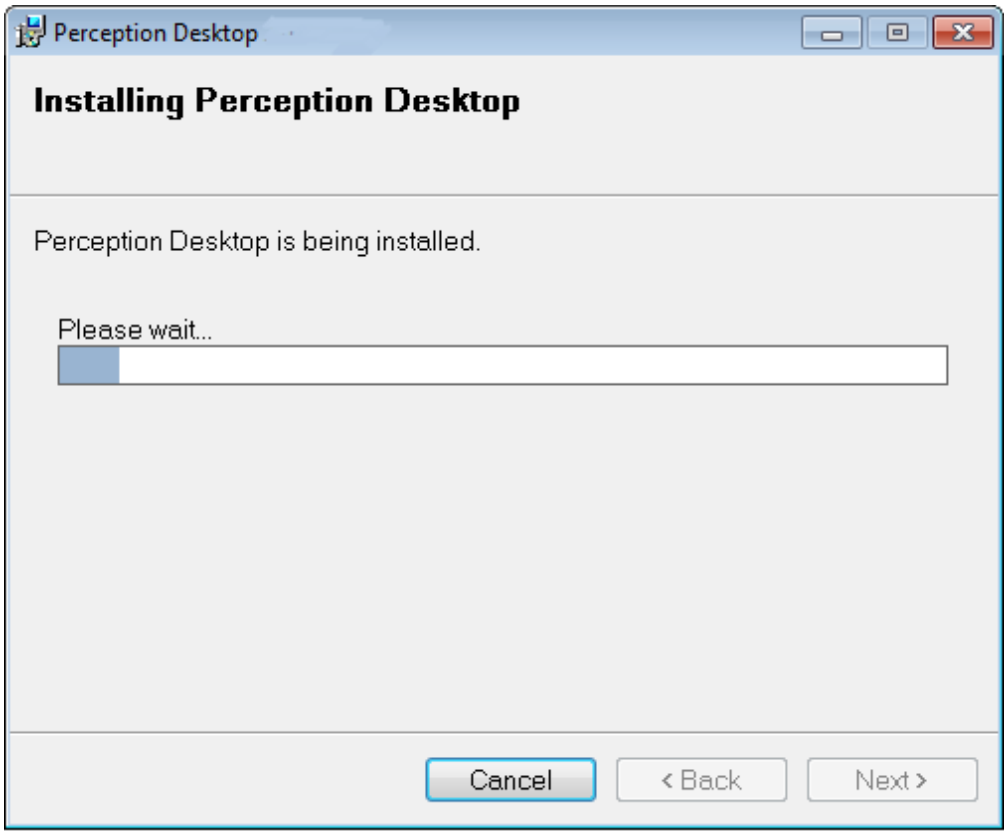


Figure 2-5: Installing Perception Desktop

2.2.6 The Setup Wizard completes the installation and presents the following message as shown in Figure 2-6. Click **Finish** to exit.

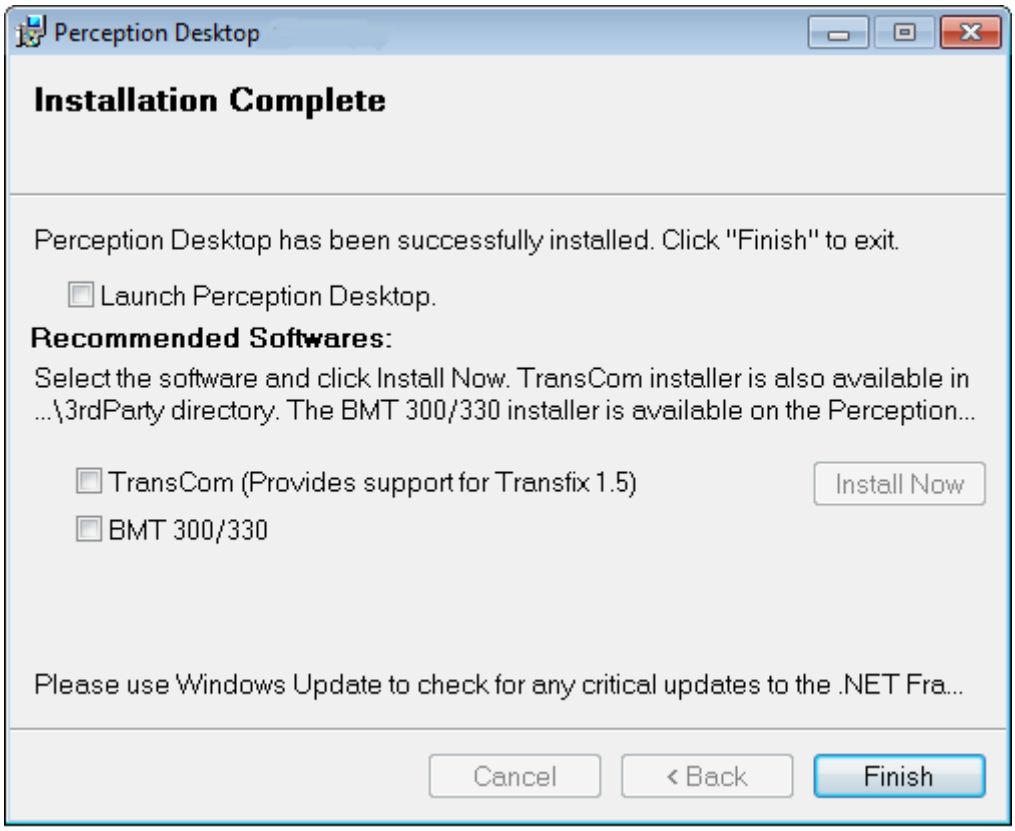


Figure 2-6: Installation Complete

Perception Desktop is now successfully installed. Other related software installations include:

- *Transport X*: the data storage software supplied with the portable Transport X products. It is used to read the data from the portable devices. Perception Desktop can automatically interface with the Transport X software to incorporate that data into the main Perception database. To do so, the Transport X device must previously be installed on your PC. See the Transport X device manual for details and 5.8 for installation details.
- *Intellix BMT 300/330*: the software used to configure and monitor Intellix BMT devices.
- *TransCom*: the software used by Perception to support Transfix 1.0/1.5 devices.

2.3 Firewall Settings

Perception Desktop must be allowed to communicate with Perception Server through your firewall. This requires opening certain ports for inbound connection on the Perception Server firewall. The UA Discovery Server application should also be added as a permissible program to send and receive through the firewall. Note: Your firewall settings are maintained by your IT administrator.

2.3.1 Perception Server ports

Perception Server requires the following ports to be opened:

- 502 (for Transfix, CB Watch and 8 series relay devices)
- 5000 (for Hydran devices)
- 62541 (to allow the client to read the server configuration via Discovery Server)
- 69 UDP (to allow TFTP data download from 8 series relays)
- 80 HTTP (for DGA 900 and CB Watch devices)
- 443 HTTPS (for DGA 900 and CB Watch devices)

It is recommended that the Perception database be located on the same server as Perception Server. If not, then the following additional port needs to be opened:

- 1433 TCP (to allow the client to connect with the SQL Server)

2.3.2 Perception Client ports

Perception Desktop requires the following ports to be opened:

- 4840 (for Perception Server to be discovered)
- 62541 (to allow the client to read the server configuration via Discovery Server)
- 1433 TCP (to allow the client to connect with the SQL Server)

2.4 Create a New Database Connection

Launching the Perception software for the first time prompts for a database connection in order to use the software as shown in Figure 2-7.

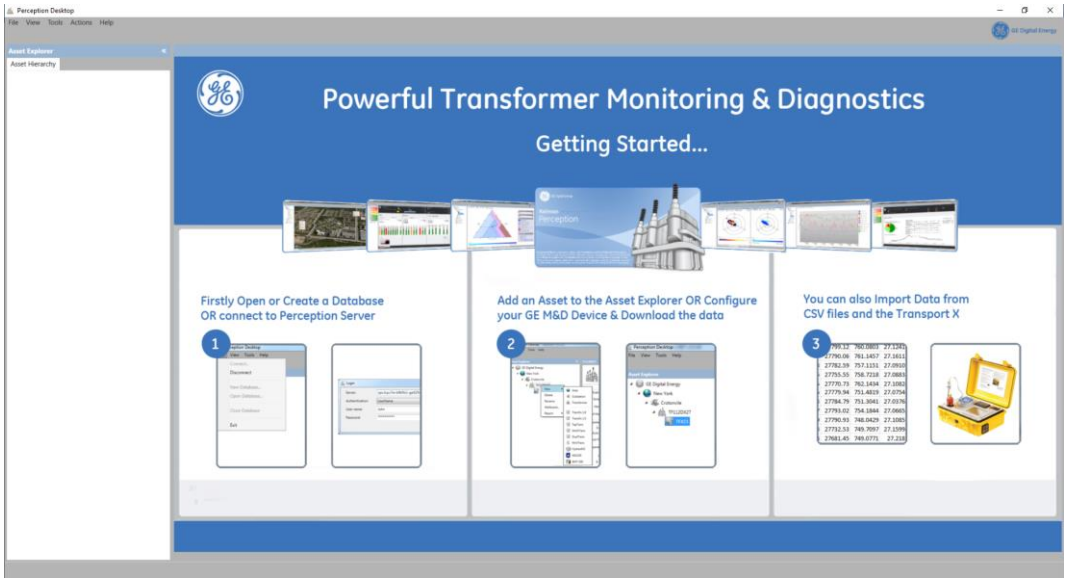


Figure 2-7: Getting Started

Having installed and authenticated the Perception Desktop software, you should now establish a database connection Note: This task need only be performed once. Perception Desktop allows the user to connect to a Perception Server database (as outlined in Section 2.4.1) or to a local (file-based) database as outlined in Section 2.4.1.1.

2.4.1 Create a new connection to a Perception Server database

Note: Perception Server must be installed prior. The Perception Server database is created and administered by your System Administrator.

To establish a new connection with a Perception Server database, start Perception Desktop and select **File** > **Connect** as shown in Figure 2-8.

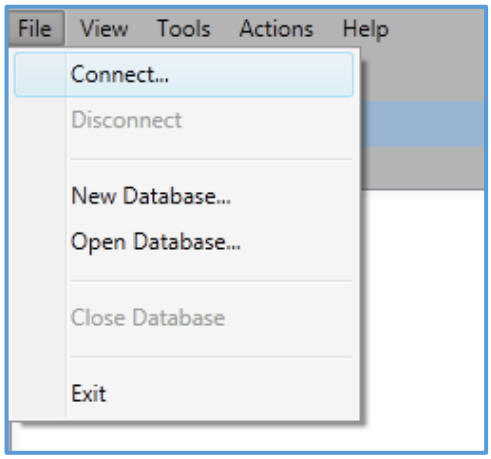


Figure 2-8: Connect to an existing database

The 'Login' dialog box as shown in Figure 2-9 allows you to specify the connection details. Click the (...) browse button to configure the server connection.

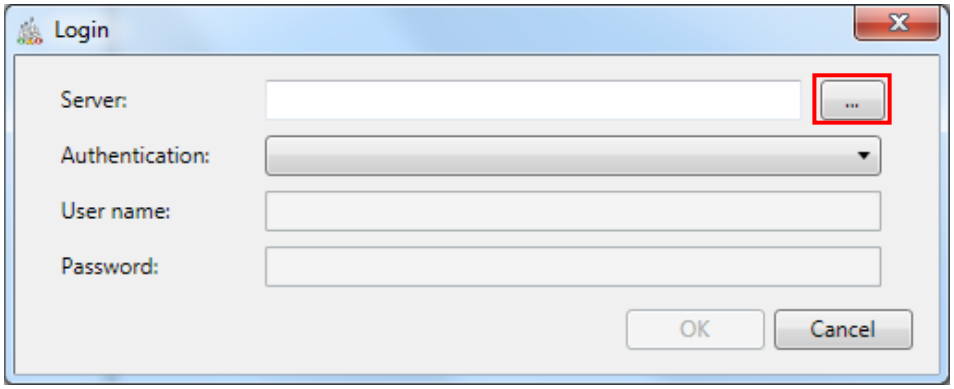


Figure 2-9: Login

The ‘Configure a Server Connection’ wizard opens as shown in Figure 2-10 and is designed to assist you with the configuration. Click **Next** to proceed.

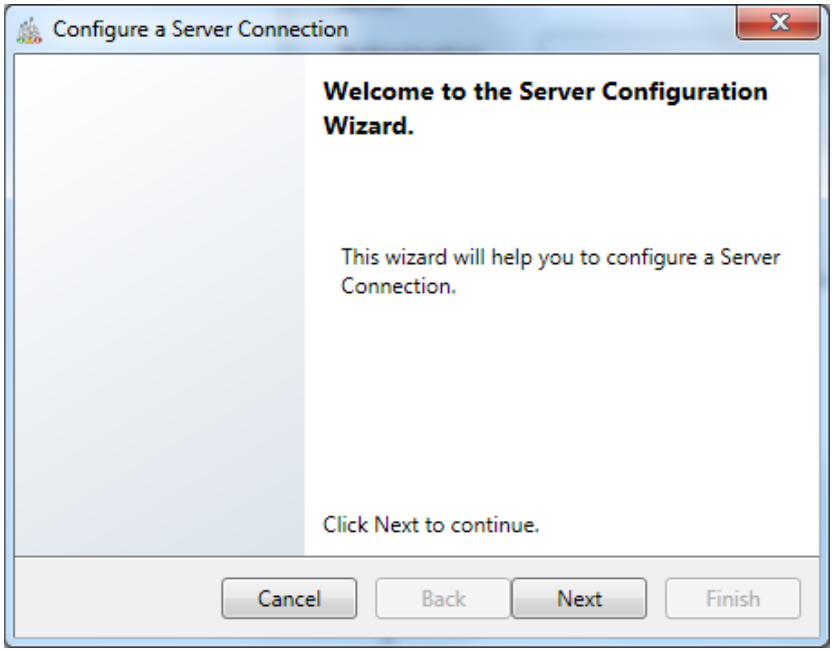


Figure 2-10: Configure a Server Connection

Type the Discovery IP Address or Discovery hostname and click **Next** as shown in Figure 2-11.

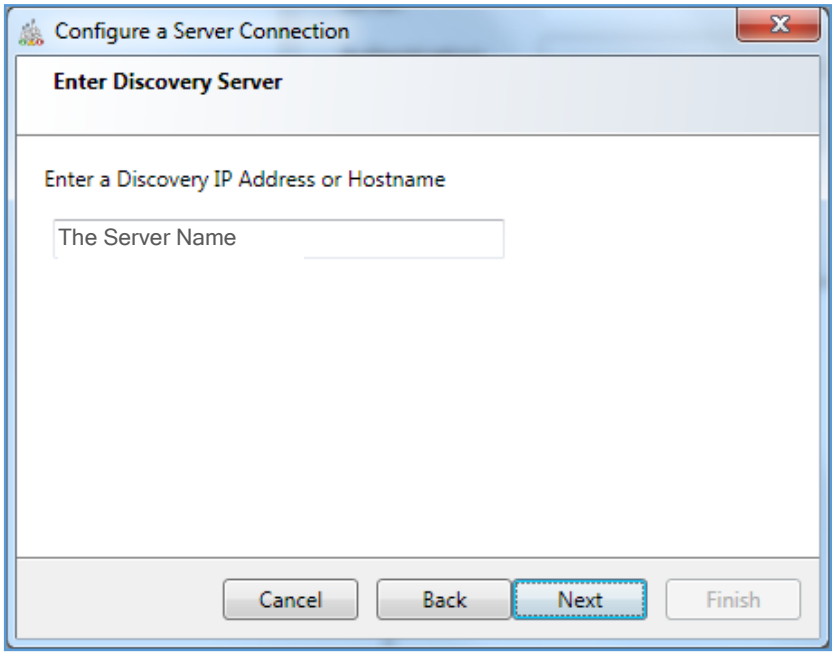


Figure 2-11: Enter Discovery Server

The Discovery Server lists all Perception Server databases that it finds as shown in Figure 2-12. Select the database that you wish to establish a connection with and click **Next**.

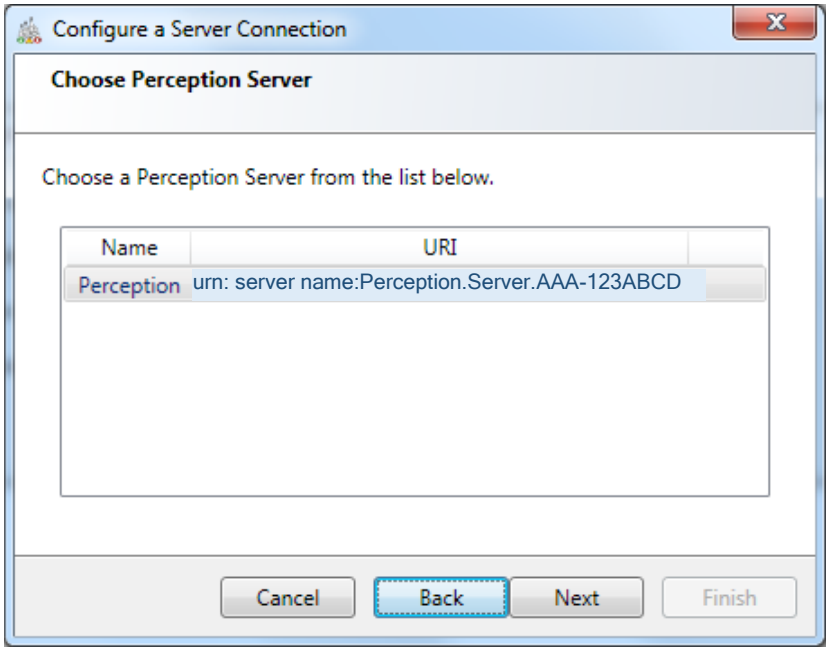


Figure 2-12: List of Perception databases

The 'Configure Options' step of the wizard then invites you to confirm the security settings for the connection. Figure 2-13 shows the default security settings — make any changes if required and click **Next**.

Note: Consult with your network administrator to confirm if any of these settings should be changed.

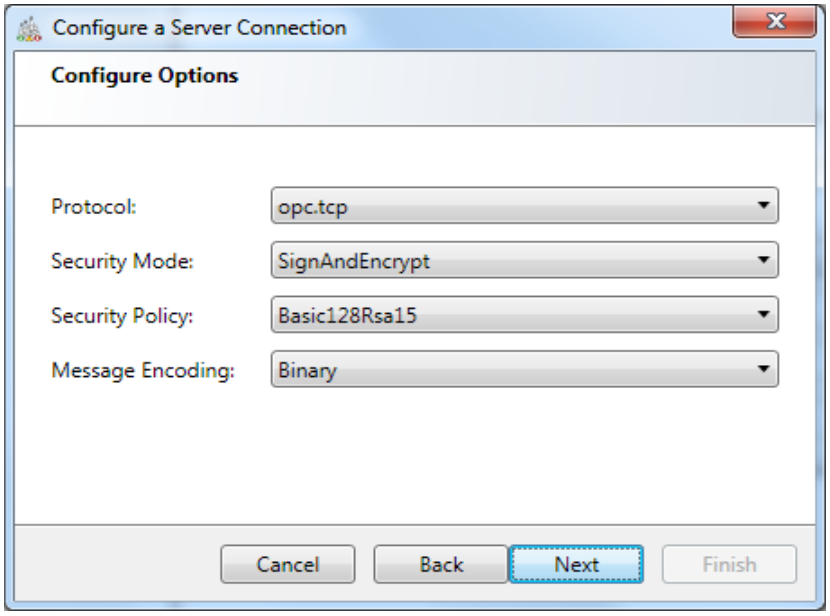


Figure 2-13: Configure Options

A confirmation message displays the chosen settings and indicates that the server configuration is now complete as shown in Figure 2-14. Click **Finish** to proceed.

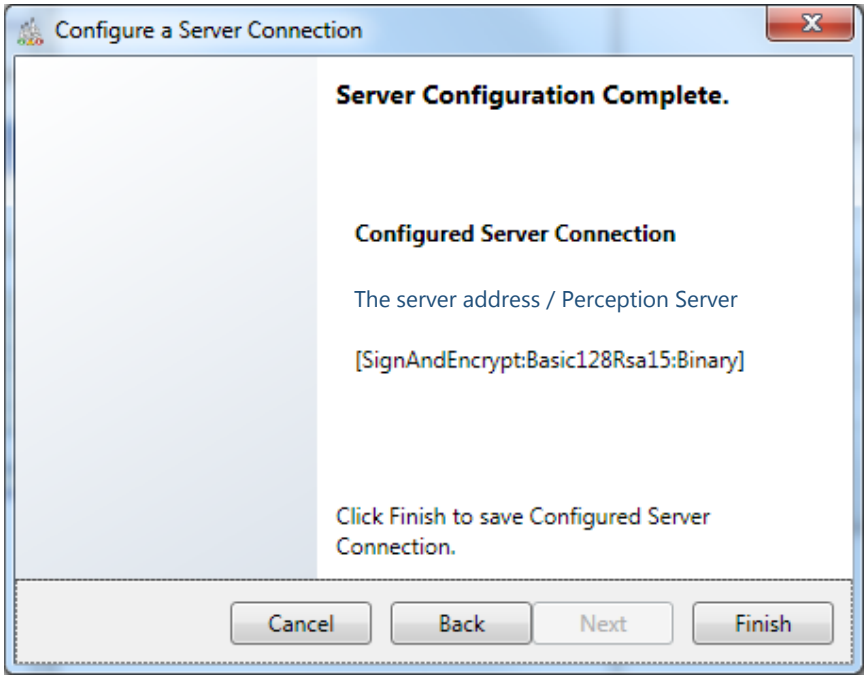


Figure 2-14: Server Configuration Complete

You are returned to the Login prompt as shown in Figure 2-15. Choose the Authentication method to be associated with this connection, and finally, enter the user name and password and click **OK**.

Note: Your System Administrator will have these login details.

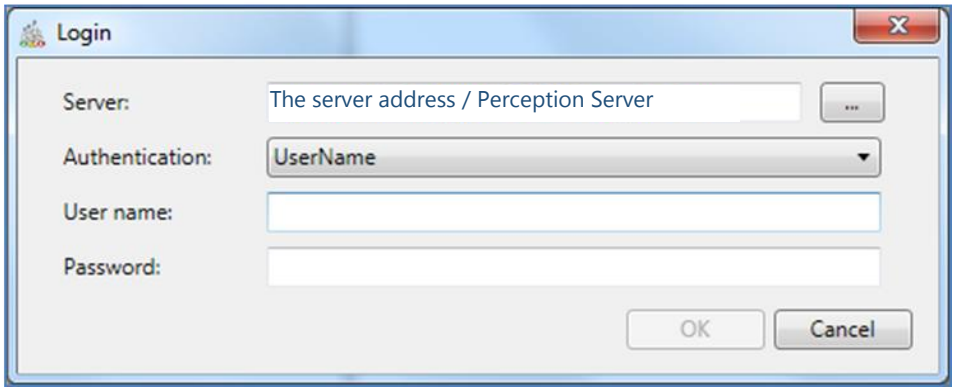


Figure 2-15: Login prompt

When connecting for the first time, you will also need to ensure that the respective certificate on both the client and server are trusted. See Section 2.4.2.1 for trusting the Server certificate and speak to your System Administrator for trusting the client certificate.

2.4.1.1 Trusting Perception Certificates

As a security measure, Perception uses electronic credentials known as certificates to authenticate clients and servers. Every time a new Perception Desktop client is added, both the client and the server administrator must trust each other's certificates (or physically exchange certificates as outlined below). This ensures that the requisite trust exists between client and server. Once the certificates have been exchanged, seamless communication can take place.

When you try and connect a Perception Desktop client to the server for the first time, the connection will be rejected as shown in Figure 2-16.

Note: With every attempted connection, the Server's certificate is automatically copied to the client's rejected folder and the client's certificate is automatically copied to the server's rejected folder.

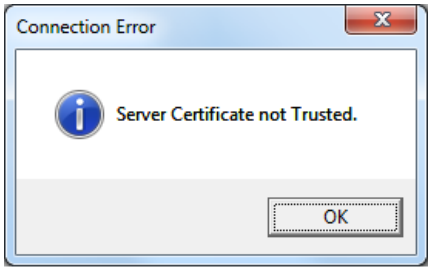


Figure 2-16: Server certificate not trusted

This is because the client does not trust the server. To trust the server certificate, the certificate must be moved from the client's rejected certificate store and added to the client's trusted certificate store.

To do this, open File Explorer and navigate to the rejected folder at this location:

```
C:\ProgramData\GE_Energy\Perception\RejectedCertificates\certs
```

Note: In Windows 10, the ProgramData folder may be hidden. If so, show hidden items in the File Explorer View menu.

Look for a certificate of the following format:

Perception.Desktop.<*computer name*>[key].der

Where <*computer name*> is the computer name of the server, and [*key*] is the public certificate key.

Move this certificate to the "TrustedCertificates\certs" folder at this location:

`C:\ProgramData\GE_Energy\Perception\TrustedCertificates\certs`

When you try to connect again you will get another connection error as shown in Figure 2-17.

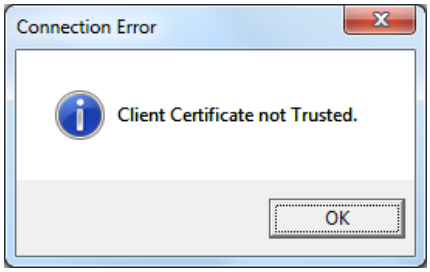


Figure 2-17: Client certificate not trusted

This is because the server does not trust the client. To trust the client certificate, the certificate must be moved from the server's rejected certificate store and added to the server's trusted certificate store.

Note: Contact your Server Administrator to have the relevant steps taken on the Server side.

All these steps must be performed after every first connection attempt of a new user and so requires both client user and Server Administrator to move the respective certificate to the "trusted folder" on their respective machine in order to establish a trusted relationship and thereby permit communication.

2.4.2 Create a new local database

To create a new local database for Perception Desktop, select **File** > **New Database** as shown in Figure 2-18.

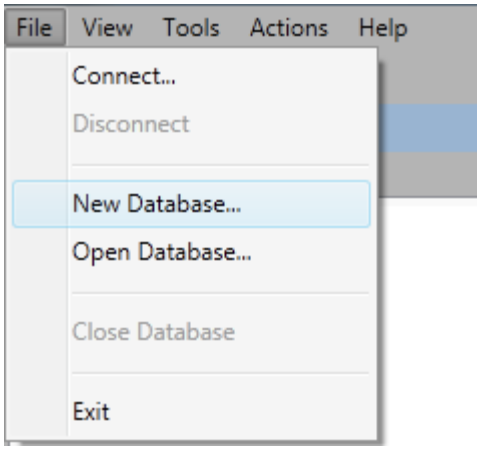


Figure 2-18: New Database option

In the Create New dialog, navigate to the save location, enter a name for the local database file and click **Save** as shown in Figure 2-19.

Note: The file type uses the file extension ".kpd" to denote a Perception Desktop database file.

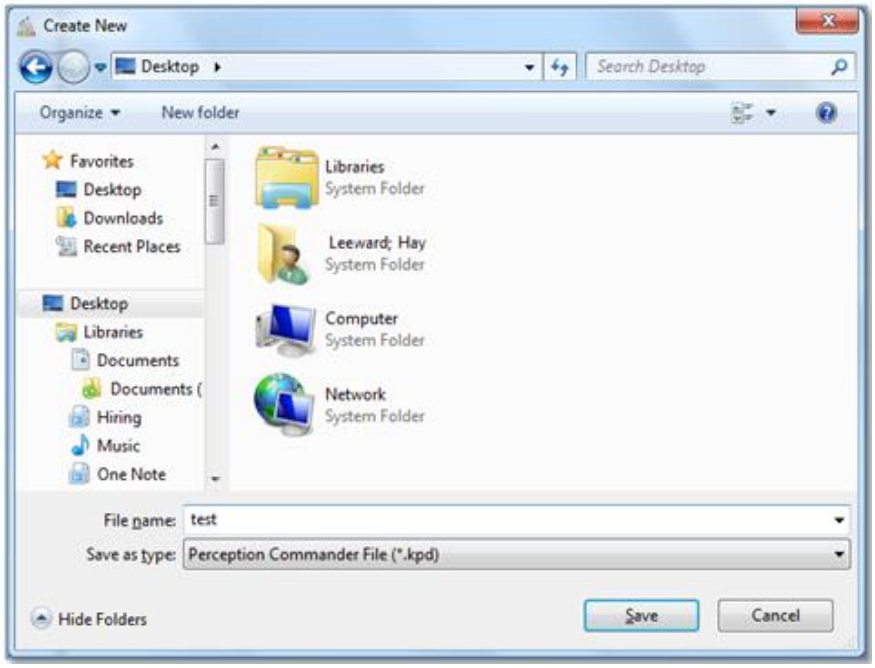


Figure 2-19: Save the local database

The new database is represented in the Asset Explorer pane of Perception Desktop as shown in Figure 2-20. See Section 3.2 for methods of adding data to the local database.

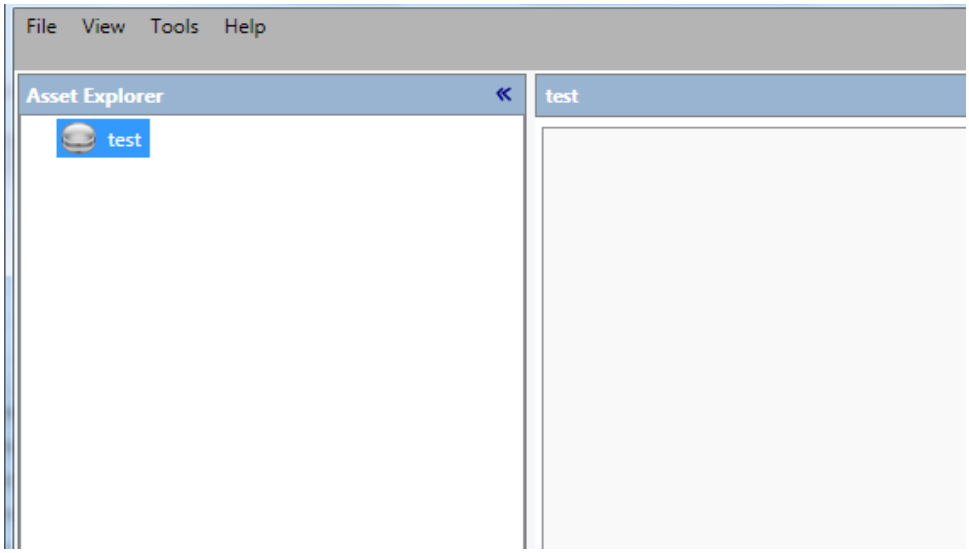


Figure 2-20: New local database

2.4.2.1 Connect to an older version KPD local database (for the first time)

When you open an older Perception local database* for the first time (i.e. after upgrading to version 2.4.*X*), it will be upgraded to the latest format. You will be prompted as shown in Figure 2-21.

*Note: This is not suitable for SEI files from Perception 0. For details of how to upgrade an SEI database, please contact GA.support@ge.com or a GE technical engineer.

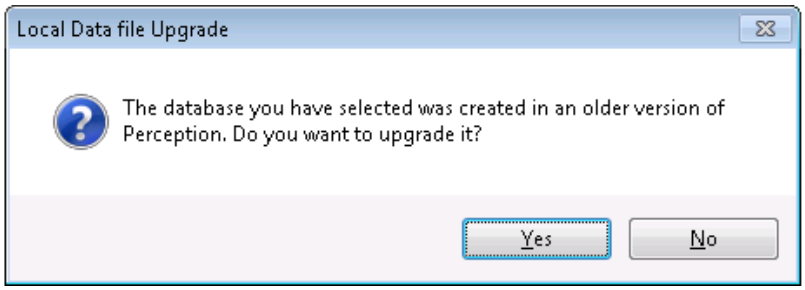


Figure 2-21: Upgrade Local Database Format

If you click **Yes**, the local database is upgraded to the latest format. A progress bar indicates progress, but it can take considerable time depending on the database size. If you click **No**, the Load operation is aborted.

Note: The upgraded database can no longer be read by previous versions of Perception. During the upgrade process, a backup copy is created in the original format, but using "3325" as the file extension instead of '.kpd' (this number represents the original database schema version number.) If you wish to use this database for historical/archival reasons, then it can be read into a previous Perception version. Before attempting to do so, change the database filename, or move its location and change its file extension back to '.kpd'.

3 ORGANISING ASSETS

3.1 Introduction

Upon successful connection to a database, Perception opens on the Database node showing a Fleet Overview page with a useful summary of the status of the entire fleet. See Section 3.2 for more details.

If you have opened a new database, then no information will be shown until you add assets and set up the asset properties. See Section 3.2 and Section 3.8.1.

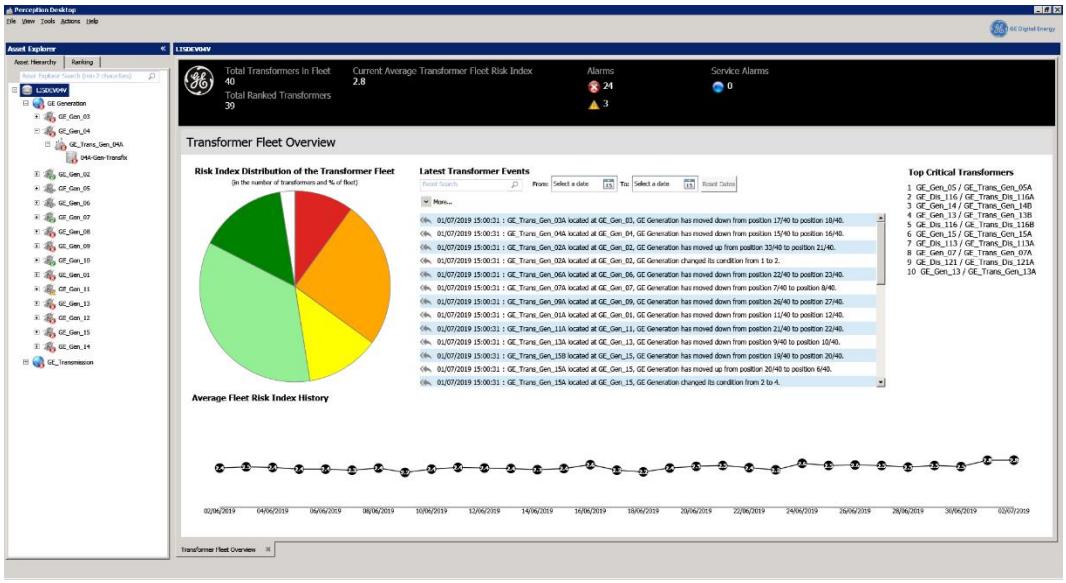


Figure 3-1: Fleet Overview (only available when connected to Perception Server)

3.1.1 Managing Database Connections

Perception Desktop allows the user to connect to a Perception Server database or to a local database.

Note: You can only be connected to one database at a time. To connect to another database requires disconnecting from the current database.

Note: For more details on the advantages of upgrading to a Perception Server database, please contact a GE sales representative.

3.1.1.1 Connect to the Server

To connect with a Perception Server database, select **File > Connect...** as shown in Figure 3-2.

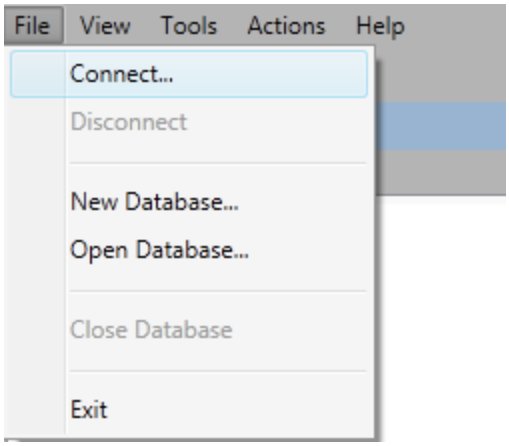


Figure 3-2: Database Connect option

The 'Login' dialog box displays as shown in Figure 3-3 with the Server field populated with the Perception Server if you have connected previously.

Note: If the Server field is not populated or if you wish to change it, see Section 2.4.1.

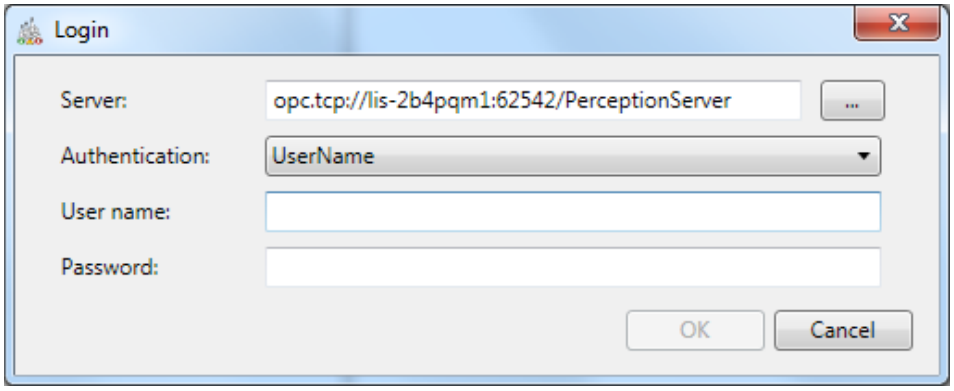


Figure 3-3: Perception database login

Enter the username, password and click **OK**.

Note: If forgotten, contact the System Administrator.

Alternatively, if the Administrator has enabled anonymous access, sign on as an 'Anonymous' user without the need for a user name or password (but with corresponding Observer status i.e. read-only permissions). This is accessed via the 'Authentication' dropdown menu.

Note: Refer to Section 2.4.1.1 if you receive a connection error relating to trusting certificates.

3.1.1.2 Disconnect from the Server

To disconnect from Perception Server, select **File** > **Disconnect** as shown in Figure 3-4.

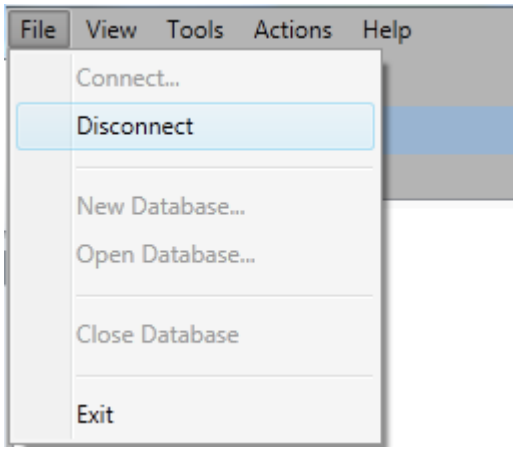


Figure 3-4: Disconnect from Perception Server

This action closes the connection to the Perception Server database and clears the Asset Explorer of all assets.

3.1.1.3 Open a local database

To connect to a local Perception database on your PC, select **File** > **Open Database...** as shown in Figure 3-5.

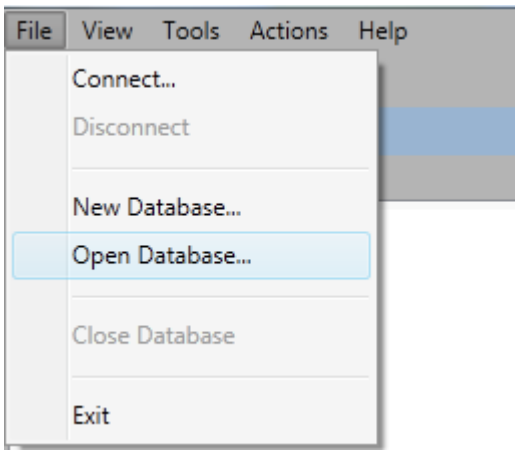


Figure 3-5: Open local database

This displays a list of local databases (those with the 'kpd' file extension), for example, as shown in Figure 3-6.

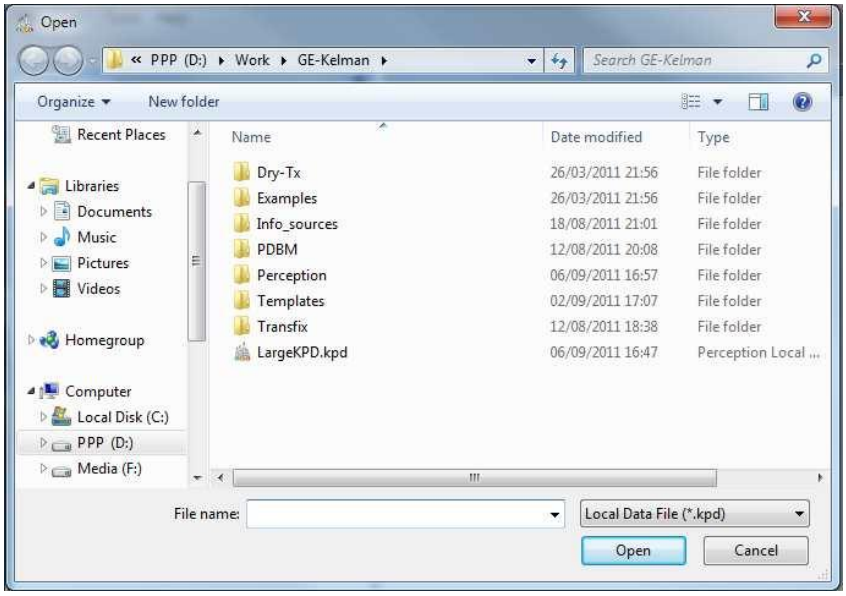


Figure 3-6: Local databases

Select the local database that you wish to open and click **Open**.

3.1.1.4 Close a local database

To close a local database, select **File** > **Close Database** as shown in Figure 3-7.

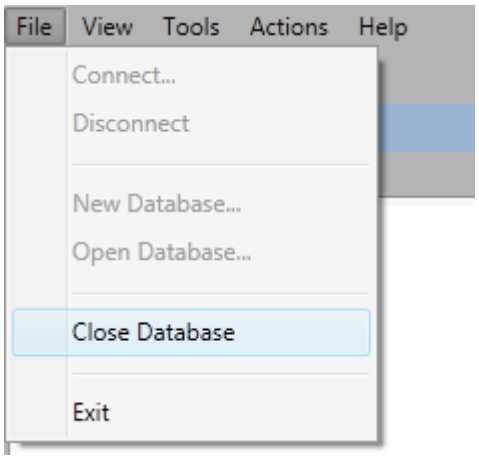


Figure 3-7: Close a local database

This closes the local database and clears the Asset Explorer of all assets.

3.1.2 Interface

The main screen of the Perception Desktop is divided into two parts as shown in Figure 3-8.

- The Asset Explorer (denoted by the blue border)
- The Data Area (denoted by the green border)

The Database node is located at the top of the Asset Explorer hierarchy with all nodes structured below it. Select a node in the Asset Explorer on the left

e.g. GE_Trans_Gen_02A to make it the active node (as highlighted in blue), and its details display in the Data Area to the right as shown in Figure 3-8.

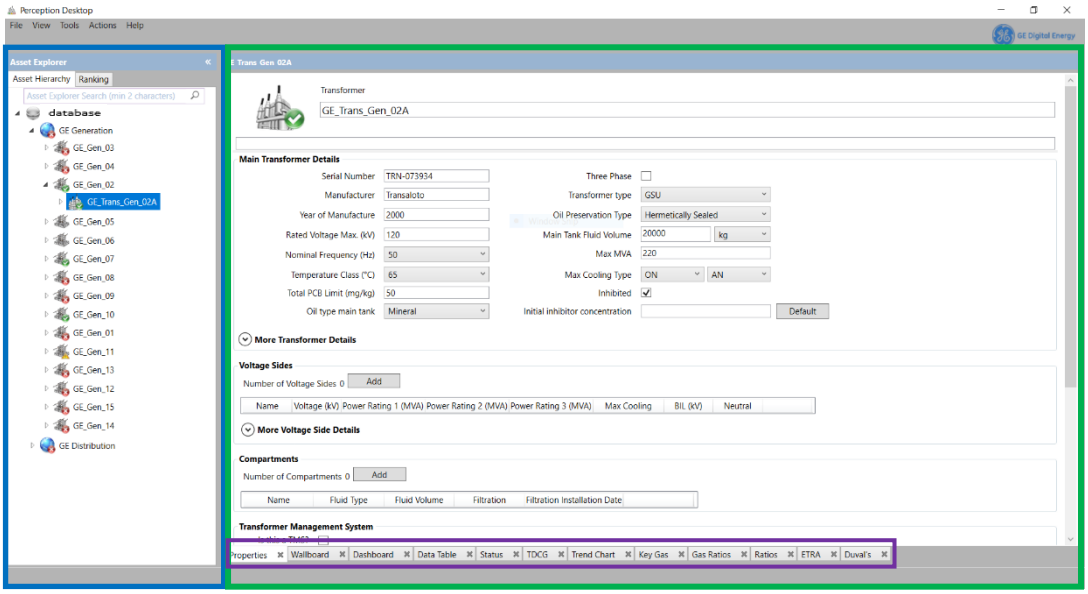


Figure 3-8: Perception Desktop main screen

3.1.2.1 Asset Explorer

The Asset Explorer uses a tree-like structure to represent the hierarchy of assets and monitoring devices across multiple areas. Distinct graphical nodes represent Areas, Substations, Transformer Banks, Transformers, Circuit breakers and monitoring devices across the entire fleet. This tree-like structure provides a logical means of organising the assets and a useful means by which to navigate the hierarchy and find an asset. The Asset Explorer also features a Search box as shown in Figure 3-9 (left). Type the first few characters (minimum 2) of the asset name to filter the asset hierarchy as shown in Figure 3-9 (right).

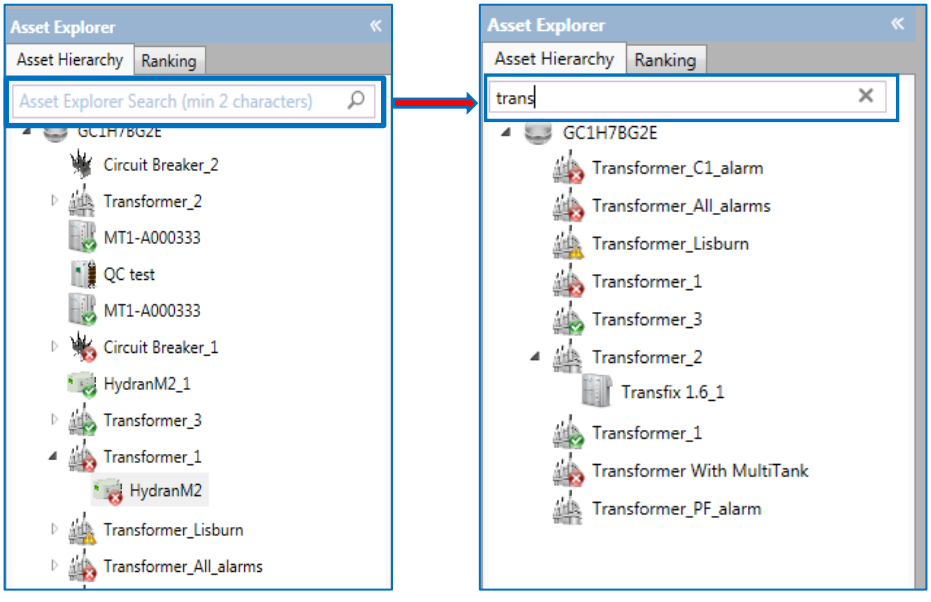


Figure 3-9: Asset Explorer – Search & results

Click a side right-pointing arrow to expand a node and reveal its hierarchy or associated monitoring device. Typically an 'Area' sits at the top of the hierarchy, while a 'monitoring device' sits at the bottom of the hierarchy.

The asset icons (or nodes) have a status indicator:

- Green Tick: All monitored parameters within bounds.
- Amber Exclamation Mark: A parameter(s) has exceeded the High or Low thresholds.
- Red Cross: A parameter(s) has exceeded the "High-High" or "Low-Low" or Ratio thresholds.
- Purple: Indicates that there is uncertainty in the latest measurement accuracy, or the latest measurement is considered to be in error. Refer to the device data table.
- Blue: Indicates the device has experienced a fault and requires a service.

Note: The device status is reproduced up the asset tree so that the related Transformer, Substation and Area also reflect the status of its worst subordinate device.

3.1.2.2 Data Area

The Data Area shows the corresponding details as calculated or retrieved from the database for the selected node in the hierarchy. For example, Figure 3-8 shows the details for the transformer GE_Trans_Gen_02A (as selected in the Asset Explorer).

The relevant data for the selected node is displayed across a series of tabs on the bottom of the screen (denoted by the purple border in Figure 3-8). The number and type of tabs vary according to the node. Selecting a tab opens the relevant tabbed page or worksheet.

The last activated tab opens the next time the node is selected. The default tab for assets and monitoring devices is Properties.

Note: To remove a tab, click the 'X' on the tab. It can be restored via the View menu, but a custom display tab can only be recreated manually. See Section 4.4.1.

3.1.3 User Roles (Network databases only)

Perception downloads the sampling data from your monitoring devices and stores it in a database. The database can be stored on your PC (known as a 'local' database), or stored at a remote location when used in conjunction with Perception Server (known as a 'network' database).

Note: A local database can only be accessed by users of that PC.

When used in conjunction with Perception Server, there are three user roles:

- *Observer*: 'Read-only' permissions to view the data of all devices, but cannot make any changes to the data or device settings.
- *Supervisor*: 'Read-write' permissions, so can alter device settings including deletion of a device.
- *Architect*: All the Supervisor permissions plus the rights to manipulate workflows including scheduling workflows.

Note: A user of a local database always has full permissions for that database.

The User role for network databases is controlled by the Administrator of Perception Server. A Supervisor or Architect role can make changes that affect all users of the database. They can alter the data upload schedule, change the device hierarchy and delete devices and data. Therefore, it's important to restrict the assignment of such roles to those that need this functionality and can be trusted with these permissions.

Wherever the database is stored, local or network, it is the Perception Desktop application that downloads the data from the monitoring devices, whereas Perception Server is used to manage access to a network database.

3.2 Managing Assets

You use the Asset Explorer to manage the network of assets and monitoring devices.

Note: A Supervisor role (or higher) allows you to create, move and delete assets and devices (if used in conjunction with Perception Server). Those changes will then be visible to all other users of the database at the next refresh (normally within a few seconds).

3.2.1 Adding Assets

To add a new node to the hierarchy, right click on the node under which the new node will sit and select **New** as shown in Figure 3-10. You have the option of adding a new **Area**, **Substation**, **Plant**, **Transformer**, **Transformer Bank**, **Circuit Breaker**, **Motor** or a variety of monitoring devices.

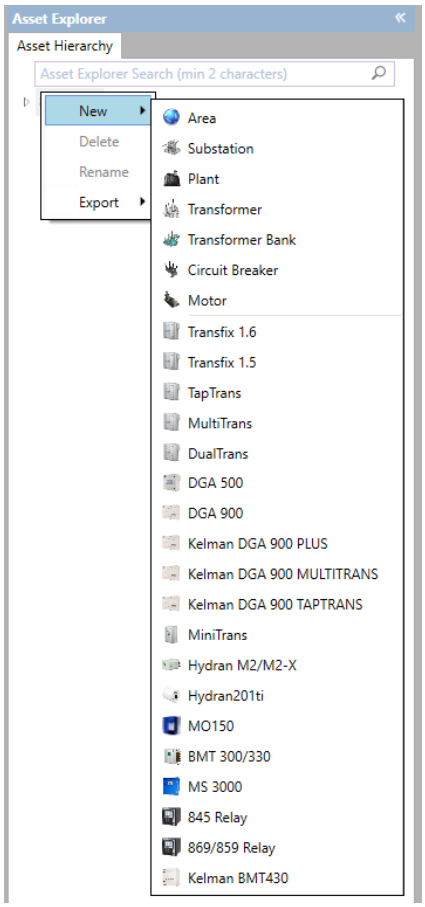


Figure 3-10: New nodes

Plant is available by default as shown above, while support has been added for GE's Multilin 845 transformer protection relay running firmware version 1.7 or later, Multilin 850 Feeder protection relay running firmware version 1.7 or later and Multilin 869 Motor protection relay running firmware version 2.00 or later.

Note: An additional installer is required to create 8 series relays. (Contact a GE sales representative to avail of this functionality.) 8 series relays are supported only in Perception Fleet.

Motor and Circuit Breaker assets are created at the same level in the asset hierarchy as a Transformer and behave in a similar manner. The 869 relay device is the only child of the Motor that can monitor a Motor asset. The 850 relay device can only be added as a child of a circuit breaker.

The 845 relay device can be added as a child of a transformer allowing users to compare the data received from the relay with other monitored transformer data using the transformer worksheets.

For assets and monitoring devices, complete their properties via the **Properties** tabbed page as shown in Section 3.8.1.

3.2.2 Renaming Assets

To rename an existing asset, right click on it and select **Rename** as shown in Figure 3-11.

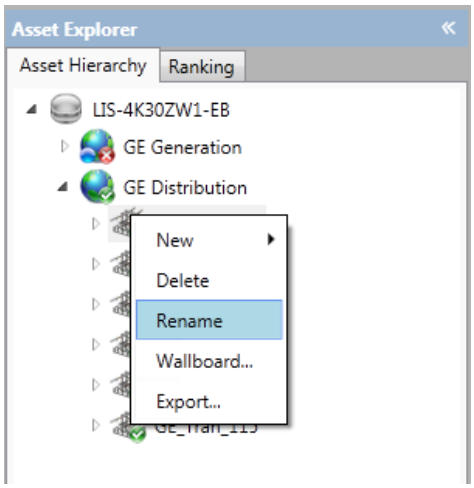


Figure 3-11: Rename a node

3.2.3 Deleting Assets

To delete an asset, right click on it and select **Delete** as shown in Figure 3-12.

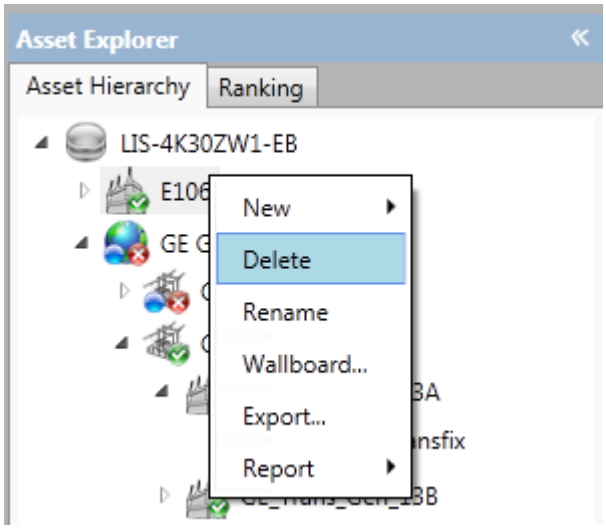


Figure 3-12: Delete a node

Warning: This action will delete the asset from the database entirely, including all data downloaded from that device.

Warning: The deletion of an asset will also delete all its subordinate assets. If you are reorganising the hierarchy into new groupings, ensure that you move all the subordinate assets to new areas within the Asset Hierarchy before the deletion of a grouping.

Before the asset is deleted, you must confirm your action as shown in Figure 3-13. Click **Yes** to delete the asset or **No** to cancel the operation.

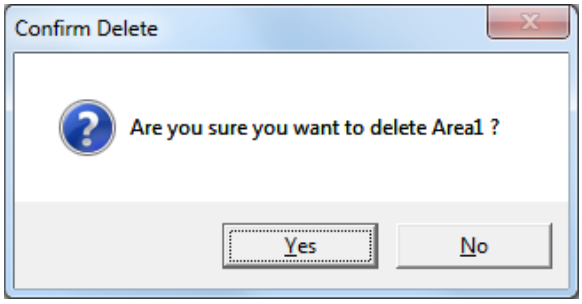


Figure 3-13: Confirm Delete

3.2.4 Moving Assets

The nodes in the Asset Hierarchy can be grouped using drag-and-drop methods. You can move individual nodes, or move a tree of nodes under another node in the asset hierarchy, depending on the hierarchical level selected.

To move a node, rest the mouse pointer over the node, then click and hold the left mouse button. Drag the node to its new position in the hierarchy before releasing the left mouse button.

Before the node is moved, you must confirm your action as shown in Figure 3-14. Select **Yes** to move the node or **No** to cancel the operation.

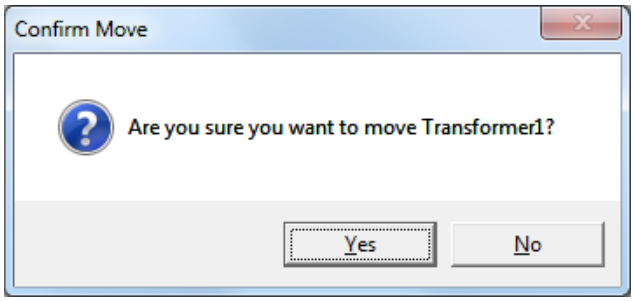


Figure 3-14: Confirm Move

In the example shown in Figure 3-14, the asset “SubStation1” has been moved from the same level as “Area1” to a subordinate level under “Area1” (denoted by the indentation).

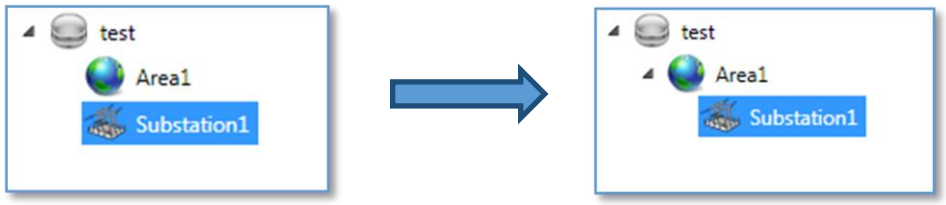


Figure 3-15: Asset Explorer drag and drop

3.3 Fleet Overview

If you select the top-level database node in the Asset Explorer, a Fleet Overview page displays with useful information summarising the health of the entire fleet as shown in Figure 3-16.

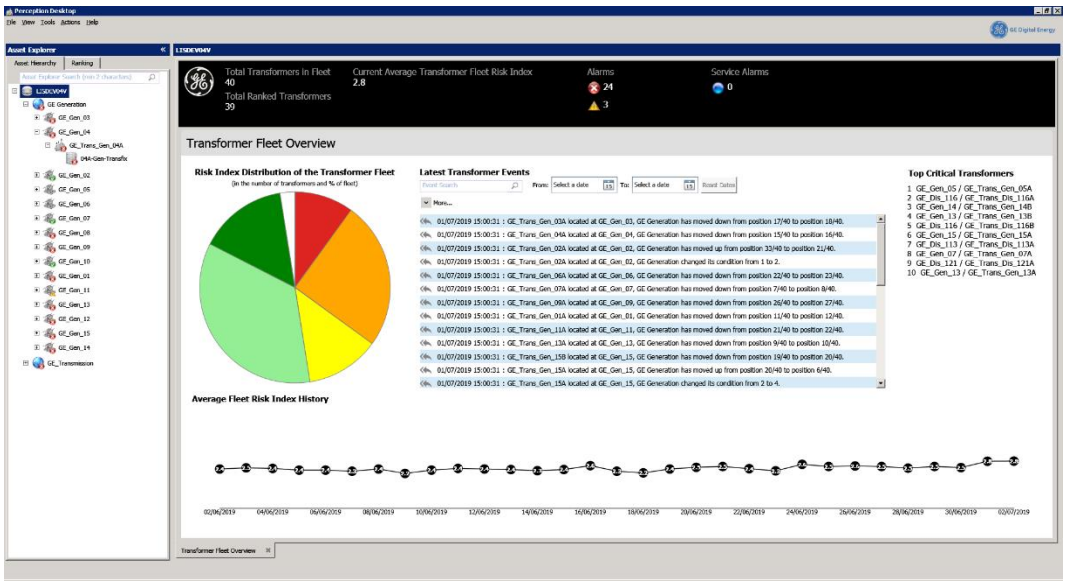


Figure 3-16: Fleet Overview

You can search for specific monitoring events using keywords in the Event Search box located at the top of the Fleet Overview page as shown in Figure 3-17. If you enter the name of an area, plant, substation or transformer, you will obtain all related transformer events for that area, plant, substation or transformer. Use the 'Navigate to Asset' link (as highlighted below) to navigate directly to the affected asset in the Asset Explorer. Use the Date boxes to filter events by date or click **More** to filter the search by event type as shown in Figure 3-17.

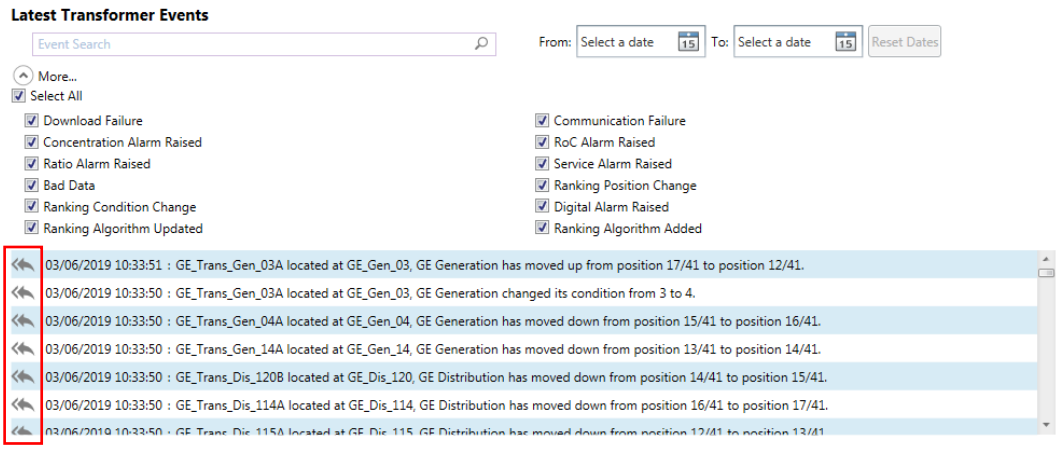


Figure 3-17: Event Search

Note: A similar Fleet Overview page exists at the database node level for Circuit Breakers.

3.4 Areas, Plants & Substations

Assets can be arranged hierarchically in the Asset Explorer under Areas, Plants and Substations. Areas, Plants and Substations contain just one tabbed page called a Wallboard. A Wallboard is a visual overview of all assets and their status shown on an image, typically a map. A Wallboard can be configured for an Area, Plant, Substation, Transformer Bank, Transformer or Circuit Breaker. An example of an Area wallboard is shown in Figure 3-18.

Note: A Plant represents a large industrial site where one or more Transformers or Motor assets reside. A Motor asset is a child asset of a Plant.

Figure 3-18: Area wallboard example

If used in conjunction with Perception Server, a Wallboard becomes a useful way to continuously monitor assets, for example, in a control room scenario. Perception Server facilitates a dynamic picture that updates as the condition of the assets change during automatic data download. See Section 3.10 for more information on setting up a Wallboard.

3.5 Transformer

Within a typical Asset Hierarchy there are multiple assets, such as Transformers and their monitoring devices. If you select a Transformer, a series of tabs display in the tabbed list at the bottom of the Data area. The default active tab is Properties as shown in Figure 3-19, but the asset opens on the last activated tab for the asset. See Section 3.9.1 for populating Transformer properties.

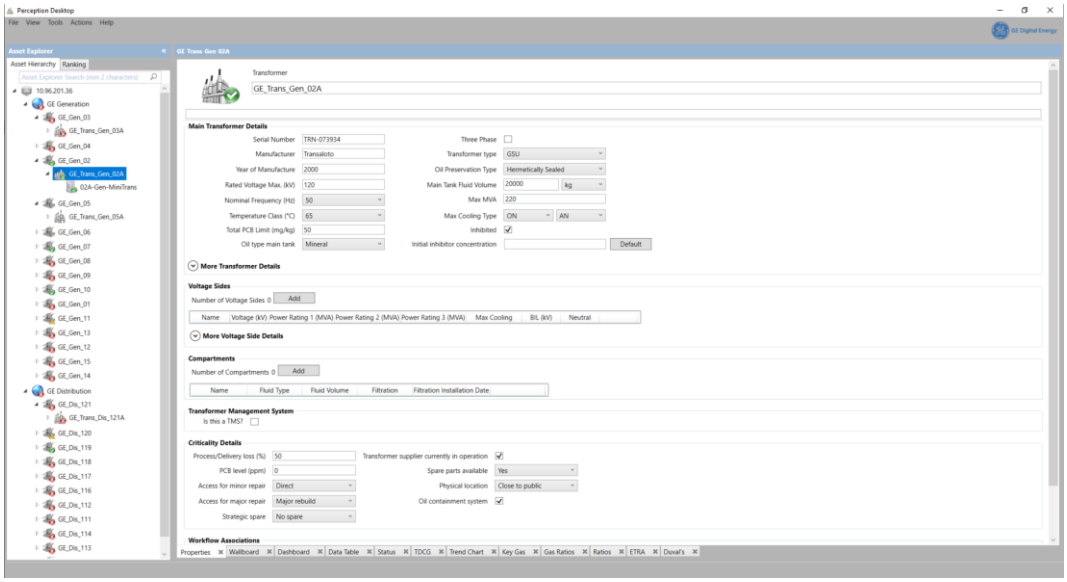


Figure 3-19: Transformer > Properties

3.5.1 Dashboard example showing MINITRANS

Select the **Dashboard** tab to display a page with useful information summarising the measurement data and ranking history for an individual transformer via two sub tabs – 'Devices Summary' and 'Ranking Graph', as shown in Figure 3-20.

The Dashboard tabbed page opens on the Devices Summary sub-tabbed page of the Transformer asset as shown in Figure 3-20. This lists each device monitoring the asset on a separate panel with summarised results from the various monitoring functions and an overall risk assessment. In this example, Transformer 02A has just one monitor, a MINITRANS device, attached.

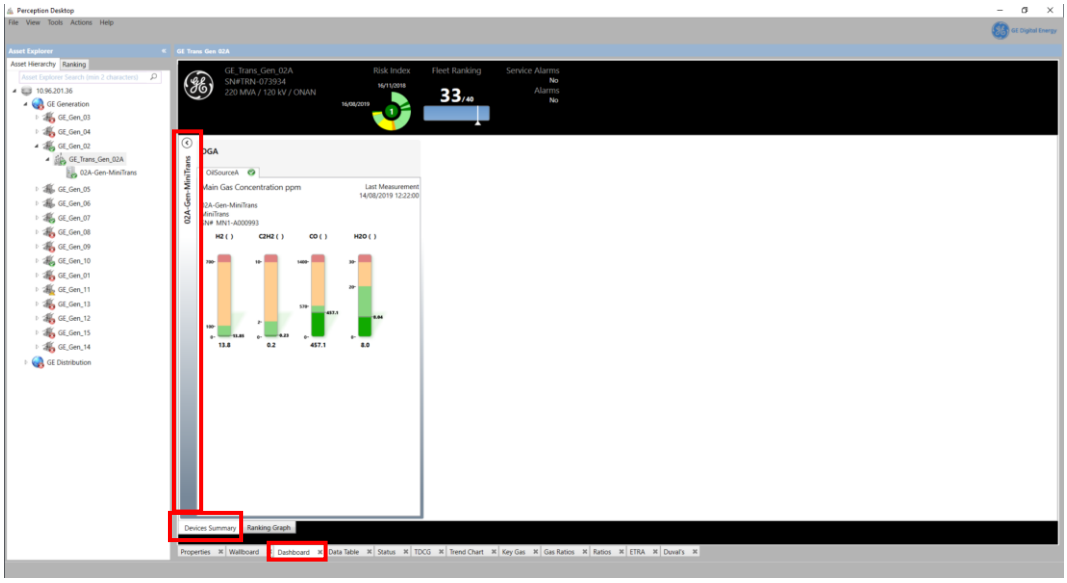


Figure 3-20: Transformer > Dashboard > Devices Summary – MINITRANS

Select the **Ranking Graph** sub tab to display the Risk and Ranking History as shown in Figure 3-21.

Figure 3-21: Transformer > Dashboard > Ranking Graph – MINITRANS

3.5.2 Dashboard example showing Intellix BMT 330

The device summary for an Intellix BMT device is shown in Figure 3-22. Depending on the inputs, there are multiple tabs, Primary Input (HV) and Partial Discharge (an additional tab is shown if the Secondary Input is in use e.g. Low Voltage).

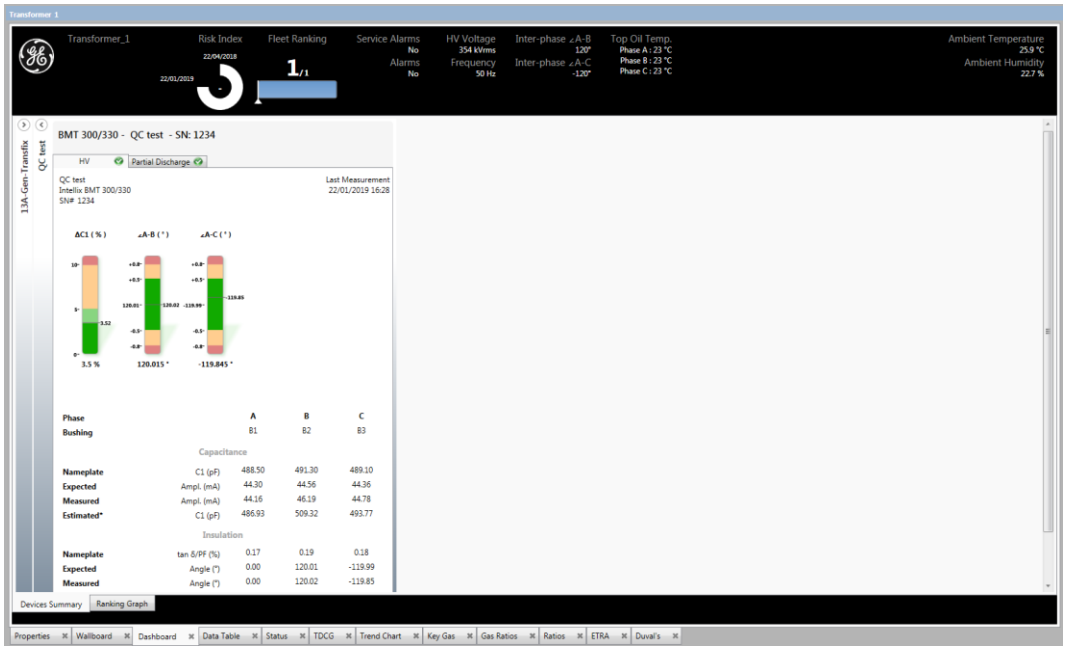
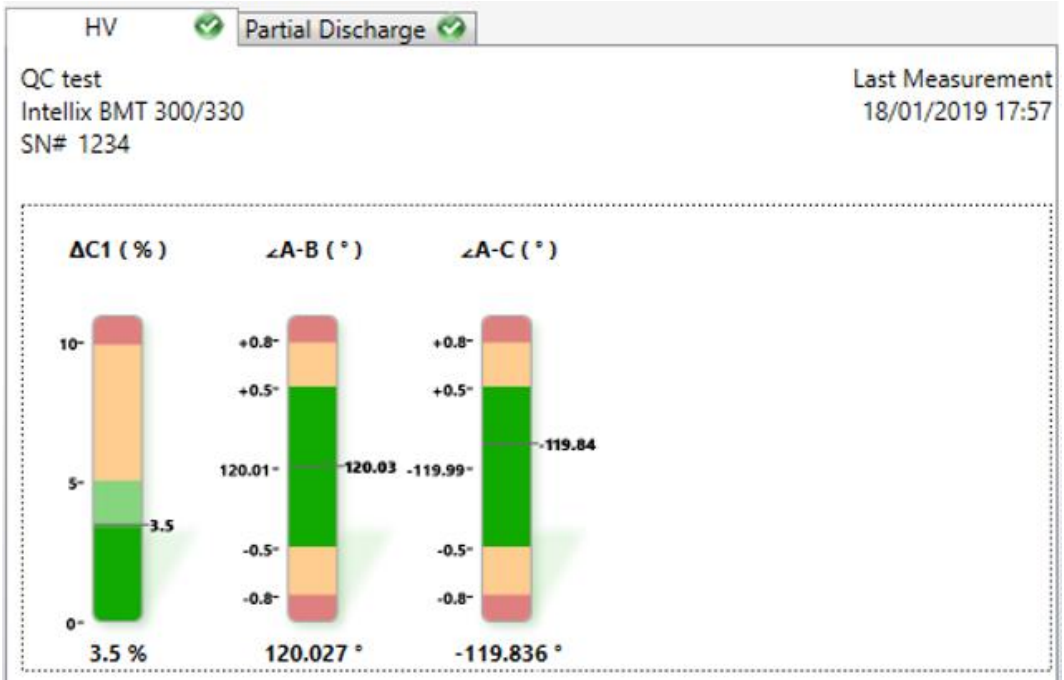


Figure 3-22: Transformer Dashboard > Devices Summary – BMT 330

In the example shown in Figure 3-23, the Primary Input labelled HV displays the following information:

- BMT device ID and Last Measurement timestamp

- A graphic summary of the bushing input set; namely ΔC1(%) (the imbalance of the displacement current amplitudes at the test taps of the three bushings, see Section 4.17 Bushing Monitor), and the angles ∠AB(°) and ∠AC(°) (the test tap currents Inter-Phase Angles, see Section 4.20).
- An extended numerical overview of the bushings' status.



Phase		A	B	C
Bushing		B1	B2	B3
	Capacitance			
Nameplate	C1 (pF)	488.50	491.30	489.10
Expected	Ampl. (mA)	44.30	44.56	44.36
Measured	Ampl. (mA)	44.16	46.18	44.79
Estimated*	C1 (pF)	486.93	509.21	493.88
	Insulation			
Nameplate	tan δ/PF (%)	0.17	0.19	0.18
Expected	Angle (°)	0.00	120.01	-119.99
Measured	Angle (°)	0.00	120.03	-119.84
Estimated*	tan δ/PF (%)	0.17	0.22	0.46

* Estimated values based on the measured bushing leakage current amplitude and inter-bushing phase, and the bushings nominal operating voltage and inter-phase angles.

Figure 3-23: BMT 330 Device Summary > Primary Input (HV)

In the example shown in Figure 3-24, the Partial Discharge tab displays the following information:

- The Last Measurement timestamp
- A graphic summary of the Partial Discharge activity for all three Primary Inputs namely PDI (mW) (the Partial Discharge Index) and the PD Avg. (pC) (Average Partial Discharge Apparent Charge) for all three inputs. See Section 4.18.
- An extended numerical overview of the PD status.

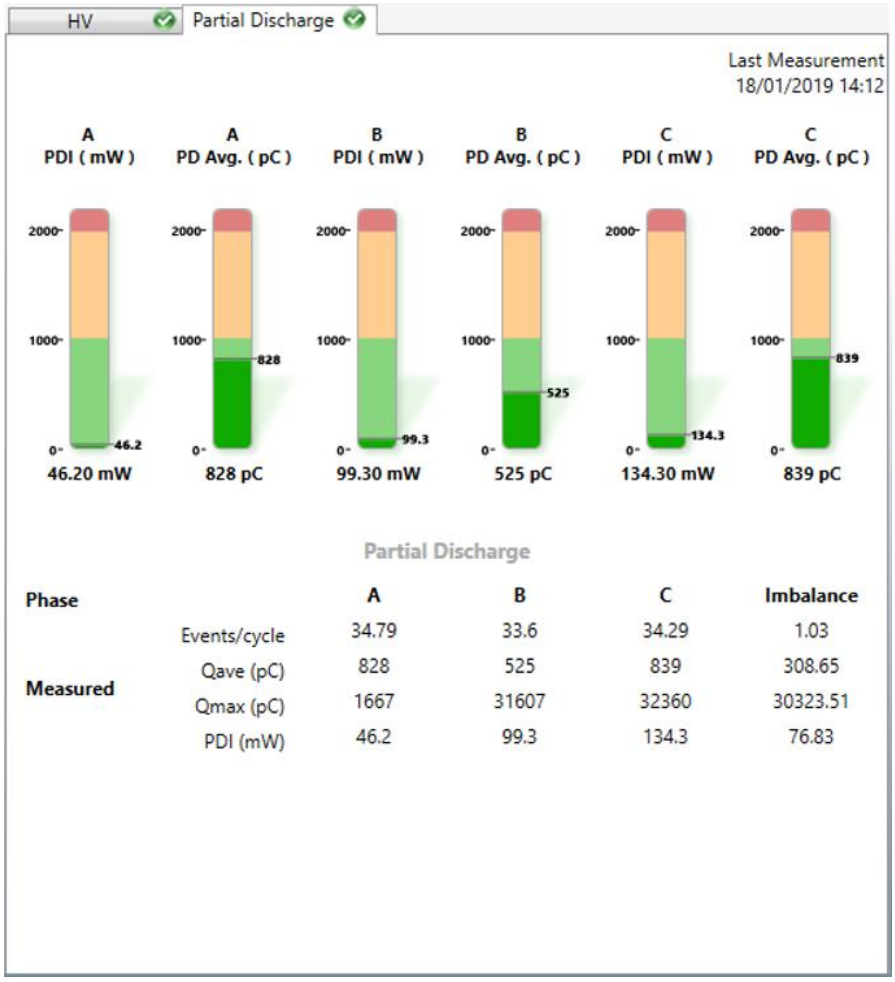


Figure 3-24: BMT 330 Device Summary > Partial Discharge

3.5.3 Dashboard example showing MS 3000

The device summary of an MS 3000 device is shown in Figure 3-25. Depending on the inputs, there are multiple tabs – Load currents, deltaC, Ageing, Gases & Moisture, Tap changer1 and Temperatures.

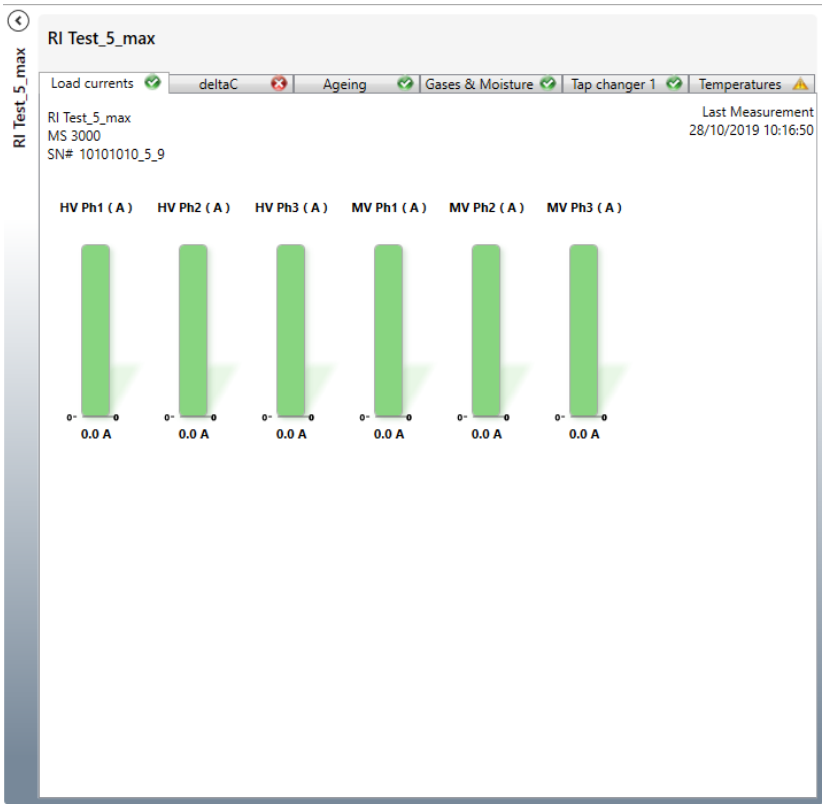


Figure 3-25: MS 3000 Device Summary

Perception downloads and visualises the Risk Index results along with the other data stored on the MS 3000. The Risk Index results are calculated directly on the MS 3000 monitor running master template 3.6.4.22p0_ 3.2.2.13p0_4.5p0 or later.

Perception can be configured to use and display only the Risk Indexes downloaded from the MS 3000, or only the Risk Index calculated in Perception or a combination of both. When both Risk Index options are configured, Perception automatically selects and displays in the most critical Risk Index result and information regardless of its origin.

Figure 3-26 shows how to assign the MS 3000 Risk Index workflow to the transformer so that the MS 3000 device's onboard Risk Index can be utilized.

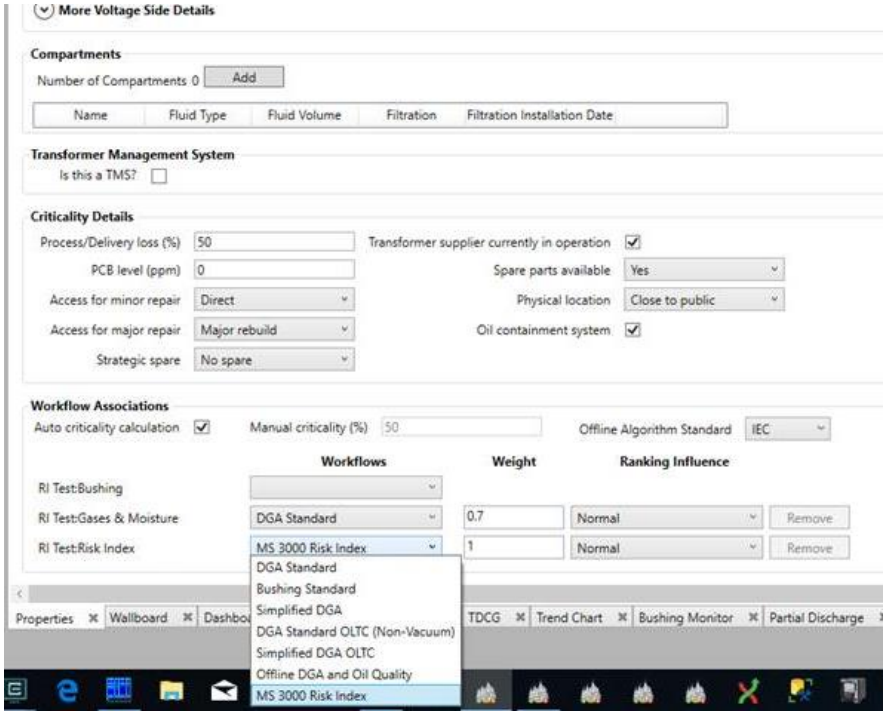


Figure 3-26: Transformer > Properties > Workflow Associations

Risk Index data downloaded from the MS 3000 can be exported and imported via the existing mechanism as outlined in Section 5.

3.6 Transformer Bank

A Transformer Bank is a grouping of single-phase transformers and their associated monitoring devices under a single visual entity in the Asset Explorer and is represented on the Area wallboard as a single node.

A Transformer Bank is treated the same as any other asset in that data can be imported/exported, alarms raised etc. An alarm status (and email notification) on any child asset propagates up to represent the status of the entire Transformer Bank with the most significant alarm determining the overall status of the Transformer Bank. A new Transformer Bank asset can be added to the Asset Hierarchy under an Area or Substation node. Right click the desired node and select **New** > **Transformer Bank** as shown in Figure 3-27. See Section 3.9.2 for populating Transformer Bank properties.

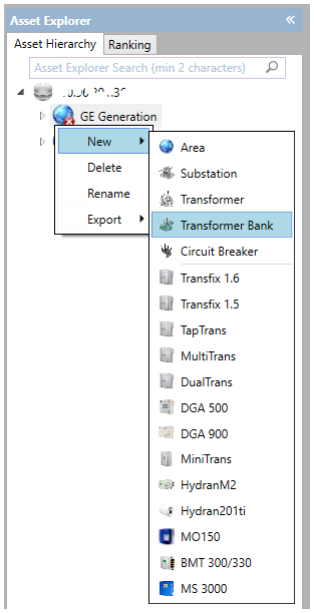


Figure 3-27: New > Transformer Bank

3.7 Circuit Breaker

A Circuit Breaker is another type of asset that can be added to the hierarchy. When a Circuit Breaker is selected in the Asset Explorer, a similar tabbed list of worksheets displays below in the Data area to the right. The default active tab is **Properties** as shown in Figure 3-49. See Section 3.9.3 for populating Circuit Breaker properties.

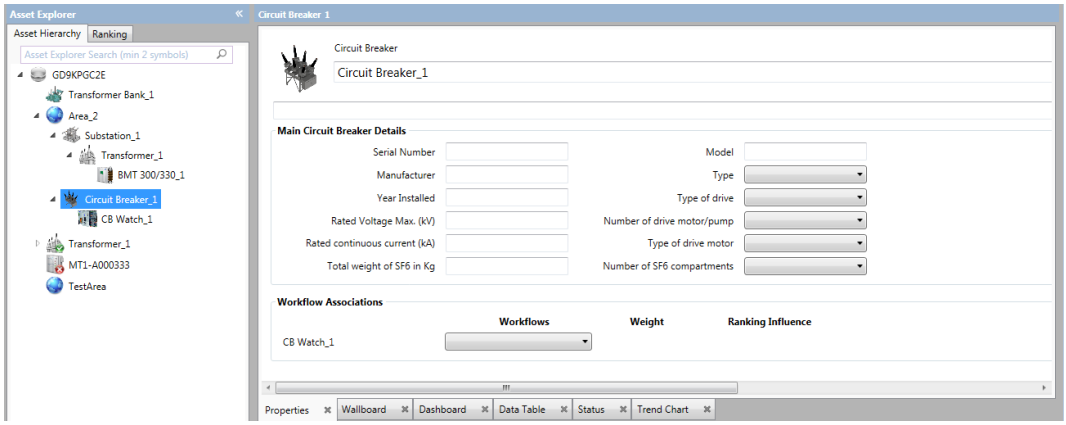


Figure 3-28: Circuit Breaker properties

Select the **Dashboard** tab to display a page with useful information summarising the measurement data and ranking history for an individual circuit breaker via two sub tabs – 'Devices Summary' and 'Ranking Graph', as shown in Figure 3-20.

The Devices Summary for a Circuit Breaker asset is shown in Figure 3-29. This lists each device monitoring the asset on a separate panel with summarised results from the various monitoring functions and an overall risk assessment.

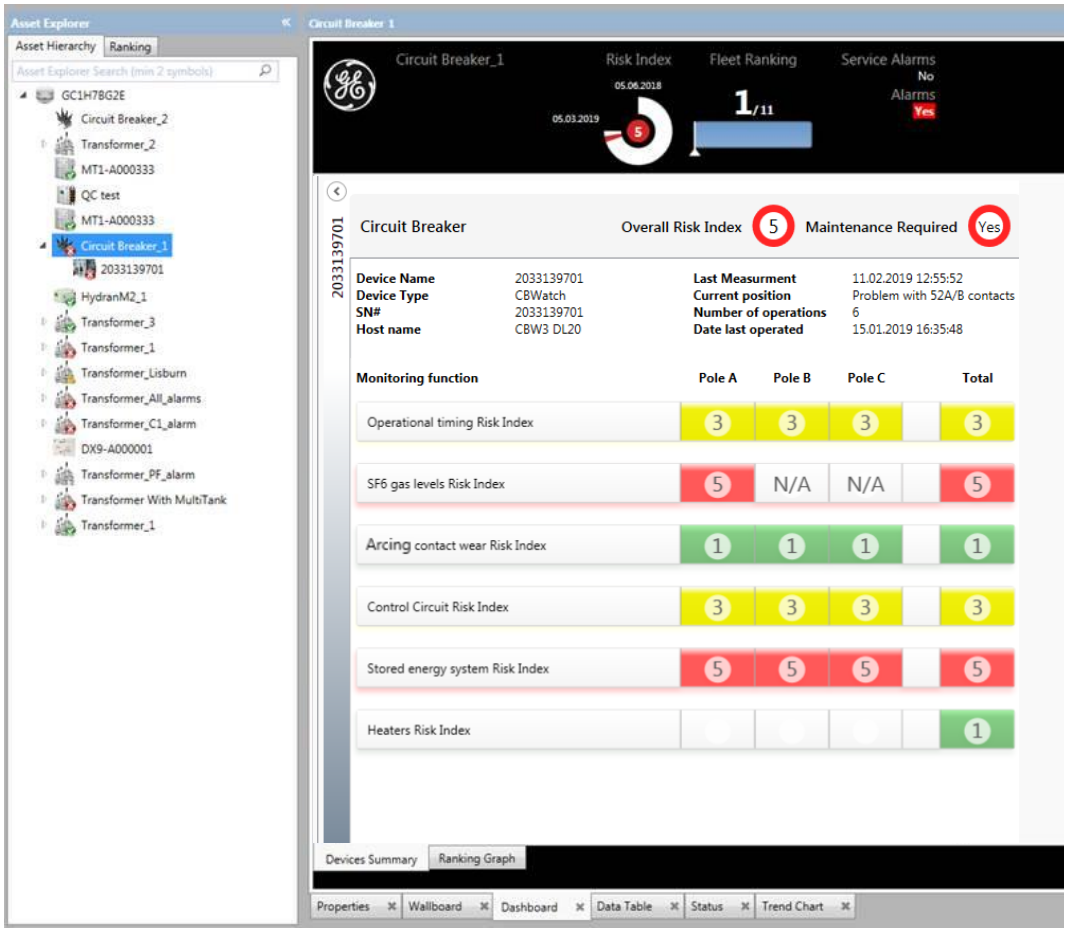


Figure 3-29: Circuit Breaker asset – Devices Summary – CB Watch 3

The CB Watch 3 monitoring device is not limited to downloading risk index and alarms data, but can also download data on the opening, pumping and closing operations, as well as the continuous measurements of the circuit breaker as shown in Figure 3-30. Perception regularly polls the CB Watch 3 device and checks if an operation has occurred. If there has been an operation, Perception then downloads the recent opening, pumping and closing data. Irrespective of any operation taking place, the continuous measurement data and risk index data is always downloaded and stored every four hours. The user can configure fast polling of the circuit breaker to allow CB Watch 3 to obtain the latest data. The polling interval will depend on the customer network, number of devices etc.

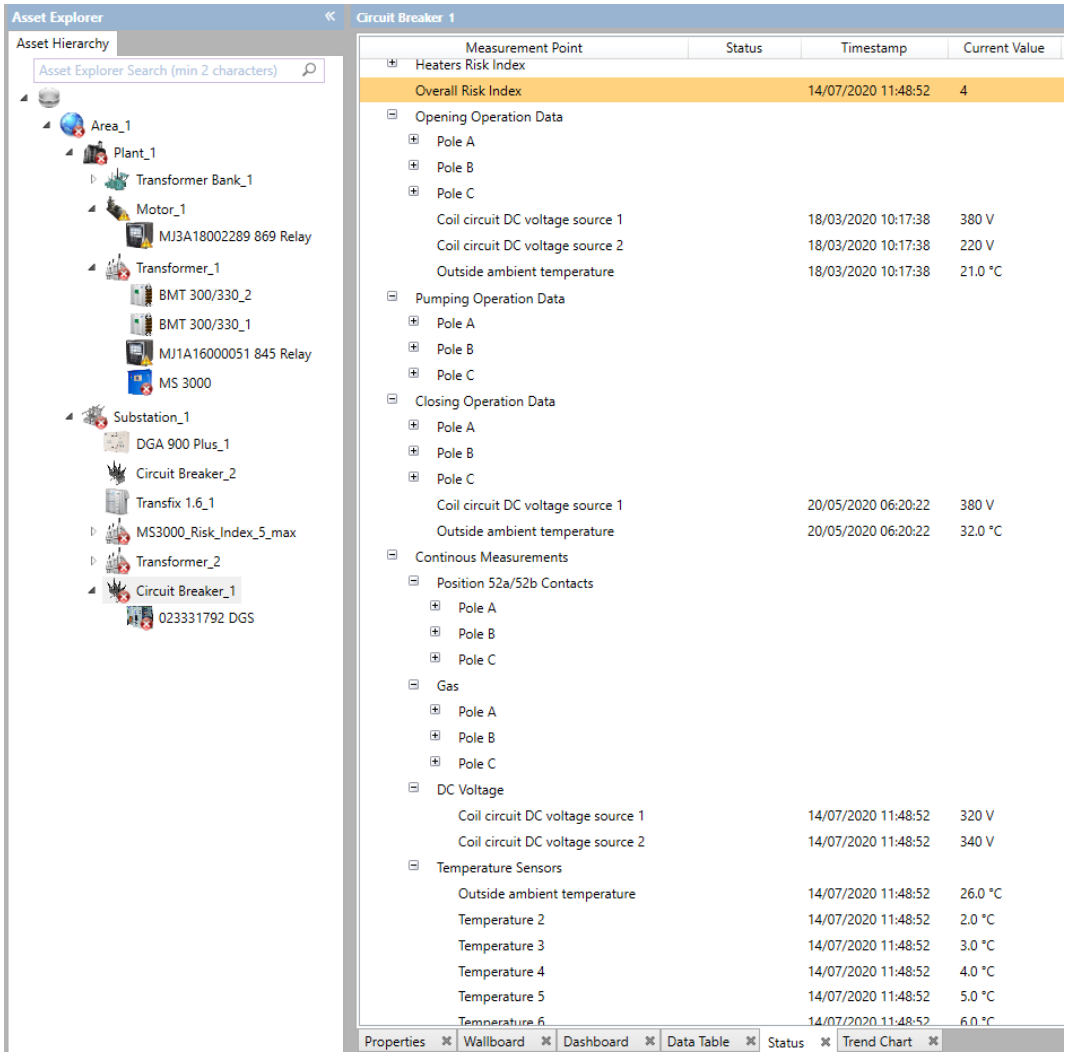


Figure 3-30: Circuit Breaker asset – CB Watch 3 – Status worksheet

3.8 Motor

A Motor is another type of asset that can be added to the hierarchy. A motor is organised under a Plant and parents a Motor protection relay. The Multilin 869 relay is a microprocessor-based unit designed for the protection, control, and management of induction and synchronous motors. Base relay models provide thermal overload and overcurrent protection including current and voltage-based backup functions.

When a Motor is selected in the Asset Explorer, a similar tabbed list of worksheets displays below in the Data area to the right. The default active tab is **Properties** as shown in Figure 3-31. See Section 3.9.4 for populating Motor properties.

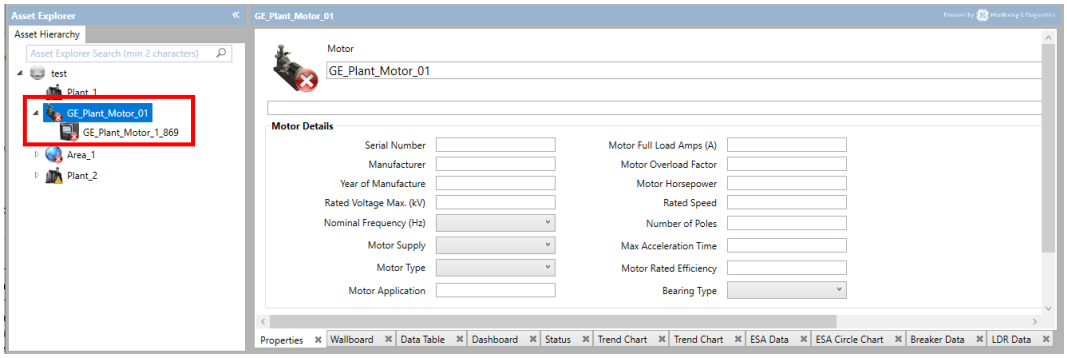


Figure 3-31: Motor properties

As well as data downloaded from the 869 motor protection relay, motor data can also be imported using the CSV file import mechanism.

Note: The motor asset is enabled as part of the 869 protection relay support. The 869 relay is the only available child device that can be added to a Motor asset.

3.8.1 Dashboard example showing Plant Motor (869 Relay)

Select the **Dashboard** tab to display a snapshot of the most relevant and important information gleaned from the Motor asset via Multilin 869 relay device. Data is grouped across a series of subtabs – **Events**, **Latest Events**, **Motor Start** and **Breaker Data**.

The Dashboard tabbed page opens on the Devices Summary **Events** sub-tabbed page of the Motor asset. The Events section shows the frequency of events captured on the 869 relay grouped by event type as well as an event count per month as shown in Figure 3-32.

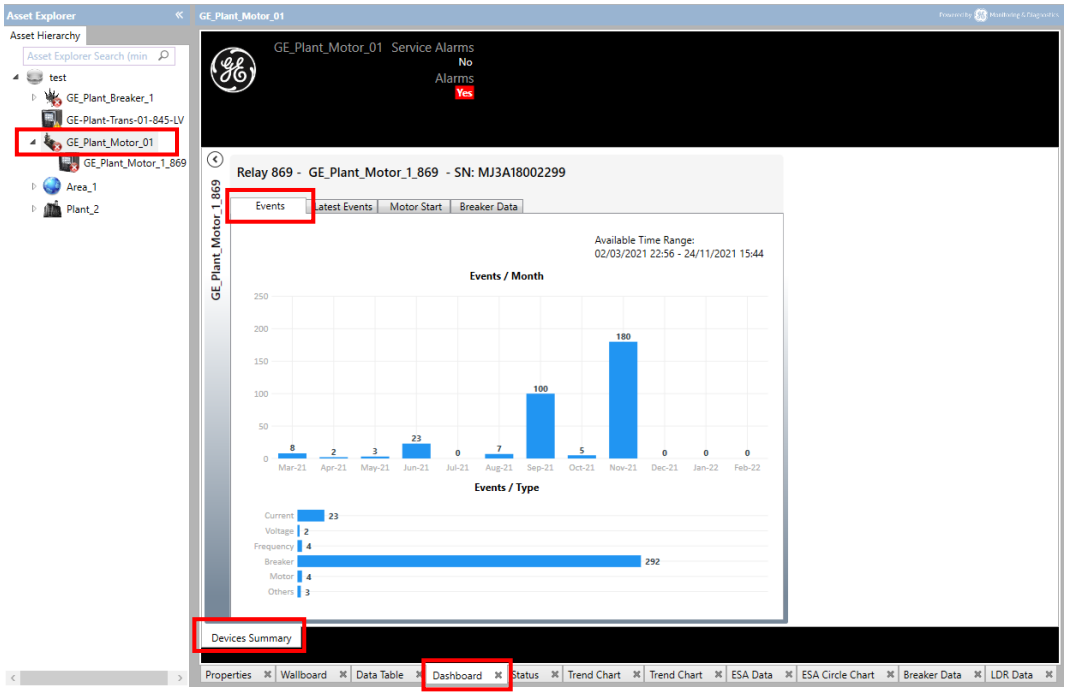


Figure 3-32: Plant Motor Device Summary

Figure 3-33 shows the **Latest Events** tabbed page. The Latest Events section lists the most recent event records in reverse chronological order.

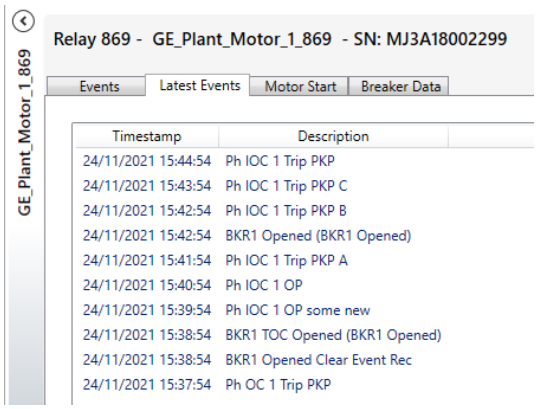


Figure 3-33: Motor > Dashboard > Latest Events

Figure 3-34 shows the **Motor Start** tabbed page. The Motor Start tabbed page plots the Acceleration Time (Ms), Effective Current (x FLA) and Peak Current (x FLA).

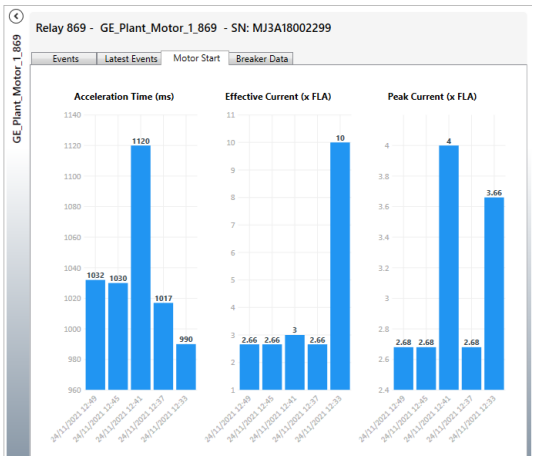


Figure 3-34: Motor > Dashboard > Motor Start

Figure 3-35 shows the **Breaker Data** tabbed page. The Breaker Data tabbed page presents two pie charts summarizing Breaker Arc Energy (kA2-Cycle) and Breaker Arc Time (ms) per phase.

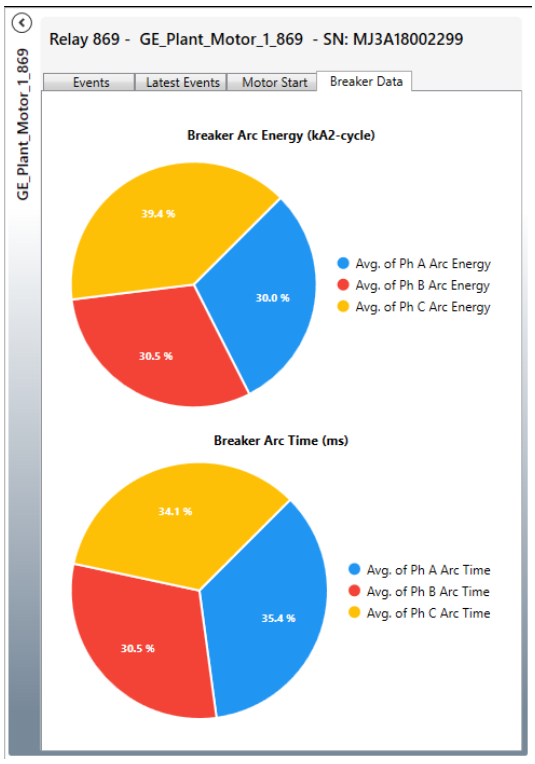


Figure 3-35: Motor > Dashboard > Breaker Data

3.9 Setting up Asset Properties

Transformers, transformer banks, circuit breakers and devices have several properties that are configured using the Properties worksheet.

3.9.1 Transformer Properties

When a transformer is selected in the Asset Explorer, the data area to the right lists all the worksheets (on the bottom) of which the **Properties** tab is first as shown in Figure 3-36. Since transformers do not have data that can be automatically downloaded, the transformer properties must be manually entered here.

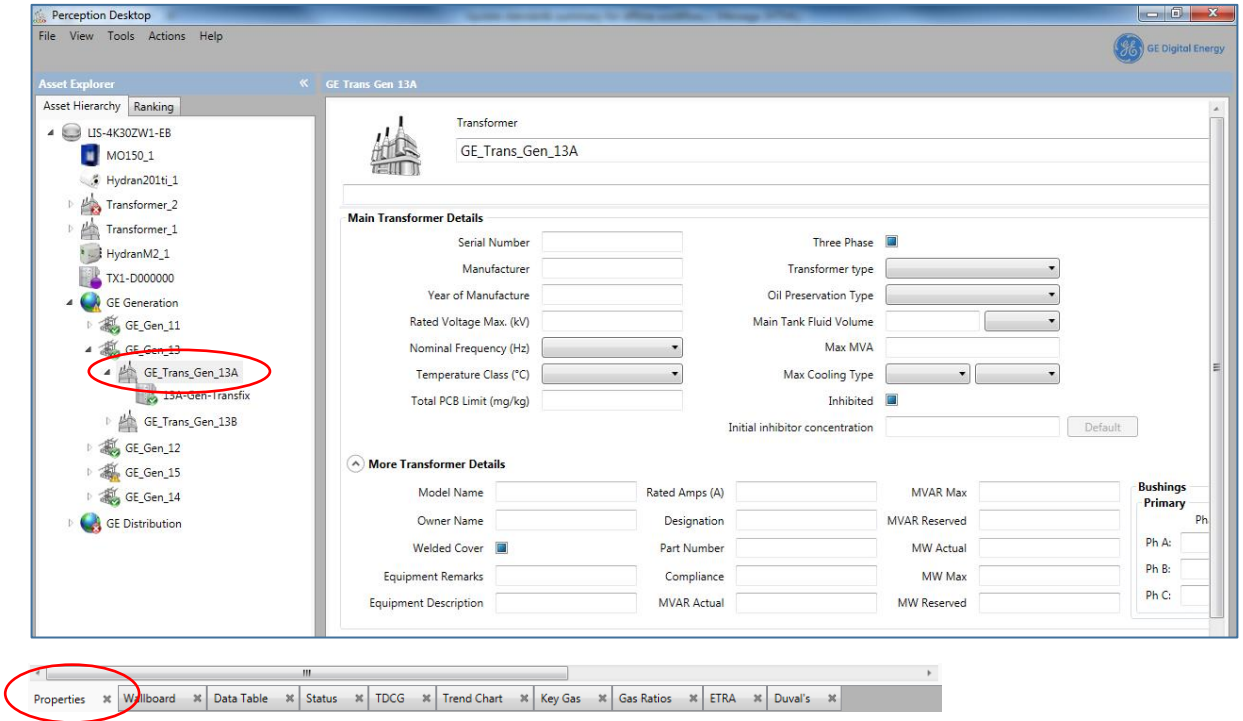


Figure 3-36: Transformer properties

The Transformer properties fields depend on whether the connection is to Perception Server or a local KPD database file. For example, there is no Workflow Associations section for a local KPD database file. The sections within the Properties worksheet are explained below.

- Transformer Name

The Transformer Name is a free text field where you can change the default name and enter more descriptive text as shown in Figure 3-37.

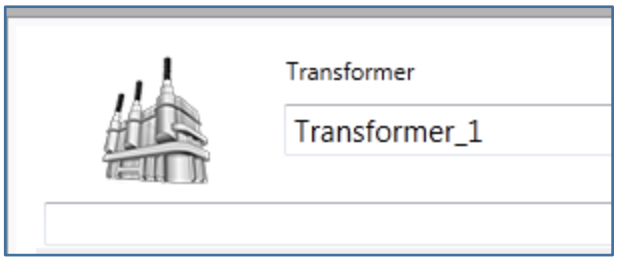


Figure 3-37: Transformer name

- Main Transformer Details

The main transformer name plate details are entered in Figure 3-38 and allow the identity and corresponding details to be stored in the database.

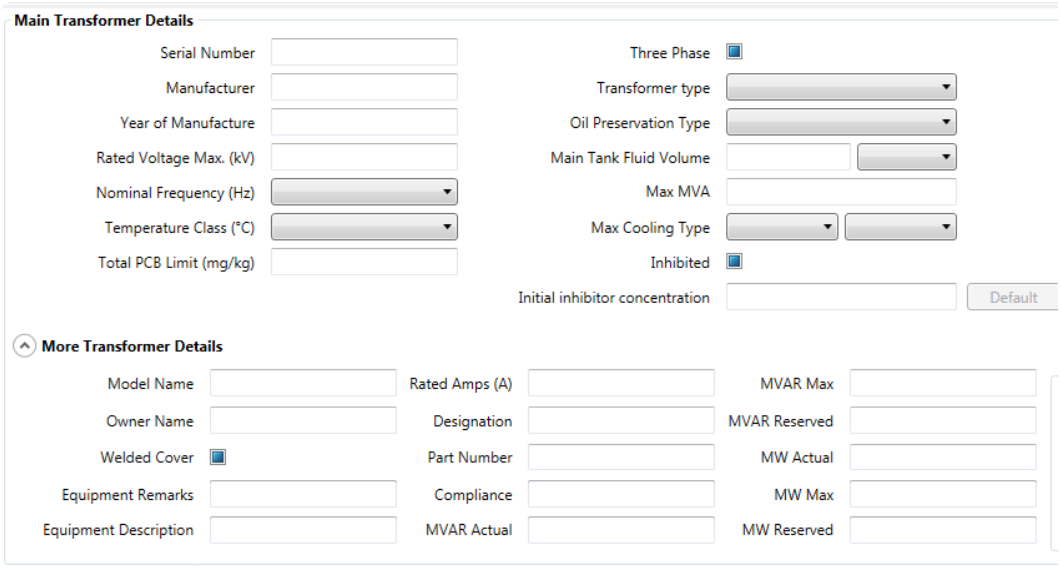


Figure 3-38: Main Transformer Details

Scroll to the right to enter primary, secondary and tertiary Bushing details as shown in Figure 3-39.

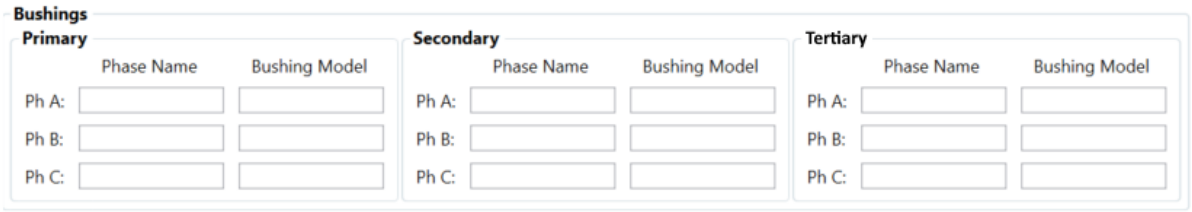


Figure 3-39: Bushings

- Voltage Sides

The Voltage Sides section as shown in Figure 3-40 allows information on the transformer's Voltage Sides to be stored in the database. To add a Side to the description, click the **Add** button.

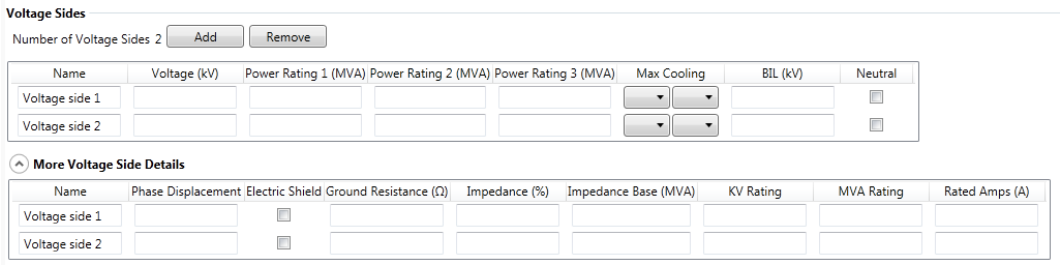


Figure 3-40: Voltage Sides

- Compartments

The Compartments section as shown in Figure 3-41 allows information on the transformer's compartments to be stored in the database. To add a Compartment to the description, click the **Add** button. To remove a Compartment, click on the compartment line to be removed and click the **Remove** button.

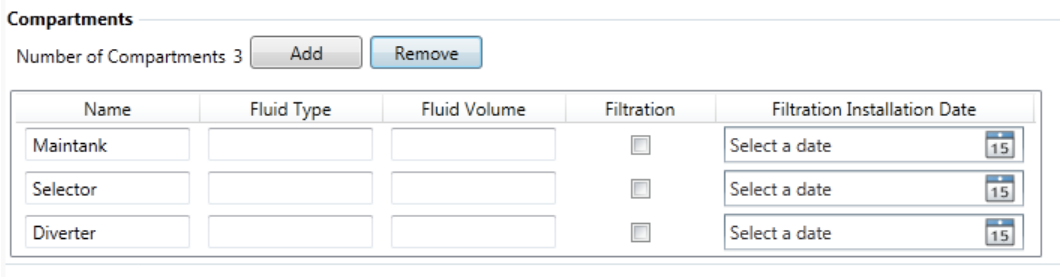


Figure 3-41: Compartments

- Criticality Details

The Criticality Details section as shown in Figure 3-42 allows additional information to be stored about the transformer, such as its physical location and the availability of spare parts. These properties may be unique critical factors or more general transformer characteristics or observations, but nonetheless could have a bearing on risk. The Criticality Details are used by the fleet ranking algorithms for a better risk assessment and more accurate transformer rankings.

Figure 3-42: Criticality Details

- Workflow Associations

The Workflow Associations section as shown in Figure 3-43 contains settings that are applied at the workflow level. The top line fields control how the Criticality Details influence the calculations. The default is to use an 'Auto criticality calculation', but this can be changed to any percentage (0-100%). The bottom field specifies the workflow associated with the transformer and the weighting of that workflow on the transformer calculations. Note: Click

'Remove' to remove a workflow association. The Ranking Influence field allows you to control the magnitude of effect that the transformer measurement parameters have on the data analysis through a sliding five-point scale. The default is 'Normal', but you can also minimize the effect by selecting 'Extra Rough' or maximize the effect by selecting 'Extra Sensitive'.

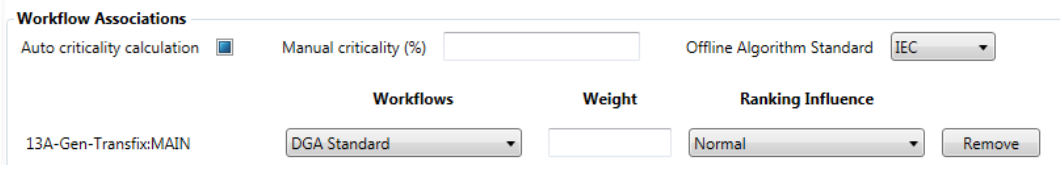


Figure 3-43: Workflow Associations

The next step is to add the monitoring devices that are associated with the transformer. See Section 3.2.1 and Section 3.9.5.

Note: Transformer measurement data can also be imported via a TOA formatted CSV file (See Section 5.1).

3.9.2 Transformer Bank Properties

The Transformer Bank's Properties worksheet allows the user to configure phase associations as shown in Figure 3-44. Phase associations allow the user to assign a transformer to its respective phase.

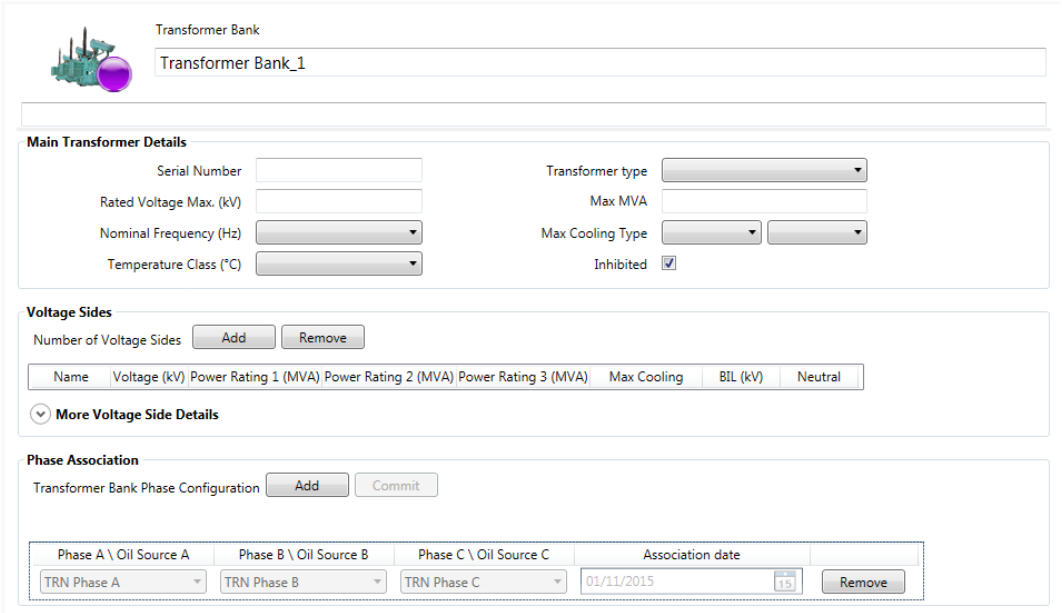


Figure 3-44: Phase Associations

Each phase configuration automatically creates an annotation at the association date in the Data Table and Trend Chart worksheets when you rest the mouse on the relevant timestamp as shown in Figure 3-45 and Figure 3-46.

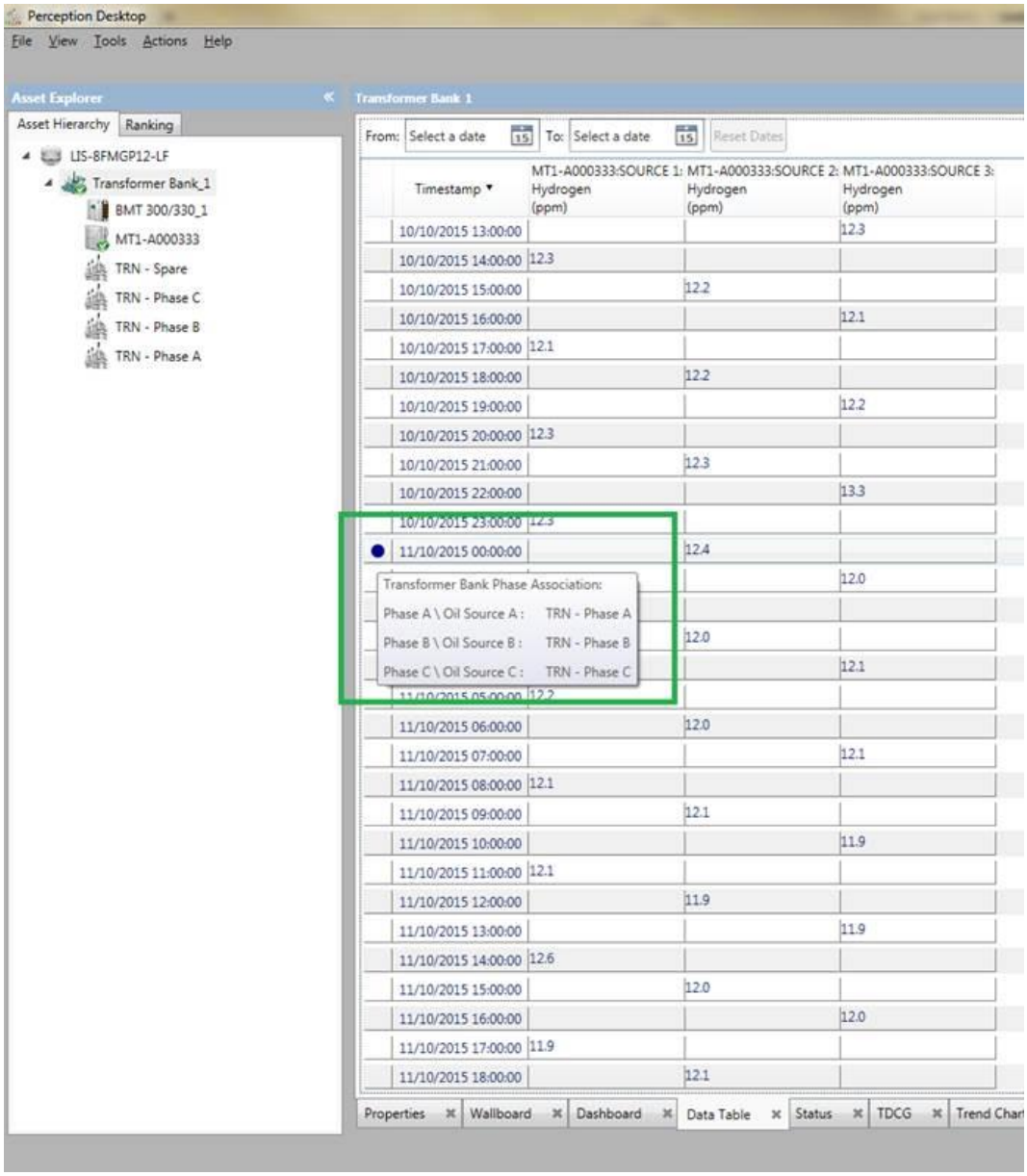


Figure 3-45: Phase Association annotation on Data Table

When a data source assignment changes for any transformer that is part of the Transformer Bank, an annotation is added to the Trend Chart to reflect the assignment change. An indication will also be made on the diagnostic worksheets to show the data being displayed crosses over a change of single phase assignment for the online device.

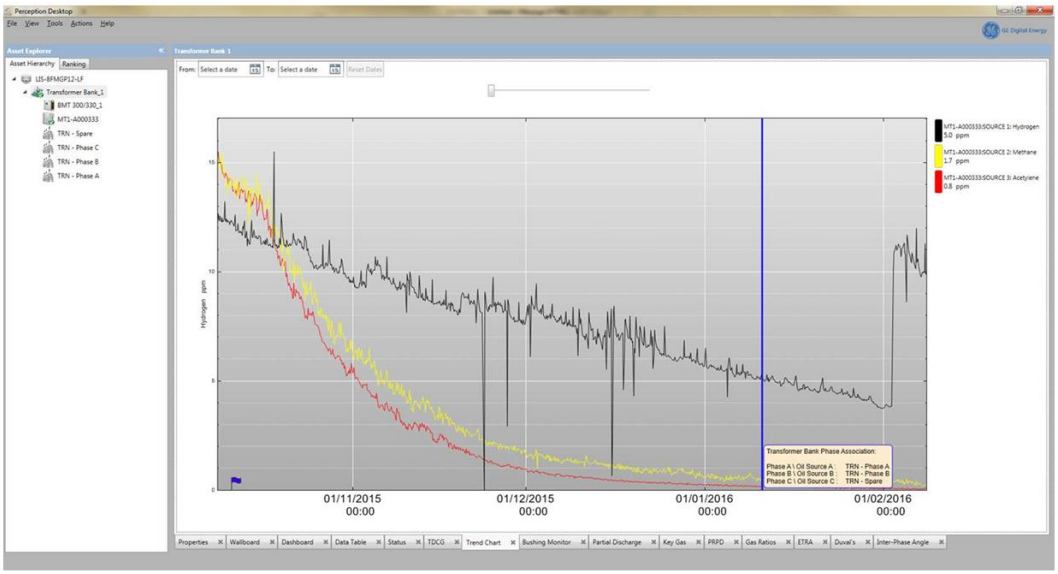


Figure 3-46: Phase Association annotation on Trend Chart

The Properties worksheet can also be used to make algorithm assignments for data sources so that the Transformer Bank and associated single phase transformers can be risk evaluated and ranked. Figure 3-47 shows how to associate the BMT Standard workflow with a Transformer Bank.

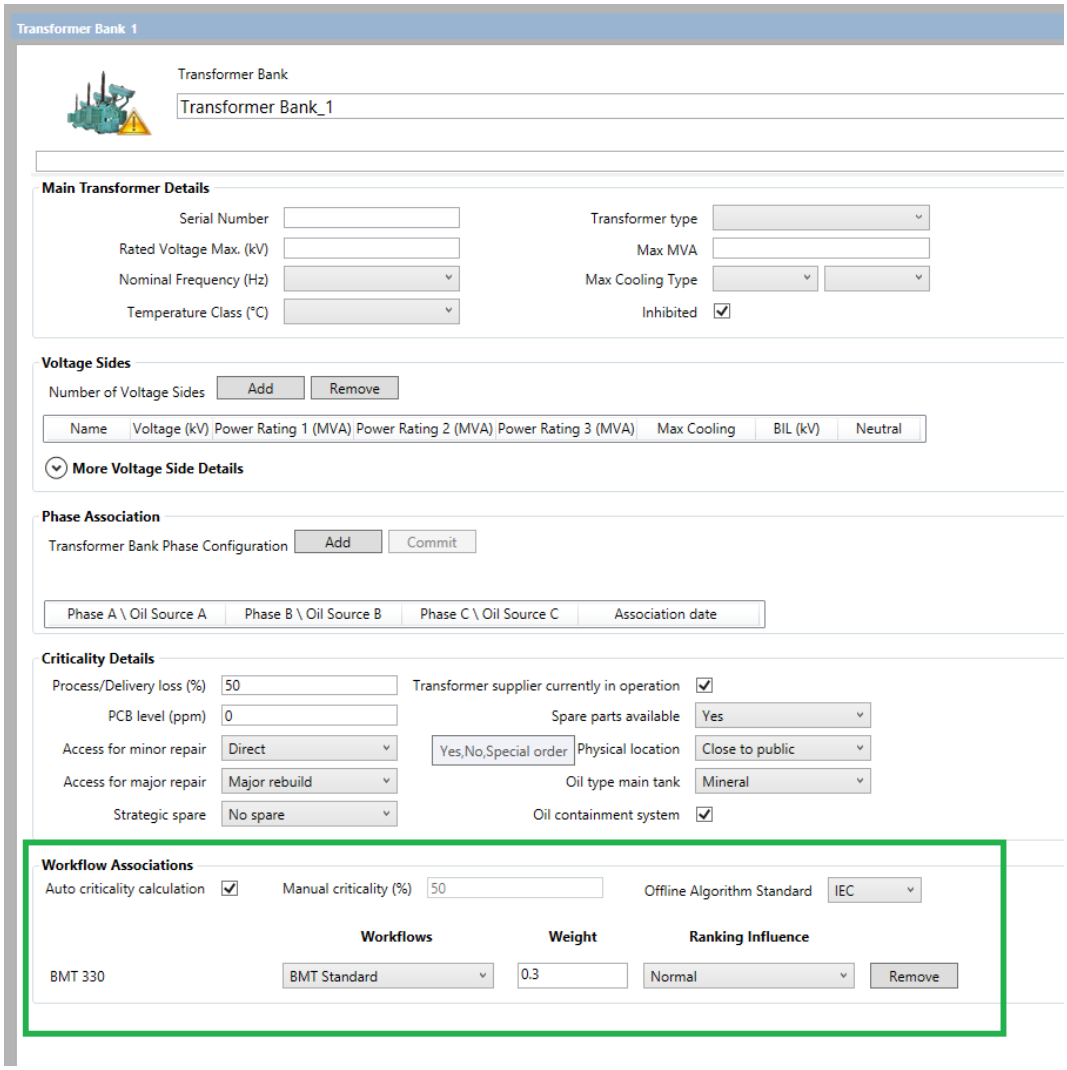


Figure 3-47: Transformer Bank

The Ranking tab shows the Transformer Bank with its condition determined by the combined risk indexes and conditions of its children including Intellix BMT devices.

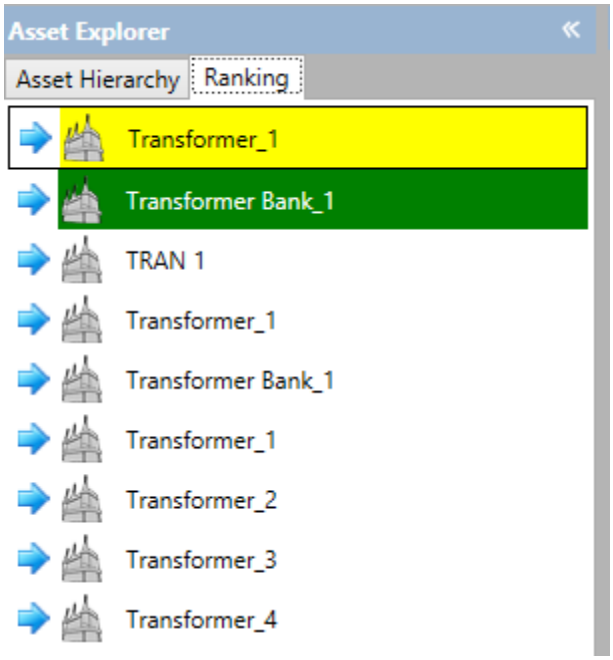


Figure 3-48: Ranking

3.9.3 Circuit Breaker Properties

When a Circuit Breaker is selected in the Asset Explorer, the data area to the right lists all the worksheets (on the bottom) of which the **Properties** tab is first as shown in Figure 3-49. Since circuit breakers do not have data that can be automatically downloaded, the circuit breaker properties must be manually entered here.

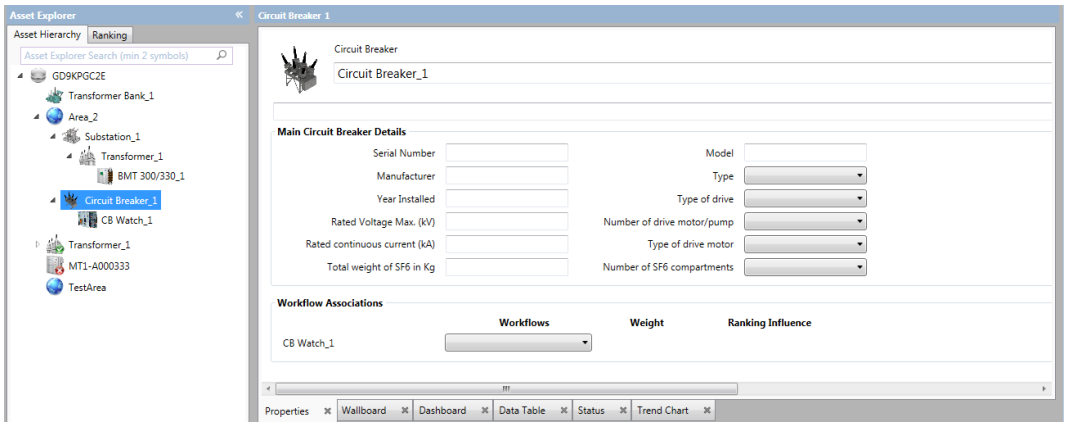


Figure 3-49: Circuit Breaker properties

The Circuit Breaker properties fields depend on whether the connection is to Perception Server or a local KPD database file. For example, there is no Workflow Associations section for a local KPD database file. The sections within the Properties worksheet are explained below.

- Circuit Breaker Name

The Circuit Breaker Name is a free text field where you can change the default name and enter more descriptive text as shown in Figure 3-50.

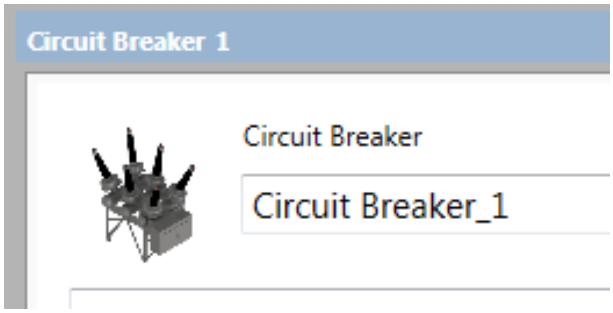


Figure 3-50: Circuit Breaker name

- Main Circuit Breaker Details

The Main Circuit Breaker Details are entered in Figure 3-51 and allow the identity and corresponding details to be stored in the database.

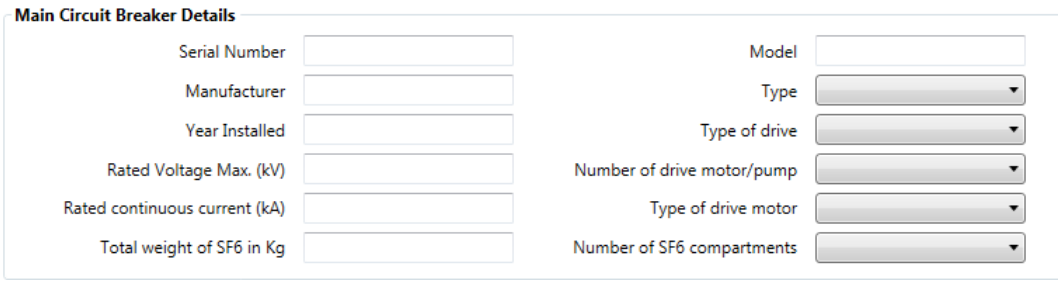


Figure 3-51: Main Circuit Breaker Details

- Workflow Associations

CB Watch 3 support is available for the Perception Workflow Risk Indexing and Ranking mechanism. A new algorithm called CB Watch has been created under the Workflows dropdown list as shown in Figure 3-52. When selected, Perception uses the Risk Index results received from the CB Watch 3 to present a Risk Index overview and rank position within the asset ranking table.

Figure 3-52: Workflow Associations

3.9.4 Motor Properties

When a Motor is selected in the Asset Explorer, the data area to the right lists all the worksheets (on the bottom) of which the **Properties** tab is first as shown in Figure 3-53. Since Motors do not have data that can be automatically downloaded, the Motor properties must be manually entered here. The motor properties page can be used to capture specific information about the motor being monitored.

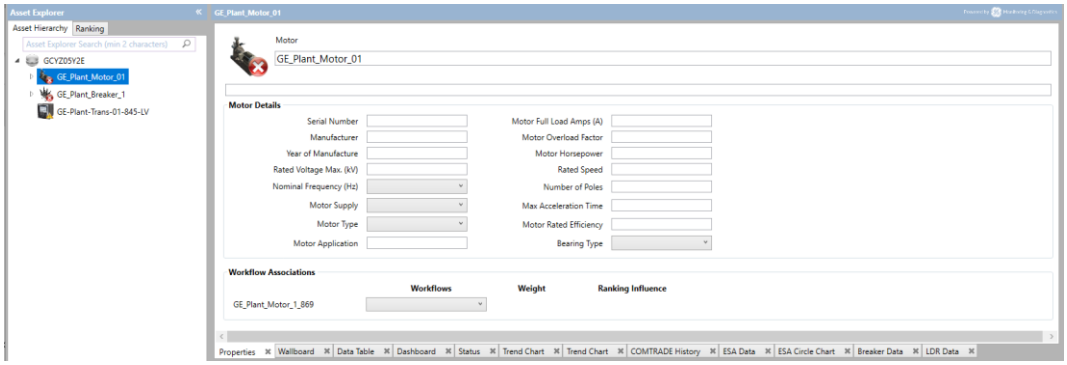


Figure 3-53: Motor properties

The Motor properties fields depend on whether the connection is to Perception Server or a local KPD database file. For example, there is no Workflow Associations section for a local KPD database file. The sections within the Properties worksheet are explained below.

- Motor Name

The Motor Name is a free text field where you can change the default name and enter more descriptive text as shown in Figure 3-54.

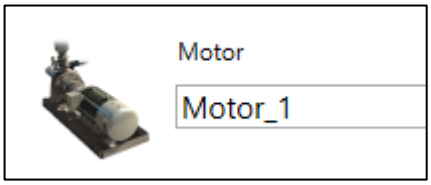


Figure 3-54: Motor name

- Motor Details

The Motor Details are entered in Figure 3-55 and allow the identity and corresponding details to be stored in the database.

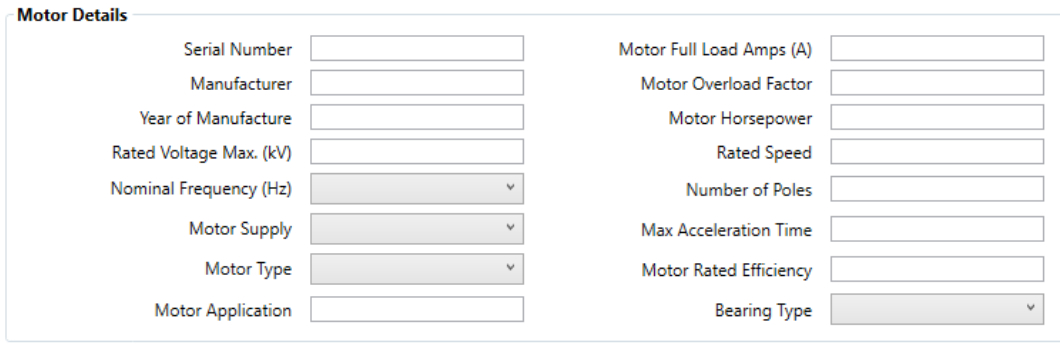


Figure 3-55: Motor Details

- Workflow Associations

A Motor supports the 869 Motor Ranking Workflow. A new algorithm has been created under the Workflows dropdown list as shown in Figure 3-52. When selected, Perception uses the Risk Index results received from the 869 Relay to present a Risk Index overview and rank position within the asset ranking table.

Figure 3-56: Workflow Associations

3.9.5 Device Properties

When a device is selected in the Asset Explorer (E.g. a Transfix 1.6), the data area to the right lists all the worksheets (on the bottom) of which the **Properties** tab is first as shown in Figure 3-57. The **Properties** worksheet is used to configure the device.

Note: If used in conjunction with Perception Server, 'Supervisor' status or higher is required to change device properties.

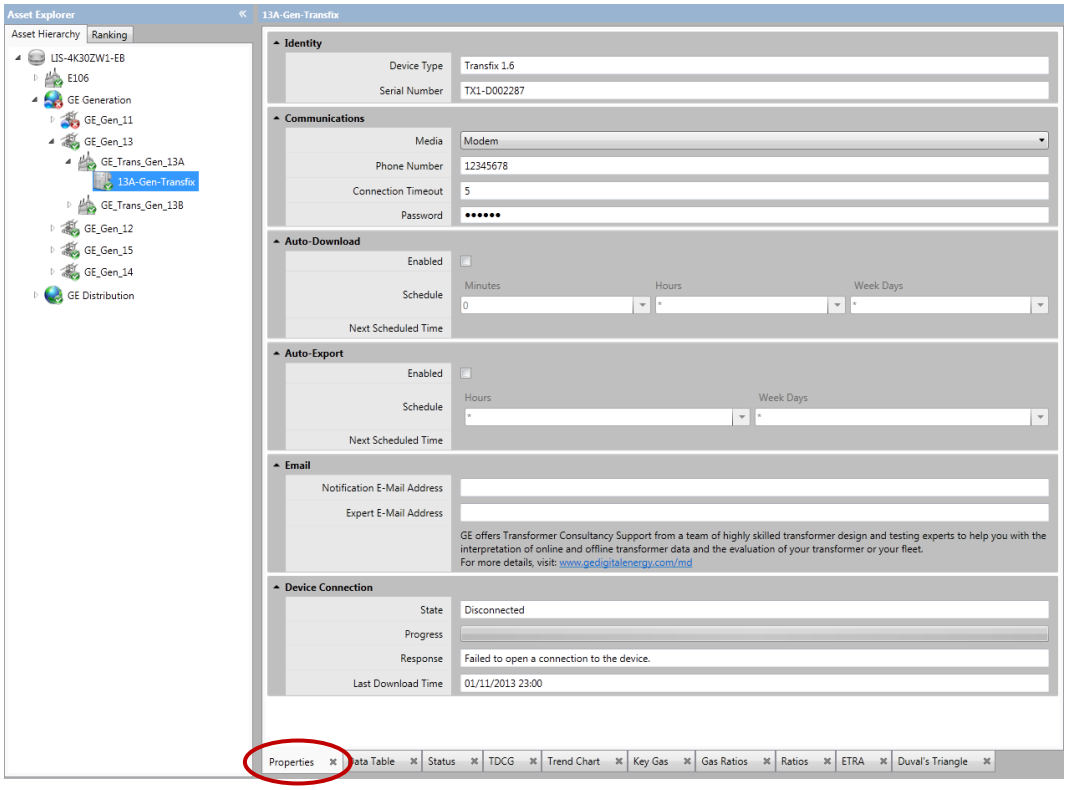


Figure 3-57: Device Properties

The Properties worksheet contains several sections that are explained below:

3.9.5.1 Identity

The Identity section details the identity of the device. It contains two read-only fields as shown in Figure 3-58:

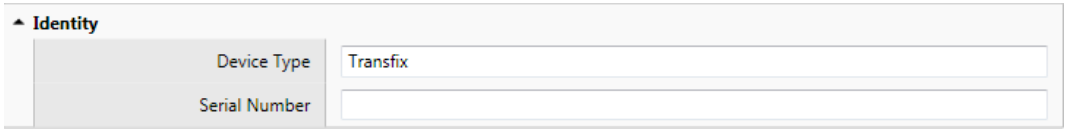


Figure 3-58: Identity

- *Device Type*: The device type is defined by the type of asset added using the Asset Explorer (see Section 3.2.1).

- *Serial Number*: The serial number is populated when the first download is performed from the device.

3.9.5.2 Communications

The Communications section allows the communication method to be defined and configured as shown in Figure 3-59. Other configuration fields are available depending on the device and your choice of Media as outlined below:

Note: When used in conjunction with Perception Server, you specify the communications with the device here. Perception Server downloads the monitoring data, but Perception Desktop is the controlling application used to specify all the configuration parameters.

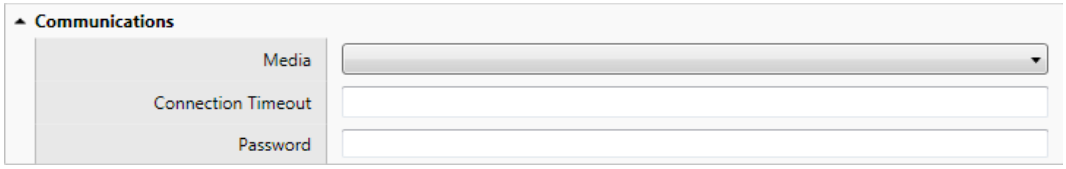


Figure 3-59: Communications

- **Media**: Defines what type of connection is used to connect with the device. Available options are:
  - ➢ Network

    This adds three additional fields:
    - *Hostname (or IP address):* The devices host name or IP address.
    - *MODBUS/TCP Port:* The MODBUS/TCP port defines the port used for communication with the host name or IP address (the default value is 502).
    - *Protocol:* When adding a DGA 900-family device, MS 3000 or CB Watch 3 there is the option to use either the HTTP (default port 80) or HTTPS (default port 443) protocol. The selected protocol must match the protocol set on the device. For DGA 900-family devices, it is possible to define a non-standard port, select the checkbox **Define network port** and specify a port from 0 to 65535 as shown in Figure 3-60.

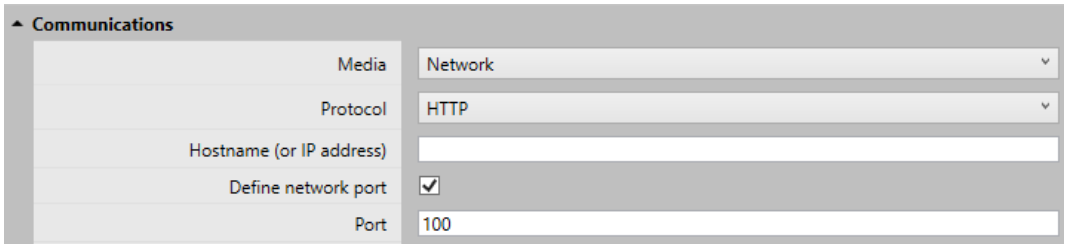


Figure 3-60: Communications > Define network port

  - ➢ Modem

    This adds one additional field:
    - *Phone Number:* The phone number of the modem in the device.
  - ➢ Serial

    This adds eight additional fields:
    - *Slave Address:* The address of the device on a multi-drop network.

- *Protocol*: The MODBUS protocol to use to communicate with the device.
- *COM Port*: The local COM port to use when connecting to the device.
- *Baud Rate*: The maximum speed at which the device talks.
- *Data bits*: The number of data bits in each character being sent.
- *Parity*: Turn on error correction.
- *Stop Bits*: Use the hardware to detect stop bits (end of messages) and re-synchronize the character stream.
- *Flow Control*: Allow the transmission of data to be paused / resumed.

If a Hydran M2 or Intellix MO150 device is selected, an additional Protocol field appears on the Properties worksheet:

➢ *Protocol*: Selects the protocol method used to communicate with the device. Perception Desktop supports the DNP3 protocol and three Modbus protocols (RTU, ASCII and TCP/IP).

If a Hydran 201Ti device is selected, an additional Protocol field appears on the Properties worksheet:

➢ *Protocol*: Selects the protocol method used to communicate with the device. Perception Desktop supports the Hydran Native Protocol and three Modbus protocols (RTU, ASCII and TCP/IP). Note: To facilitate TCP/IP communication, the unit requires an RS-485 to Ethernet conversion.

Note: For Hydran devices, the Media field displays after you select the Protocol. Serial refers to a USB or RS-485 connection.

- **Connection** Timeout: Defines the time to wait before reporting a connection timeout. Enter a value in seconds.

Note: A default value is created in this field when you select the **Media** type.

- **Password**: The password for the device.

3.9.5.3 Auto-Download

When used in conjunction with Perception Server, the Auto-Download section becomes available in the device Properties as shown in Figure 3-61.

Note: A local database permits only manual downloads. See Section 5.1.

The Auto-Download section allows the connection and downloading from devices to be automatically scheduled. The schedule settings are unique to the device allowing a simultaneous download to be scheduled.

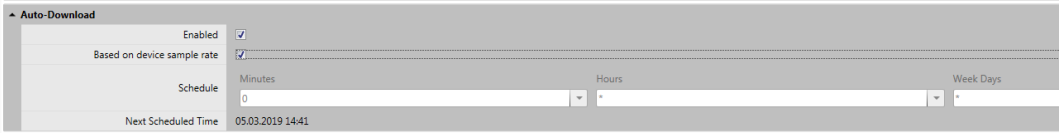


Figure 3-61: Auto-Download

- **Enabled**: Enables/disables the scheduling of downloads from the device.
- **Based on device sample rate**: Ensures that the auto-download takes place based on the device sampling rate rather than the Perception schedule, meaning that data is downloaded as soon as new measurements become

available. This effectively means the Perception schedule below is ignored. This option is useful if the online monitor goes into alarm mode and starts to sample more regularly. Previously, Perception would not have been aware that more regular samples were being taken, so would only have downloaded data based on the Perception schedule.

Note: Users may notice that there is a time difference of one hour between the download time and measurement schedule time. This difference is required as it can take up to 1 hour for a measurement sample to complete fully.

- **Schedule**: Defines the download schedule in terms of specific days and times using the "Unix Cron" notation. The essential Unix Cron field values supported in Perception scheduling are the "*" character and the "0" value.
  - "0" means "at the top of" e.g. if used in the hour field, then "at the top of the hour".
  - "*" means "every" e.g. if used in the hour field, then "every hour".

Table 3-1 shows some example Cron values used in Perception scheduling and the corresponding meaning in terms of the expected download result.

Table 3-1: Examples illustrating scheduling using Cron values

Minutes	Hours	Week Days	Download Result
30	08	*	08:30 every day
0	*	Mon	On the hour, every hour on Mondays
0	0	Wed	At 0:00 every Wednesday
0	*	*	On the hour, every hour, every day of the week

- **Next Scheduled Time**: Time of the next scheduled download.

3.9.5.4 Auto-Export

When used in conjunction with Perception Server, the Auto-Export option becomes available in the device Properties page as shown in Figure 3-62.

Figure 3-62: Auto-Export

You can enable the auto export to occur at scheduled intervals. The Perception Server export table is empty by default, which results in the use of the default Perception export format. To define a custom CSV format, you must define the export table with appropriate mappings for the data using the Perception Server Configuration Tool. See Section 5.1. The data is automatically exported to the following location:

`C:\ProgramData\GE_Energy\Perception`

Note: Use the shortcut "%programdata%"to access C:\ProgramData.

3.9.5.5 Email

When used in conjunction with Perception Server, e-mail notification options become available in the device Properties page as shown in Figure 3-63.

Figure 3-63: Email

Note: This is device specific, so if you need to be on the distribution email list for several devices, complete this field for all required devices.

- **Notification E-Mail Address**: defines the email address of the person who receives condition alerts (or communication issues) for that device. To add more than one e-mail address to the list, separate the addresses with ";". If on subsequent data downloads the condition of the device changes or Perception Server fails to communicate with the device, an automatic email is generated and sent to the recipients specified in this field.
- **Segregate Notification emails**: allows the user to define the recipients of the emails based on the notification type. Select the checkbox to specify the three types of notification address as shown in Figure 3-64.

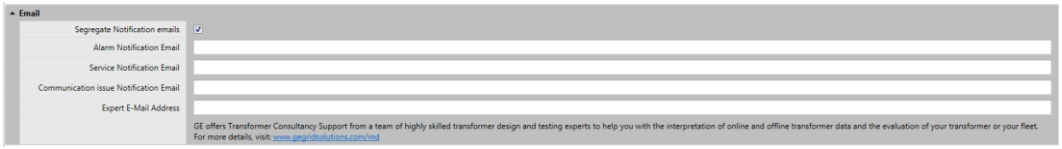


Figure 3-64: Email – Segregate Notification emails

  - Alarm – notification that an alarm level breach has occurred on the online monitor.
  - Service – notification that the online monitor requires service attention. When a service alarm is triggered on a DGA 900-family, Transfix, TAPTRANS, MULTITRANS, MINITRANS, or Hydran M2, M2-X & 201Ti device, the service log files are automatically downloaded from the device and included as an attachment in the service notification email.
  - Communication issue – notification that Perception was unable to communicate with the online monitor.
- **Expert E-mail Address**: (if enabled in Perception Server) defines the email address of the person who receives enhanced alarm notification emails. The e-mail is a comprehensive account of a transformer's details so that any expert within or outside the organisation has all the necessary detail at hand. This includes transformer nameplate details, triggered alarm information for High High, Low Low, Digital Alarms and ROC alarms. It also includes ambient temperature, top oil temperature and load currents information. A CSV attachment with data records for the device in alarm is also included. Note: For the MO150 device, excessive measurement data could exceed the allowable attachment size as defined on the mail server.

3.9.5.6 Device Connection

The Device Connection section displays the state of automated downloads to the user as shown in Figure 3-65.

Figure 3-65: Device Connection

- State: Displays the current state of the connection to the device. E.g. Connecting, Connected, Downloading, Disconnected.
- Progress: A progress bar shows the overall progress of a download, if one is in progress.
- Response: Textual error message showing the last communications error that has occurred. This may be from a previous communications session.
- Last download time: Updated with the last download time.

The Intellix BMT devices have an additional field in the Device Connection pane, called Service Alarm:

- Service Alarm: Reports the nature of a service alarm that has been flagged by the BMT devices. The possible alarms are listed below:
  - High Comms cpu temperature status
  - High FPGA temperature status
  - Field Devices Comms Error
  - Rejected Phase Packet Status
  - Rejected PD Packet Status
  - Low Bushing Current Warning Status
  - Power System Frequency Warning Status
  - Inter cpu CANBUS device error status
  - High Bushing Adapter Temperature Status
  - Modbus comm. error status
  - No Signal warning status
  - Bushing R Failure Warning status

If the BMT devices have any of these alarms triggered, the Blue service icon will show on the device icon in the Asset Explorer. See Section 3.1.2.1 for an example.

3.9.6 Setting up the Device

Once the communications settings have been established, the device-specific setup can be run. To set up the device, right click on the device in the Asset Explorer and select **Setup...** as shown in Figure 3-66. This loads a setup utility specific to the device.

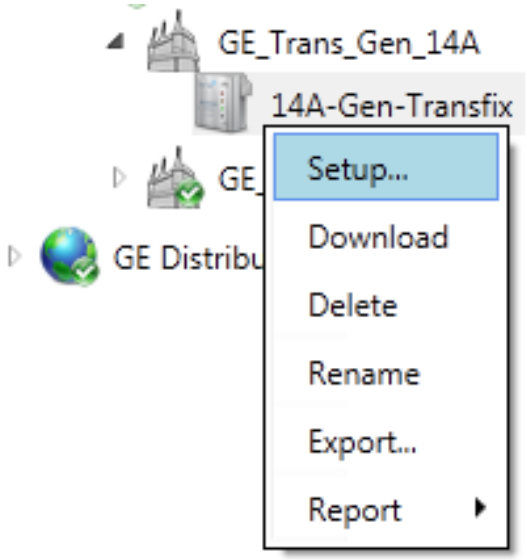


Figure 3-66: Setup

Note: If you are connecting to the device via Modem or Serial, then the Setup option must be performed on an instance of Perception Desktop running on the Perception Server. This is because it will be using the local Perception Desktop resources to communicate with the device.

3.9.7 Workflows

The following workflows are available:

- *DGA Standard*: Evaluates dissolved gas analysis and moisture absolute concentrations compared to IEEE C57.104 & IEC 60422 (2013) standards, as well as dissolved gas Rate of Change compared to the IEC 60599 standard. Along with best practice information taken from Cigré TB227.
- *Simplified DGA*: Uses alarm breach information sent from DGA 900-family, MS 3000, Transfix, MULTITRANS, TAPTRANS, MINITRANS, Hydran M2 & Hydran 201Ti for absolute dissolved gas concentrations and moisture.
- *DGA Standard OLTC (Non-vacuum)*: Evaluates dissolved gas concentration and dissolved gas rate of change for resistor type tap changer diverter, using gas ratio information taken from EPRI (Electronic Power Research Institute).
- *Simplified DGA OLTC*: Uses alarm breach information sent from DGA 900-family, MS 3000, Transfix, MULTITRANS, TAPTRANS, MINITRANS, Hydran M2 & Hydran 201Ti for absolute dissolved gas concentrations and moisture.
- *Bushing Standard*: Evaluates the alarm limits configured on bushing monitor devices for Power Factor, Capacitance, PD Count, PD Index & PD Average Apparent Power and compares it to the measured values for proximity to

alarm breach as well as breaches. Evaluates the alarm limits configured on the MS 3000 device for DeltaC, tanDelta and Voltages and compares it to the measured values for proximity to alarm breach as well as breaches

- *Offline DGA and Oil Quality*: Evaluates oil dissolved gas analysis, quality and properties data received from a lab compared to a variety of international standards. Refer to Appendix F for more information on the Offline DGA & Oil Quality Workflow.
- *CBWatch:* When selected Perception uses the Risk Index results received from the CB Watch 3 to present a Risk Index overview and rank position within the asset ranking table.
- *MS 3000 Risk Index:* Support has been added for the download of the onboard Risk Index results from MS 3000 monitoring devices. Perception now downloads and visualises the Risk Index results along with the other data stored on the MS 3000. The Risk Index results are calculated directly on the MS 3000 monitor running master template 3.6.4.22p0_ 3.2.2.13p0_4.5p0 or later. Perception can be configured to use and display only the Risk Indexes downloaded from the MS 3000, or only the Risk Index calculated in Perception or a combination of both. When both Risk Index options are configured Perception automatically selects and displays in the most critical Risk Index result and information regardless of its origin.
- *Transformer Models:* A workflow algorithm has been created named Transformer Models Ranking that analyses and provides a Risk Index for transformers using the model's data downloaded from the Kelman DGA 900 PLUS with models. The workflow calculates a Risk Index using the following model's data:
  - *Winding Hottest Hotspot*
    - *Condensation Temperature*
    - *Bubbling Temperature Margin*
    - *Moisture in Insulation Barrier*
    - *Cooling Efficiency*
    - *Cooling Malfunction*
    - *Continuous non-operation time of cooling banks*
    - *Cooling Deficiency Banks*
    - *Cooling Over Current Banks*
    - *OLTC Short Term Average of OLTC Temperature Differential*
    - *OLTC Long Term Average of OLTC Temperature Differential*
    - *Tap Position OLTC Operations per Day*
    - *Tap Position OLTC Operations per Hour*
    - *OLTC Motor Torque Total Time percentage*
    - *OLTC Motor Torque In-Rush Time percentage*
    - *OLTC Motor Torque Torque Maximum 1 percentage*
    - *OLTC Motor Torque Torque Maximum 2 percentage*
    - *OLTC Motor Torque Torque Maximum 3 percentage*

- *OLTC Motor Torque Average Torque percentage*

- *869 Motor Ranking:* Evaluates the motor data provided by GE's 869 protection relay to determine the Risk Index and ranked position of the motors with regards to the other motors being monitored. The evaluation uses the measured parameters and alarm set points for the motors electrical, thermal and mechanical systems to determine the Risk Index.
- *845 Transformer Ranking:* A workflow algorithm has been created named 845 Risk Ranking that analyses and provides a Risk Index for transformers using the model's data downloaded from an 845 Relay with the advanced monitoring option. The workflow calculates a Risk Index using the following model's data:
  - *Winding 1/2/3 Loading*
  - *Winding 1/2/3 Harmonic Derating Factor*
  - *Winding Hottest Spot Temperature*
  - *Transformer Aging Factor*
  - *Loss of Transformer Life*
- *850 Circuit Breaker Ranking:* Evaluates the circuit breaker data provided by GE's 850 protection relay to determine the Risk Index and ranked position of the circuit breakers with regards to the other circuit breakers being monitored. The evaluation uses the measured parameters and alarm set points for the circuit breaker trips details, arching information and charge time to determine the Risk Index.

For more information on workflows, see the Perception Workflow Designer manual.

3.10 Adding a Wallboard

At an Area, Plant, Substation, Transformer Bank or Transformer level, you can add a wallboard to give an instant overview of the status of all subordinate assets. Each client PC with an instance of Perception Desktop that connects to Perception Server must have its own wallboard configured. The image used for the wallboard background is user defined and can be any BMP, JPEG, GIF or PNG file.

To add a wallboard, select an Area, Plant, Substation, Transformer Bank or Transformer in the Asset Explorer and from the menu bar, select **View > New > Wallboard** as shown in Figure 3-67. A new Wallboard tab then appears in the list of tabs.

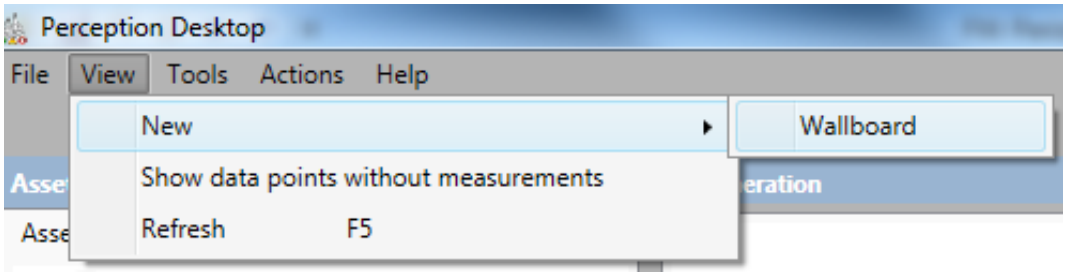


Figure 3-67: Wallboard

Right-click in the wallboard area and choose **Change map file** to browse to the location of a suitable image to use as a map file. The chosen image is displayed at minimum zoom within the workspace on the right along with randomly placed subordinate assets for you to position as required.

It is recommended that the resolution of the image file matches the display resolution of the monitor that will display the wallboard. For example, if the monitor displaying the wallboard has a resolution of 1920x1080, then the image file used should also have the same resolution.

Note: A range of charts are also available for some assets. See Section 4.2.

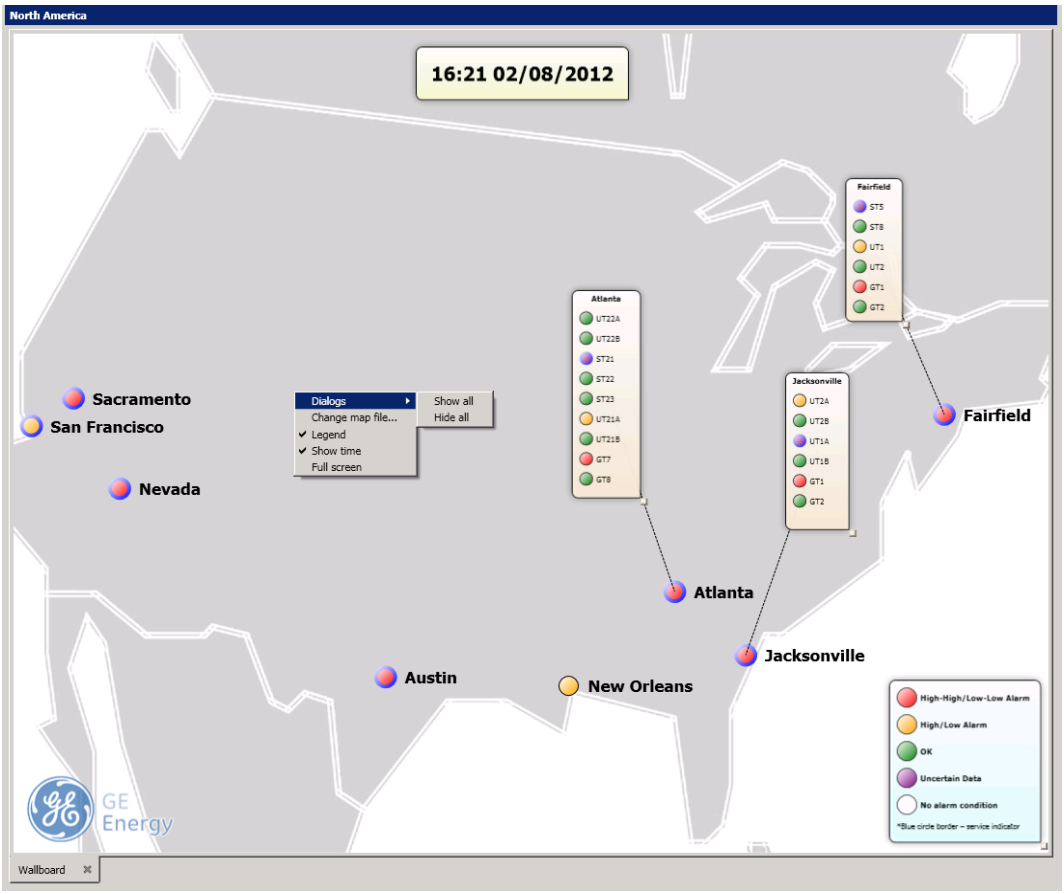


Figure 3-68: An example wallboard

Perform any of the following actions to alter the map display:

- To drag the map in any direction, left click while the mouse pointer is within the map.
- To zoom in and out, use the scroll wheel while the mouse pointer is within the map.
- To drag the asset to a new location, left click while the mouse pointer is over the asset location icon. Note: The mouse pointer changes to a hand.
- A useful way to distinguish assets is to change the icon used to depict the asset location. Right click while resting the mouse pointer over the asset location icon and choose from a circle or a square.
- For other display options as shown in Figure 3-69, right click on the map.

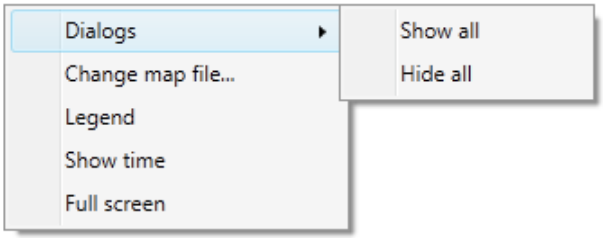


Figure 3-69: Display options

- *Dialogs*: Each asset has a titled information dialog that lists all attached monitoring devices and corresponding statuses. This option allows you to show or hide all asset dialogs. A single dialog box can also be manipulated independently as follows:
  - To show or hide a dialog box, double click its asset location icon.
  - To change the size of a dialog box, rest the mouse pointer over the lower-right corner symbol of the dialog box (the mouse pointer changes to a double-headed arrow) and then left click-and-drag to resize.
  - To move a dialog box, left click-and-drag the dialog box. Note: A dashed connecting line indicates the relevant asset location icon.
  - To change the dialog box title, right click and choose **Edit title.**
  - **To view the ranking details, right click and choose Ranking.**

Note: The size and position of the dialog boxes are retained.

- *Change map file…* allows you to browse for a new map file.
- *Legend*: toggles the display of the legend for the asset status.
- *Show time*: toggles the display of the current time and date.
- *Full screen*: shows the wallboard in full screen mode. To revert to normal display, press `Escape` or right click and select **Exit full screen.**

A fully configured Wallboard in full screen mode is shown in Figure 3-70.

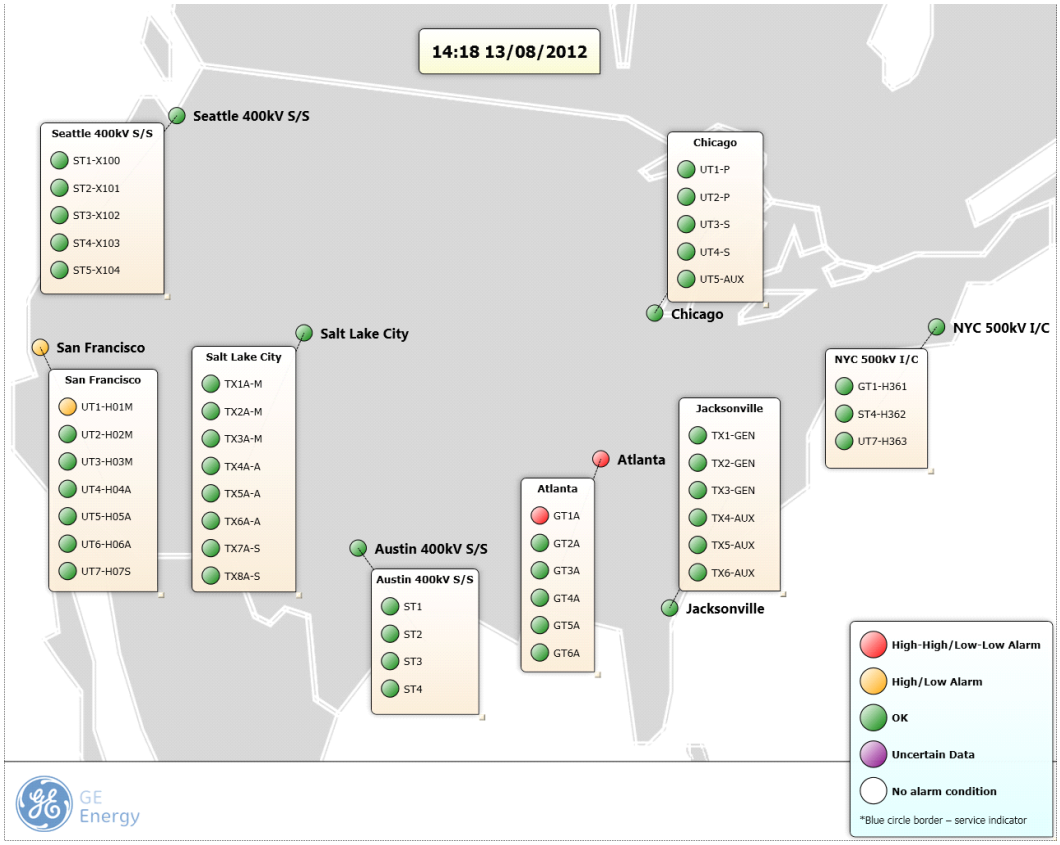


Figure 3-70: Fully configured wallboard

Other examples of wallboard images are shown from Figure 3-71 to Figure 3-75. If the condition of any of the monitoring devices changes to reflect an alarm, service or bad sample condition, this will be denoted by a change in color of the respective device node. This change will also be reflected in the asset hierarchy and on the wallboard asset node (where an animation causes the node to pulse as shown in Figure 3-71 — if configured in Perception Server). Note: By default, all animations are disabled.

Note: In conjunction with Perception Server, the wallboard dynamically changes to reflect condition updates if the monitoring devices are configured with automatic download schedules.

Figure 3-71: Wallboard with pulsing node

The wallboard asset node will match the status of the device with the worst result. This helps alert the user to a problem in that area, plant, substation, transformer bank or transformer at the earliest opportunity. Right-click any pulsing device in the asset summary box to acknowledge the alarm (at the device level only) as shown in Figure 3-72 — this turns off the pulsing animation.

Figure 3-72: Acknowledge an alarm

Any movement in the asset risk index for transformer or circuit breakers nodes is denoted by a corresponding colour-coded directional arrow (up or down accordingly) next to the asset label as shown in Figure 3-73, which also has a ripple animation.

Figure 3-73: Asset node showing increased movement up the asset risk index

To acknowledge an asset's change in position in the asset risk index, right click the asset and select **Acknowledge Risk Index** as shown in Figure 3-74 to turn off the ripple animation.

Figure 3-74: Acknowledge Risk Index

The shortcut menu in Figure 3-74 also offers customization options to display an individual node as a circle or a square to provide a further visual differentiation of assets, if required, as shown in Figure 3-75. The default node for all assets is a circle.

Asset labels on the wallboard or asset summary box are also active hyperlinks as shown in Figure 3-75. Click the asset label to see where the asset sits in the Asset Hierarchy, for example as shown in Figure 3-76, and if required, examine its properties etc.

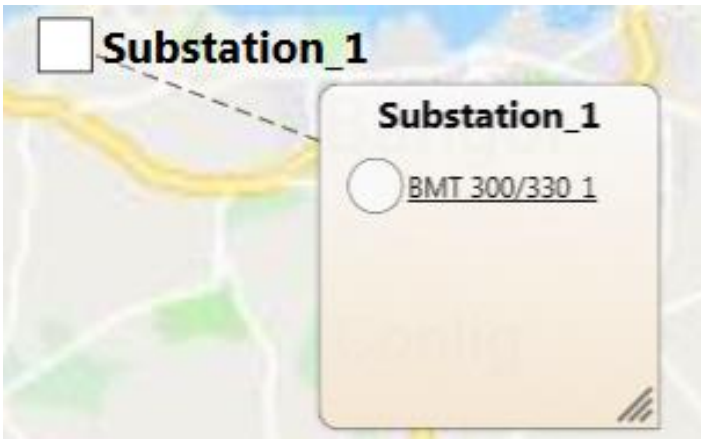


Figure 3-75: Customizing asset nodes

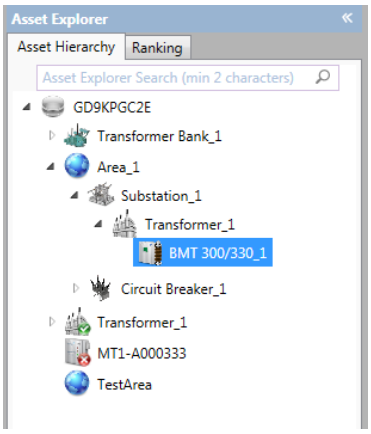


Figure 3-76: Asset Hierarchy

3.11 Ranking Assets

The Ranking page in the Asset Explorer as shown in Figure 3-77 automatically ranks assets according to an algorithm in the Perception workflow to give an overall health index. Assets are colour-banded accordingly with the least healthy transformers listed at the top in red and the healthiest in green at the bottom. Unranked transformers appear at the bottom of the list without a colour band. A transformer is unranked if it is not associated with the relevant Perception workflow, has no measurement devices connected to it or there is no measurement data e.g. a new install with the first measurement cycle yet to occur.

Table 3-2: Colour designation

Colour	Meaning
White	Without evaluation (Asset not evaluated or ranked for any reason)
Dark green	Good condition
Light green	Minor defects not affecting reliability
Yellow	Defects that may affect future reliability
Amber	Serious defects that may have serious consequences
Red	Dangerous defects that may cause faults

Ranking movement at each periodic refresh is denoted by colour-coded arrows. A red up-pointing arrow denotes that the transformer has moved up in ranking order, a green down-pointing arrow denotes that it has moved down in ranking order and a blue double-headed horizontal arrow denotes no change in ranking order.

Note: Rest your mouse on any transformer to reveal its actual health index.

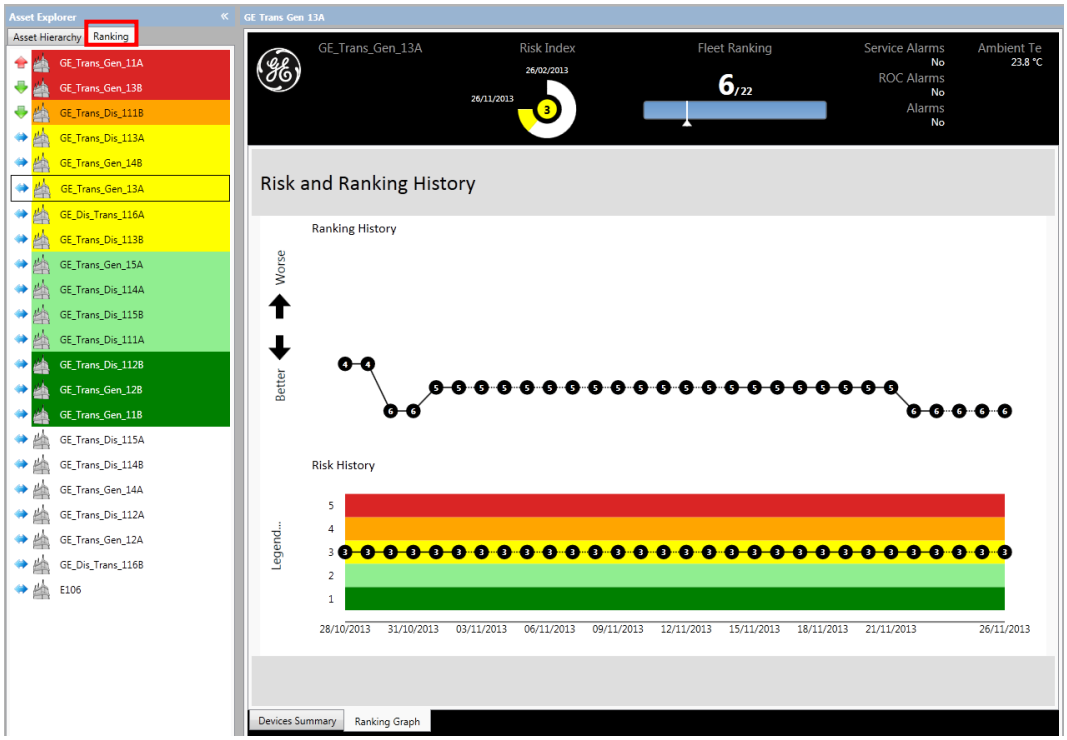


Figure 3-77: Ranking

To review the Risk and Ranking history for an individual transformer, select the transformer followed by the **Dashboard** tab. Then select the **Ranking Graph** tab as shown in Figure 3-78. Rest your mouse pointer on any data point for more information.

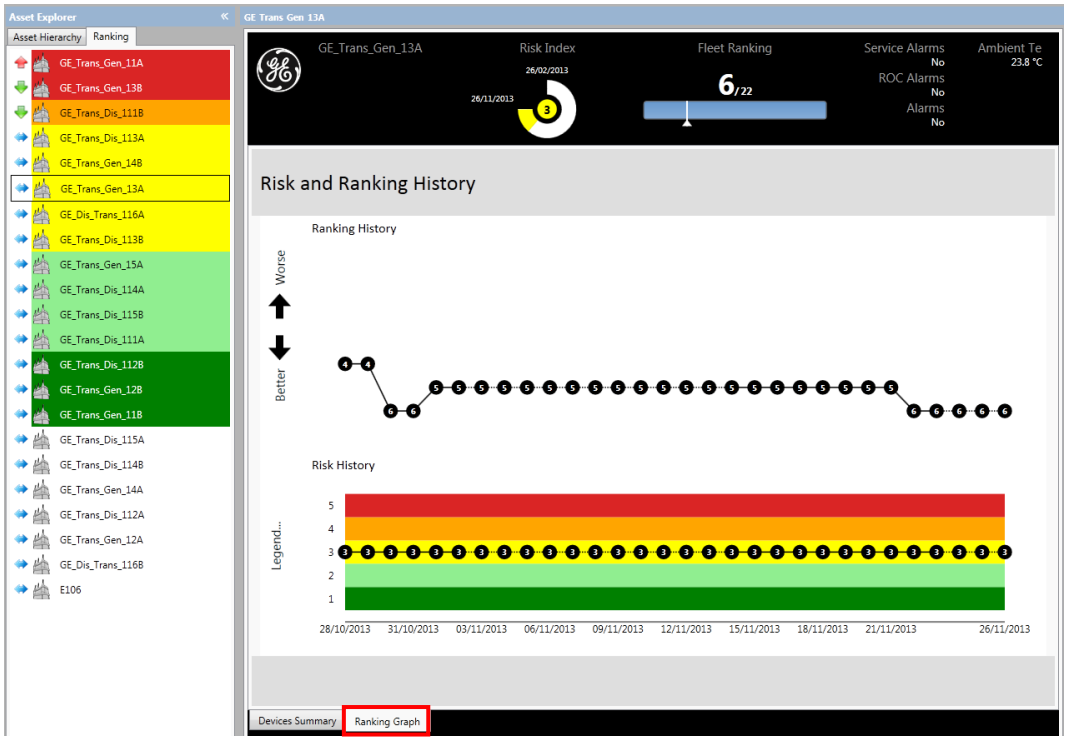


Figure 3-78: Risk and ranking history

Note: Data points may refer to 'EPRI' (Electrical Power Research Institute).

4 ANALYSING DATA

4.1 Data Area Worksheet Tabs

The Data Area contains several worksheets that are used to visualise the data and diagnose faults. The worksheets are accessed via a series of tabs at the bottom of the screen. The available worksheets depend on the type of item selected in the Asset Explorer. For example, Figure 4-1 lists the worksheets for a Transformer.

Figure 4-1: Transformer worksheet tabs

All available worksheets and a link for further details are listed below:

Properties: See Section 3.8.1.

Wallboard: See Section 3.10.

Dashboard: See Section 3.5.1.

Trend Chart: Line charts are used to display the raw data for user-selected measurements. Multiple trend charts can be created, each displaying different sets of gases or peripherals. See Section 4.4.

Data Table: Lists the individual samples for each parameter. You can select the data range and the parameters to suit. See Section 4.5.

Status: Lists the latest downloaded values of the measured parameters and their status against the alarm thresholds. See Section 4.6. Note: The alarm thresholds can be set by launching the device setup in Perception Desktop.

Rate of Change: Displays multiple line charts depicting the rate of change for each gas based on raw data for user-selected measurements on DGA 900-family, Transfix-family and MINITRANS devices. Multiple trend charts can be created, each displaying different sets of gases or peripherals. See Section 4.7.

TDCG: The Total Dissolved Combustible Gases (TDCG) chart displays a stacked chart containing the temporal values of each gas and the cumulative values for all gases. See Section 4.9.

Key Gas: IEEE C57-104 offers diagnosis through calculating the relative proportions (in percent) of these key gases to the rest of the gases in the transformer. See Section 4.10.

Gas Ratios: Displays the proportions of key gases on a three-dimensional cube lattice or table, using ratios defined by IEC 60599, IEEE C57.104, Rogers Ratio and Doernenburg Ratios. See Section 4.12.

Ratios: Trends any gas ratios that have been set up for Transfix devices. You can also add your own custom gas ratio. See Section 4.13.

ETRA: Japanese ETRA Analysis is an alternative visualisation and diagnostic tool. Diagrams A & B are available. See Section 4.14.

Duval's: Describes how the concentrations of dissolved gases or free gases may be interpreted to diagnose the condition of oil-filled electrical equipment in service and suggests future action. There is the choice of six different formats of Duval's diagnostics: four triangles — Classic, LTC (oil filled) and Duval's 4 & 5 low temperature, —and two pentagons. See Section 4.15.

Models: Provides diagnostics using state of the art mathematical transformer models based on IEEE or IEC standards. Calculated using monitored transformer characteristics taken by the Intellix MO150 and Hydran M2. See Section 4.16.

Bushing Monitor: BMT & DGA 900 PLUS devices only. Shows two polar plots with a choice of plot styles, C1 or PF% data, and Primary, Secondary or Teriary input. See Section 4.17.

Partial Discharge: BMT & DGA 900 PLUS devices only. Shows three polar plots — PD Count, PD Average Apparent Charge and PD Index. See Section 4.18.

PRPD: BMT & DGA 900 PLUS devices only. Shows the measured Phase Resolve Partial Discharge data. See Section 4.19.

Inter-Phase Angle: BMT & DGA 900 PLUS devices only. Shows a polar plot with the measured and expected inter-phase angles. See Section 4.20.

Web Browser: MS 3000, CBWatch, BMT 430 and DGA 900-family devices only. Shows web content as rendered on the remote HMI of the device. See Section 4.21.

4.1.1 Worksheet Options

Right click any worksheet tab to see the available options as shown in Figure 4-2.

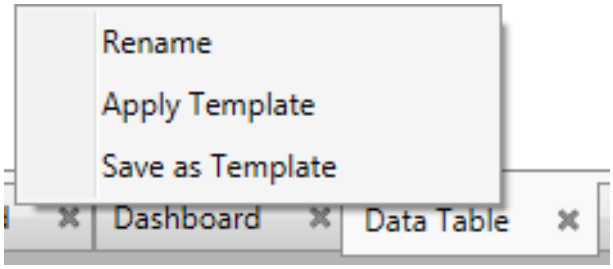


Figure 4-2: Worksheet options

4.1.1.1 Rename a Worksheet

To rename a worksheet, right click on the tab and select **Rename**.

4.1.1.2 Save or Apply Templates

Users can save worksheet settings as a template. The template contains the customizable features of a worksheet. For example, the selected measurement points, appearance settings, date range, selected charts etc. These settings are all stored in the template XML file and can be applied to another worksheet or the same worksheet in another instance of Perception.

Right click on the relevant worksheet tab and select the relevant option.

4.2 Default Asset Charts

When a new asset is added and selected in the Asset Explorer, a default set of charts is enabled as listed in Table 4-1. Additional charts can be added by the user (see Section 4.4.1).

Table 4-1: Charts per asset

	Trends	Status	Data Table	TDCG	Key Gas	Gas Ratio	Ratios	Duvals	ETRA	Models	Bushing Monitor	Partial Discharge	PRPD	Inter-Phase Angle	Web Browser	Rate of Change	COMTRADE	Breaker Trend	ESA Data	ESA Circle	Breaker Data	LDR Data	ESA Models	LDR Trends
Transformer	●	●	●	●	●	●	●	●	●		●	●	●	●										
Transformer Bank	●	●	●	●	●	●	●	●	●		●	●	●	●										
Circuit Breaker	●	●	●														●							
Motor	●	●	●														●	●	●	●	●	●		

4.3 Default Device Charts

When a new device is added and selected in the Asset Explorer, a default set of charts is enabled as listed in Table 4-2. Additional charts can be added by the user (see Section 4.4.1).

Table 4-2: Charts per device

[1] ● Denotes: Available, but requires bushing monitoring option / configuration

	Trends	Status	Data Table	TDCG	Key Gas	Gas Ratio	Ratios	Duvals	ETRA	Models	Bushing	Partial	PRPD	Inter-Phase	Web Browser	Rate of	COMTRADE	Breaker Trend	ESA Data	ESA Circle	Breaker Data	LDR Data	ESA Models	LDR Trends
MS 3000	●	●	●	●	●	●	●	●	●						●									
DGA 500	●	●	●	●			●	●								●								
Transfix 1.6	●	●	●	●	●	●	●	●	●							●								
Transfix 1.5	●	●	●	●	●	●		●	●															
TAPTRANS	●	●	●	●	●	●	●	●	●							●								
DUALTRANS	●	●	●	●	●	●	●	●	●							●								
MULTITRANS	●	●	●	●	●	●	●	●	●							●								
Transfix PLUS	●	●	●	●	●	●	●	●	●	●						●								
MINITRANS	●	●	●				●									●								
Hydran M2 / M2-X	●	●	●							●														
Hydran 201Ti	●	●	●																					
MO150	●	●	●							●														
BMT 300	●	●	●								●	●		●										
BMT 330	●	●	●								●	●	●	●										
BMT 430	●	●	●								●	●	●	●										
DGA 900	●	●	●	●	●	●	●	●	●						●	●								
DGA 900 TAPTRANS [1]	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●								
DGA 900 MULTITRANS [1]	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●								
DGA 900 PLUS [1]	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●								
CB Watch	●	●	●												●		●							
845 Relay	●	●	●														●							
850 Relay	●	●	●																					
869 Relay	●	●	●														●	●	●	●	●	●	●	●

4.4 Trend Chart

The trend chart is typical of all the diagnostic charts as shown in Figure 4-3. It can be configured to show groups of gases or other measurable parameters with multiple versions of the chart being open concurrently.

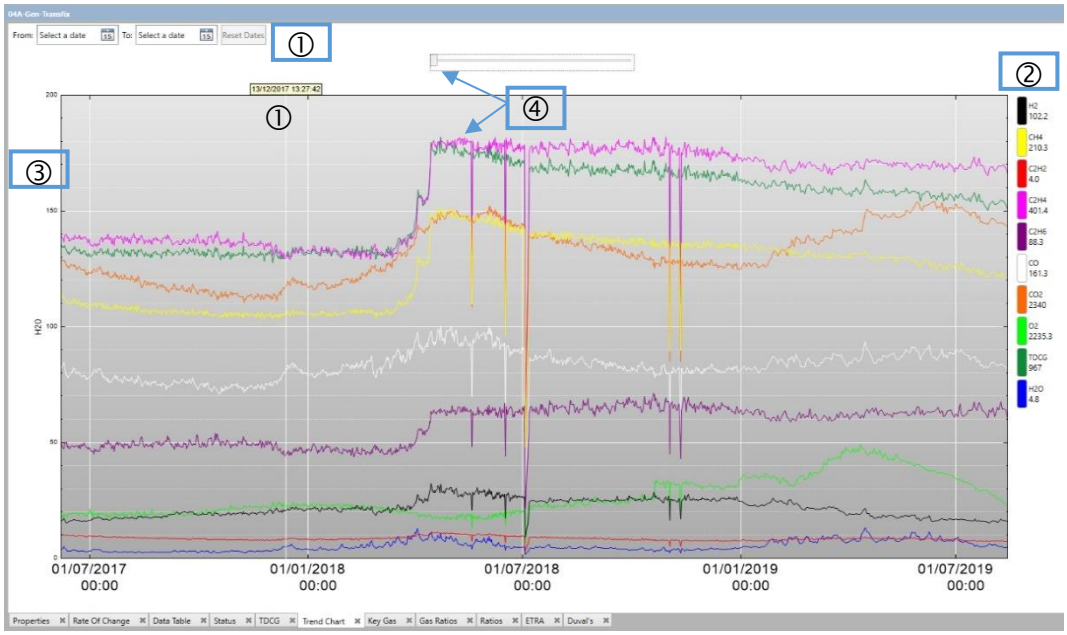


Figure 4-3: Dissolved gas trend analysis

Key to the Chart areas:

1. X axis date(s): Select the date range for the X axis of the chart. Whenever you place your cursor within the grey plotting area, a vertical date line follows the cursor with the precise date and time reported in the yellow box.
2. Legend: The value next to each item is the value of the item at the yellow box date and time (①) time on the X axis. If the cursor is not within the plot area, the values are as at the right-hand extreme end of the plot lines. To change the plotted colour of an item, a double click on the legend colour launches a format dialog as shown in Figure 4-4.

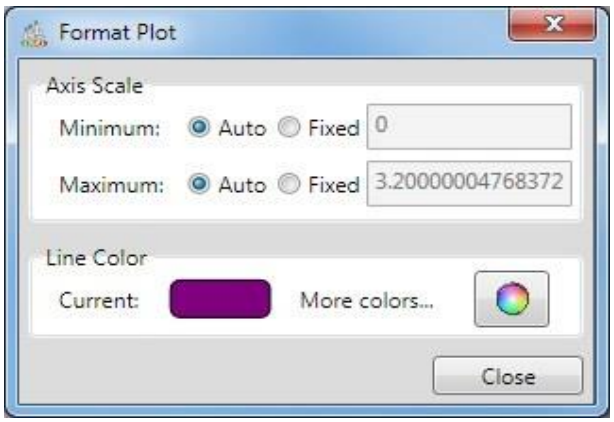


Figure 4-4: Format Plot

3. Y axis: The Y axis values for the selected item from the legend. Although all the parameters are plotted, they have, by default, individual scales. Other scaling methods are selectable. See Section 4.4.4.
4. Slider: The slider allows you to control the degree of 'smoothing' that is applied to the trend lines; the leftmost position (shown) has least smoothing and sliding it leftwards progressively applies more smoothing. This can be useful in removing spikes and revealing the overall trend of the parameters.

If you right click when your cursor is within the plot area, an options menu is displayed, as shown in Figure 4-5.

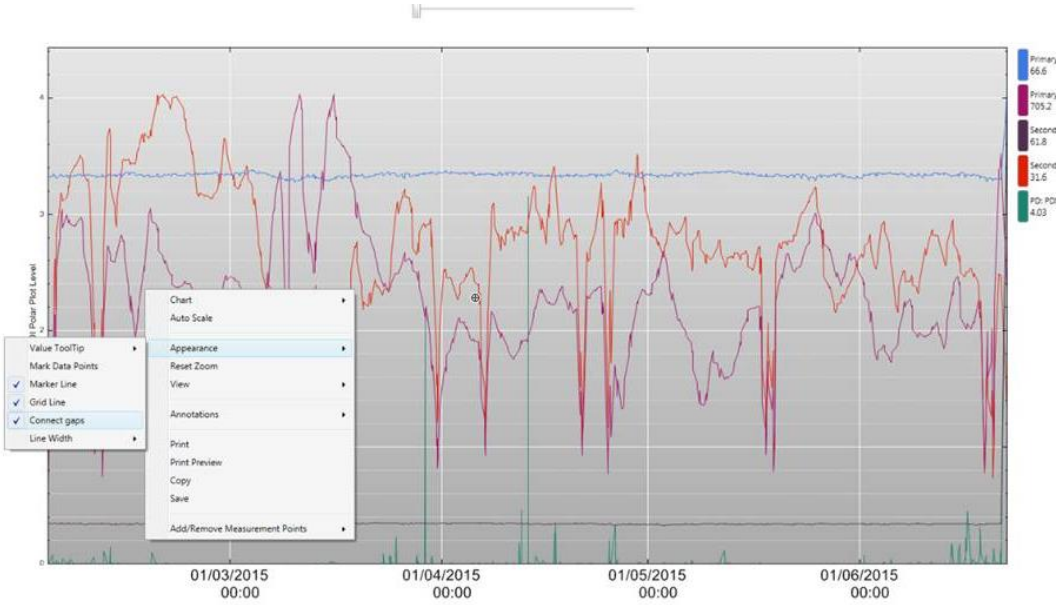


Figure 4-5: Chart options

- *Chart*: Changes the method of scaling the Y axis. See Section4.4.4.
- *Auto scale*: Returns the Y axis scaling to default.
- *Appearance*: Alters the appearance of details within the trend chart.
- *Reset Zoom*: Returns the trend plot to display all points between the start and finish dates.
- *View*: Alters whether the legend is displayed or not.
- *Annotations*: Allow you to place notes on the trend chart. See Section 4.4.5
- *Print*: Prints the trend graph to your printer.
- *Print Preview*: Allows you to configure the print output and see the effects before printing.
- *Copy*: Copies the trend chart to the Windows Clipboard, so that it can be pasted into another application, for instance a document.
- *Save*: Creates a 'png' image of the trend chart that can be saved as a picture.
- *Add/Remove Measurement Points:* Allows you to select/deselect which parameters are plotted on the trend graph. See Section 4.4.2.

You can zoom into part of a plot as shown in Figure 4-6. To do so, place the cursor in the grey plotting area at the top left X-Y position of the desired zoom area and then left-click-and-drag your mouse to the bottom right of the desired zoom area (as illustrated by the red arrow). When you release the mouse button, the plot range will be 'zoomed'. The zoom can be reversed by left clicking and dragging back in the opposite direction to the red arrow. It can also be reset by right clicking and selecting **Reset Zoom**.

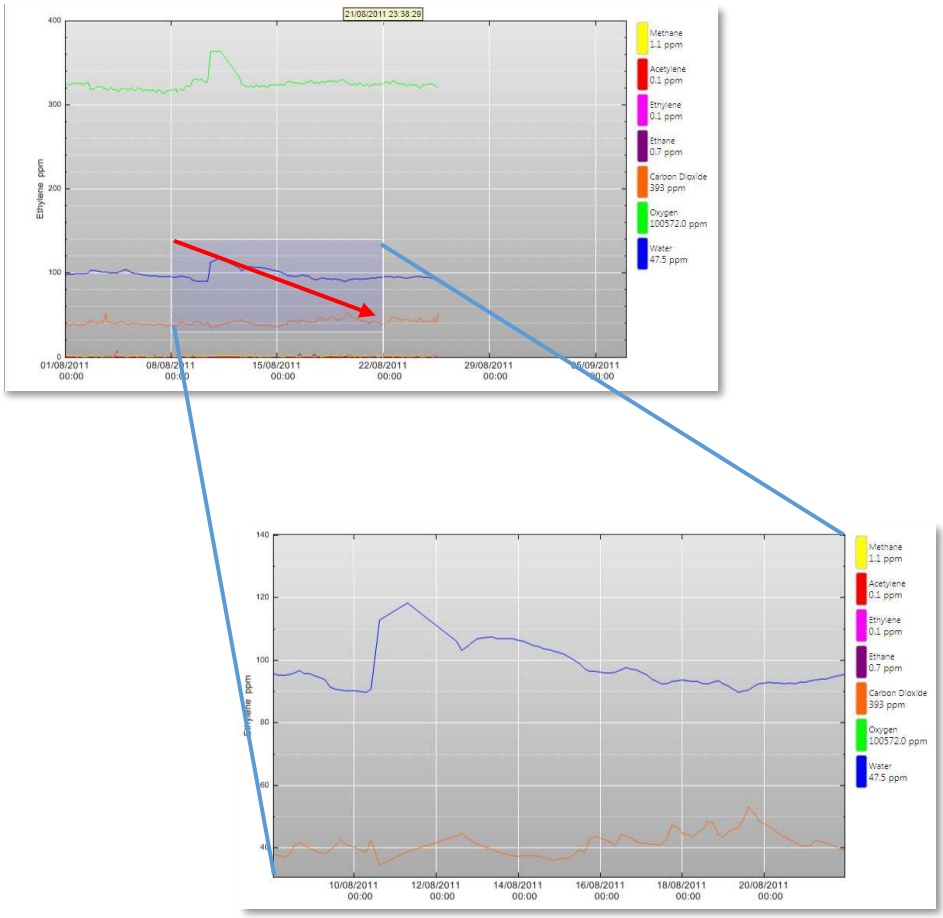


Figure 4-6: Zoom plot

By default, the **Appearance > Connect gaps** option is enabled. This plots the trend line between two good measurements and omits any bad quality data with zero-value measurements effectively smoothing out the trend line. If disabled, Perception will plot all data points and any invalid zero-value measurements will appear as gaps in the chart.

4.4.1 Create a new Trend Chart

To create a new trend chart, select **View > New** and choose the type of chart, for example **Trend Chart** as shown in Figure 4-7.

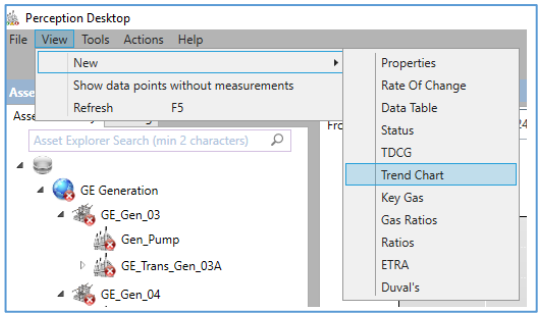


Figure 4-7: Create a new Trend Chart

This action opens a new blank trend chart that can be configured to display groups of measurements.

4.4.2 Add Measurements to the Chart

To add measurements to a trend chart, right click anywhere on the trend chart and select **Add/Remove Measurement Points**. Select the measurements to be trended in the chart as shown in Figure 4-8.

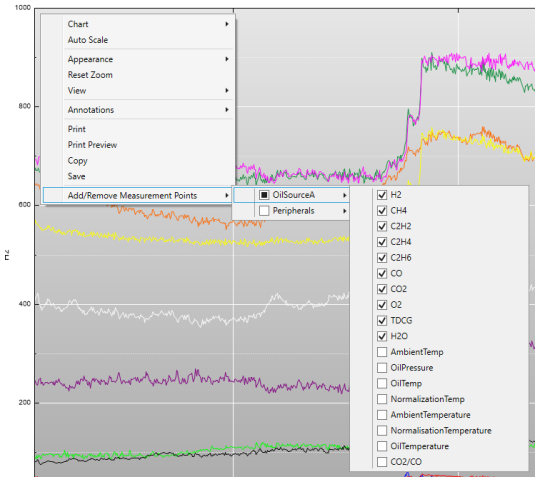


Figure 4-8: Add measurements to the trend chart

The measurement parameters offered are device specific: a Transfix will offer gas measurements, whereas a BMT device will offer discharge and phase measurements. The Total Dissolved Combustible Gases (TDCG) from the TDCG worksheet is also available as a parameter for trending.

4.4.3 Remove Measurements from the Chart

To remove measurements from a trend chart, right click anywhere on the trend chart and select **Add/Remove Measurement Points**. Uncheck the measurements not to be trended in the chart as shown in Figure 4-9.

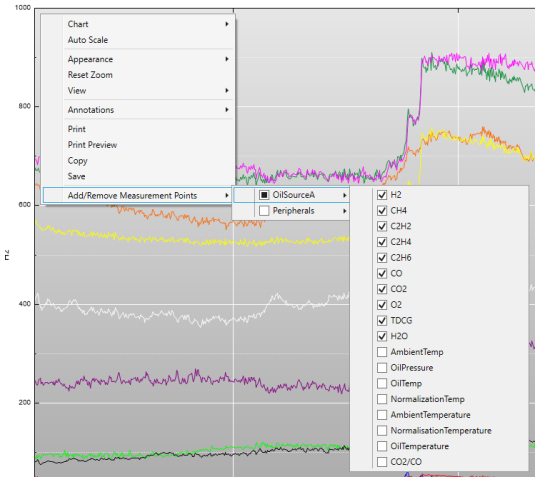


Figure 4-9: Remove measurements from the trend chart

4.4.4 Change Y Scale method

A number of Y scale methods are available for the trend chart. Right click anywhere within the trend chart and select **Chart** as shown in Figure 4-10.

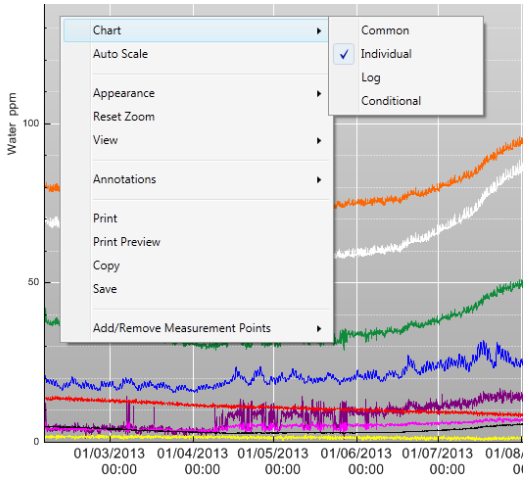


Figure 4-10: Change Y Scale method

The available options are as follows:

- ***Common***: All parameters are on a common Y scale. Small concentrations will be squeezed together at the bottom of the chart.
- ***Individual***: The default method. Each parameter is plotted with its own vertical scale, which gives some vertical separation to the trend lines. The parameter selected from the legend then has its Y scale indicated on the Y axis.
- ***Log***: All items plotted together, but the Y axis is logarithmic. This separates out the parameters at the lower end of the chart, but will have the effect of squashing the high value parameters.
- C***onditional***: Only parameters that have alarmed during the selected time period are plotted on the graph.

4.4.5 Add Annotations

To add annotations to a trend chart, position the pointer on the X axis (time) where you wish to place the annotation, then right click and select **Annotations > New...** as shown in Figure 4-11.

Figure 4-11: Add annotations

Enter the desired text in the text box that appears on the X axis and click outside the text box when finished to commit the text as shown in Figure 4-12.

Note: A time repeater at the top of the graph may assist in accurate placement of the annotation.

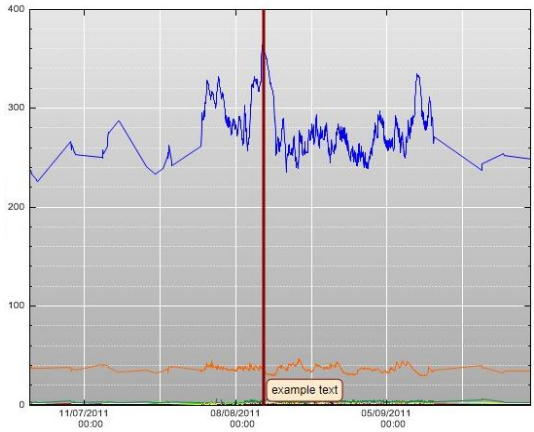


Figure 4-12: Example annotation

Other available options as shown in Figure 4-11 are:

- ***Show All***: Reveal all annotations (if hidden).
- ***Hide All***: Hide all annotations allows you to see the chart without any annotations obscuring the data.

To edit or delete an annotation, right click the annotation and choose **Edit** or **Delete**.

Note: When used in conjunction with Perception Server, annotations appear on the trend chart of the device for all connected Perception Desktop clients.

4.5 Data Table

The Data Table Tab lists all received data, which can be filtered for the selected dates. You can add and remove measurement parameters by right clicking within the display area as shown in Figure 4-13.

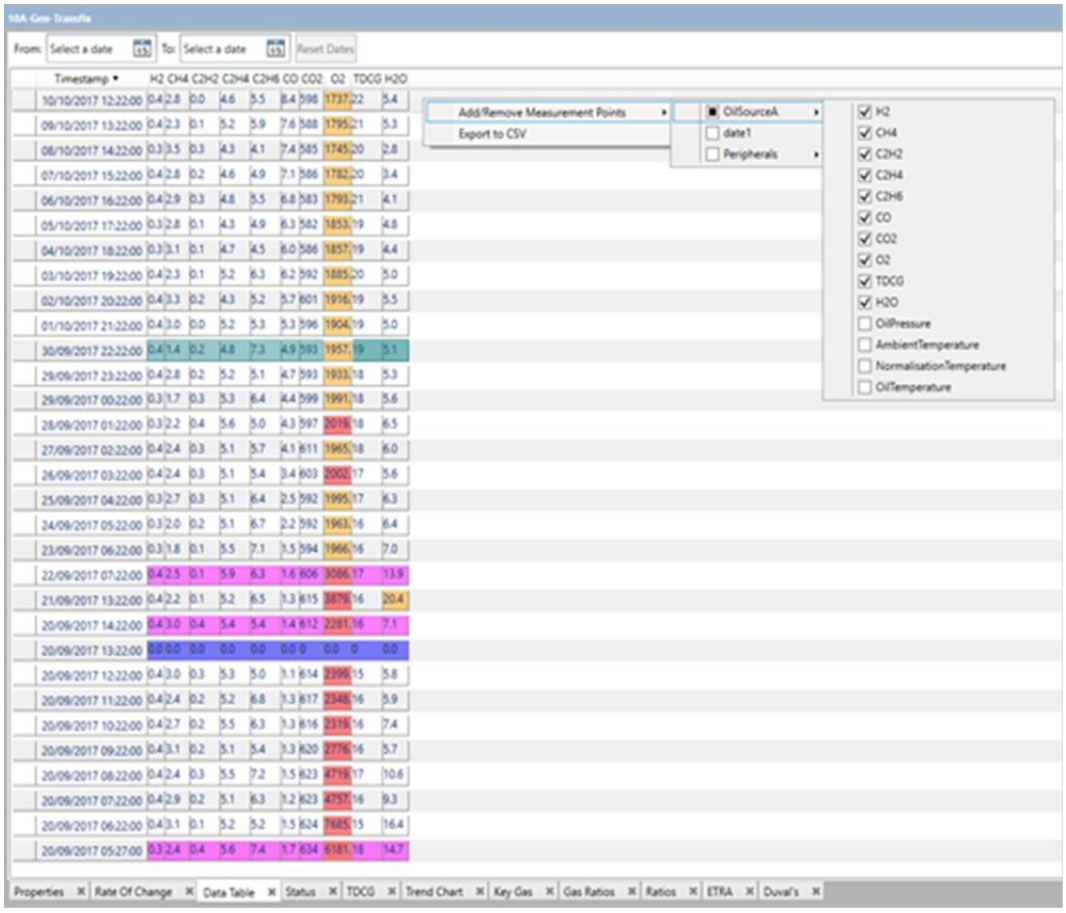


Figure 4-13: Data Table with colour-coding – add / remove measurement points

The selected parameters are colour-coded as follows:

White	Normal (data is within all limits).
Amber	Caution (i.e. data has exceeded a high or low threshold).
Red	Alarming (i.e. data has exceeded a high-high or low-low threshold).
Pink	Uncertainty in the measurement accuracy.
Blue	Erroneous data.
Teal	First measurement after a reboot

Rest the mouse pointer on any measurement value to see the corresponding Data Table tooltip, an example of which is shown in Figure 4-14. The tool tip lists the PGA diagnostic error codes and offers a description below. Note: See Appendix D for an explanation of the PGA diagnostic details.

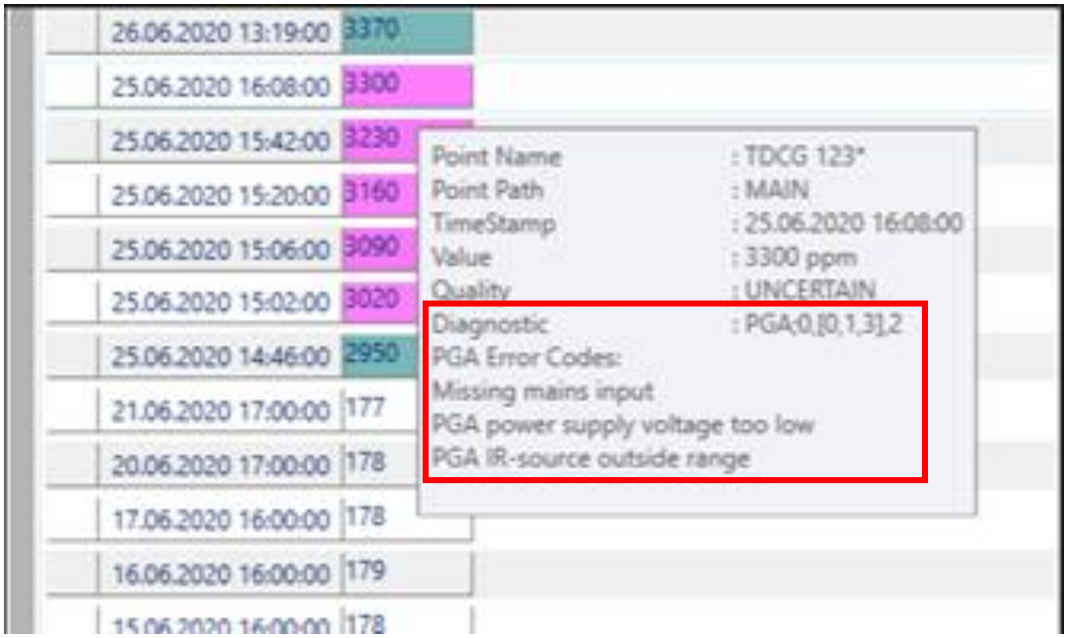


Figure 4-14: Data Table tooltip

4.6 Status

The Status worksheet shows the latest downloaded parameter values and is the suggested view to start with when investigating an alarm occurrence. The alarming parameters are highlighted with the latest downloaded data date. An example is shown in Figure 4-15.

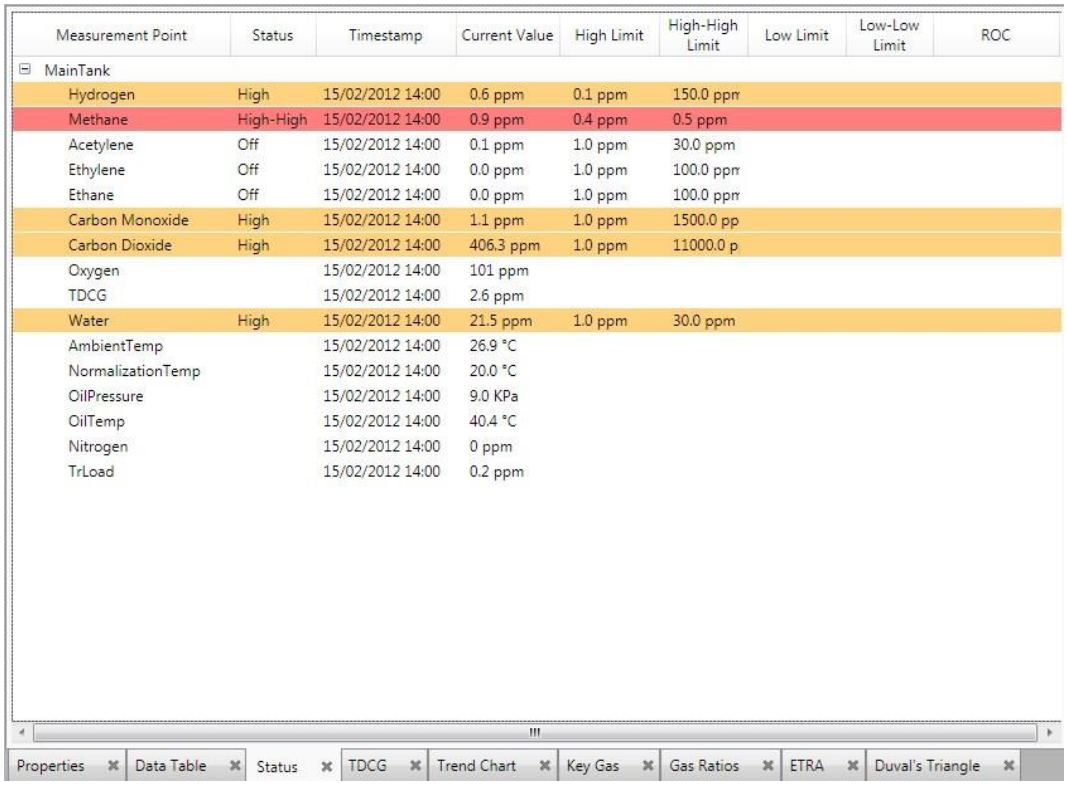


Figure 4-15: Status worksheet

The ‘High-High’ and ‘Low-Low’ alarms are highlighted in red, the ‘High’ and ‘Low’ alarms in amber. The ROC column indicates whether a Rate of Change alarm has been set for that item. If the ROC alarm is activated, the Status column will show ‘ROC’.

Note: Certain alarms triggered on the MS 3000 and CBWatch 3 devices require the user to connect directly with the device via its user interface to see alarm details. If such an alarm is triggered, a message appears at the bottom of the Status worksheet stating, ‘Device is in alarm or caution state – please refer to the Web Browser for the details!’. The user should then open the Web Browser worksheet and login to the remote interface of the device to see the alarm details.

Ratio alarm measurement points are also displayed if they are configured on the device.

Right click anywhere in the status area to see further options to print or customise the display of columns as shown in Figure 4-16.

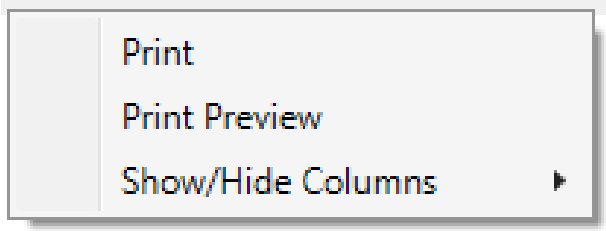


Figure 4-16: Status area columns

4.6.1 Event Point Type

A new point type called ‘Event’ registers the occurrence of an event. No measurement value is stored with this point type, only the existence of the event and when it last occurred. For example, Figure 4-17 shows an MS 3000 Status worksheet with a last OLTC operation event listed as ‘Event triggered’ as the current value and a corresponding date/time stamp.

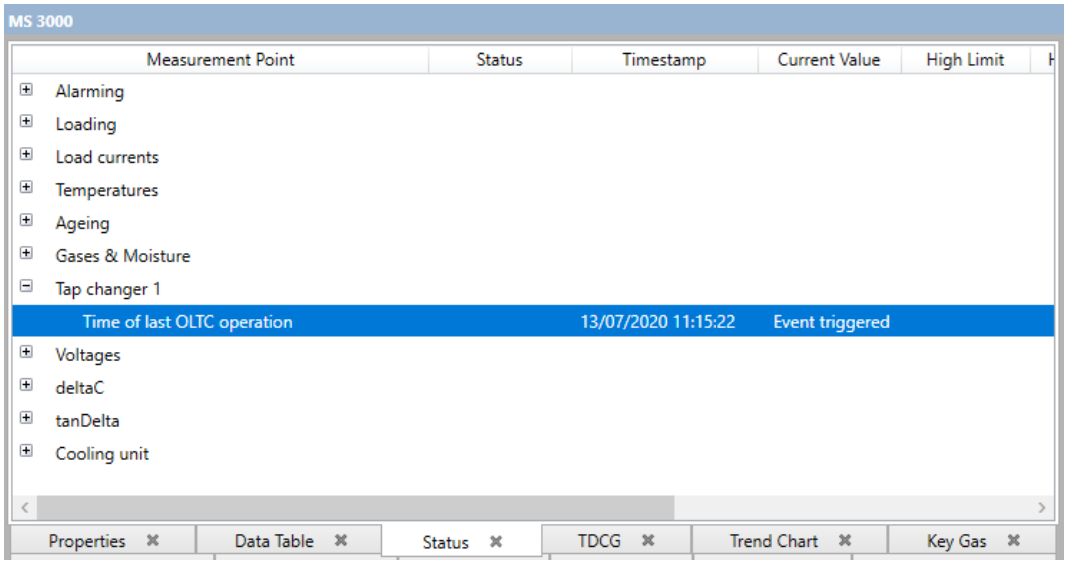


Figure 4-17: Status > Event Point type

Note: Available for MS 3000 and 869 Relay assets.

Note: The event is listed as 'Event triggered' in the tabulated Status and Data Table worksheets, but in the Trend Chart it is rendered as a vertical line.

4.6.2 Rename a Measurement Point

Right click on a display name to edit or reset the names as shown in Figure 4-18.

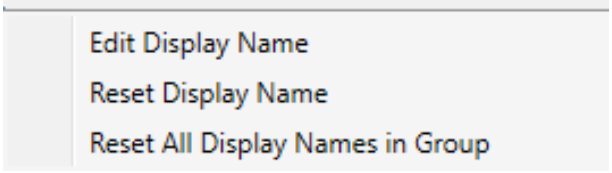


Figure 4-18: Display names

A measurement point display name can also be changed. Right click in the Measurement Point field, select **Edit Display Name** (or double click the Measurement Point field) and edit the text inline as shown in Figure 4-19. The renamed measurement point will be used for all occurrences of the measurement point throughout the application.

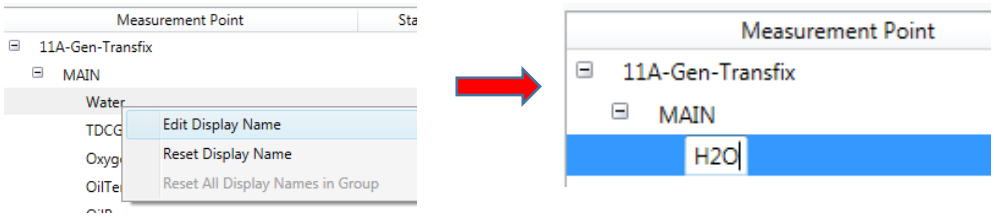


Figure 4-19: Rename a measurement point

Note: You can also reset a single display name or all display names back to the original in the same manner.

4.7 Rate of Change

The Rate of Change worksheet visually represents the rate of change for different sets of gases or peripherals on a trend chart. The ROC trend chart can be rendered for any Transfix-family device including MINITRANS, and is based on the parameters configured on the device or as user-defined in Perception.

Note: The ROC chart is manipulated in a similar way to other trend charts described in Section 0, but does not display alarm limits.

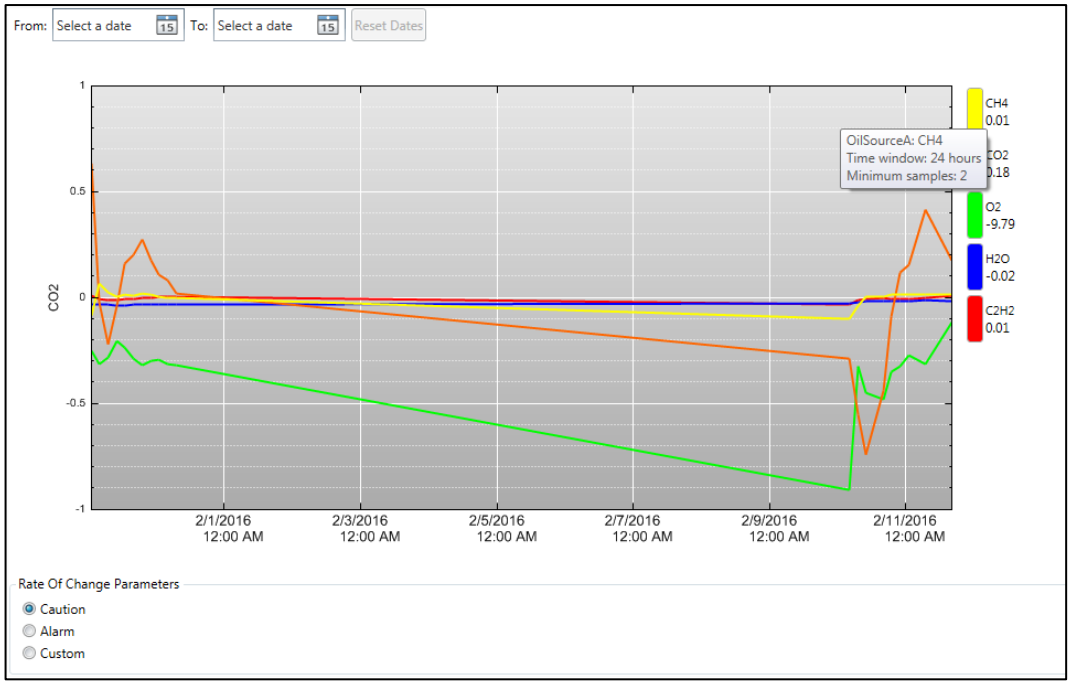


Figure 4-20: Rate of Change chart

4.7.1 Rate of Change Parameters

The ROC chart is derived from either the 'Caution', 'Alarm' or 'Custom' option using two parameters, 'Time Window' and 'Minimum Samples'. Selecting either 'Caution' or 'Alarm' means the parameters are downloaded from the respective Caution or Alarm limits on the relevant device as configured in TransConnect (see Figure 4-24). The 'Custom' option allows the user to manually define the values for the ROC parameters as shown in Figure 4-21. Note: Both fields accept any value from 1 to 32767.

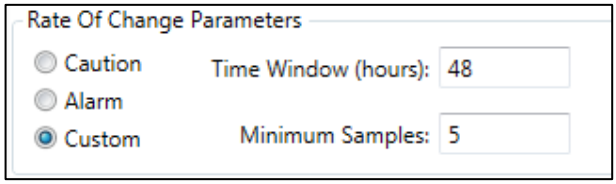


Figure 4-21: Custom: Rate Of Change Parameters

The parameters are also shown in the gas legend tooltip on the chart as shown in Figure 4-22.

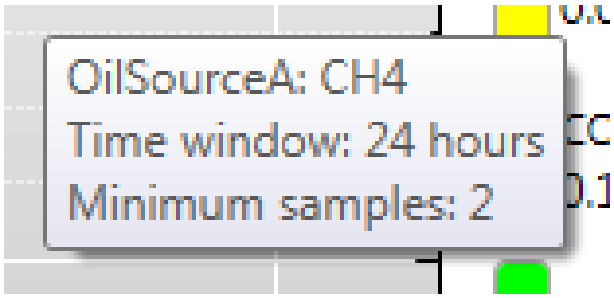


Figure 4-22: ROC tooltip showing parameters

The Custom option is useful for devices with multiple oil sources to ensure that the ROC parameters are consistent across all oil sources thereby allowing data to be reliably aggregated for plotting.

A blank chart occurs where the supplied values are insufficient for any data to be plotted, the 'Time Window' is less than the set measurement period on the device, or if the number of measurements is less than the 'Minimum Samples' value within the 'Time Window' period. If the device is not configured with Caution or Alarm limits, or ROC parameters are not specified, then the chart on the ROC worksheet will be blank since there is nothing to plot.

Note: A chart is not displayed for a gas or peripheral (including devices imported from a CSV file) without ROC parameters set for 'Caution' and 'Alarm' cases. Instead, a popup message states 'ROC Parameters are not available'.

4.8 Rate of Change Alarm

The Rate of Change (ROC) alarm is designed to alert the user of a gradual change in the gas levels of the transformer over a set period. The user will receive notification in the Status worksheet.

When used in conjunction with Perception Server, with e-mail notification configured (see Section 3.9.5.5), an alarm notification email similar to that shown in Figure 4-23 will be sent to the designated recipients.

From: TransFix1@plant.com
Sent: 20th April 2011 14:29
To: Plant_Manager@plant.com
Subject: Kelman Transfix (/TransFix1) has exceeded an alarm limit.

Kelman Transfix (/TransFix1) has exceeded an alarm limit.

Latest Measurements:

MAIN

Name	Value	Timestamp	Status	LowLow Limit	Low Limit	High Limit	HighHigh Limit
Hydrogen	280.0 ppm	12/8/2011 3:24:00 PM	High & ROC			240.0 ppm	
Methane	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
Acetylene	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
Ethylene	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
Ethane	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
Carbon Monoxide	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
Carbon Dioxide	280 ppm	12/8/2011 3:24:00 PM	ROC				
Oxygen	280.0 ppm	12/8/2011 3:24:00 PM	ROC				
TDCG	1680 ppm	12/8/2011 3:24:00 PM	ROC				
Water	2.0 ppm	12/8/2011 3:24:00 PM					
AmbientTemp	0.0 °C	12/8/2011 3:24:00 PM					
NormalizationTemp	0.0 °C	12/8/2011 3:24:00 PM					
OilPressure	0 KPa	12/8/2011 3:24:00 PM					
OilTemp	0.0 °C	12/8/2011 3:24:00 PM					
Nitrogen	280 ppm	12/8/2011 3:24:00 PM	ROC				
TDG	2520 ppm	12/8/2011 3:24:00 PM					
Ambient Temperature	0.0 deg C	12/8/2011 3:24:00 PM					
Normalisation Temperature	0.0 deg C	12/8/2011 3:24:00 PM					
Oil Temperature	0.0 deg C	12/8/2011 3:24:00 PM					
Schedule Mode	Alarm						

Previous Measurements:

MAIN

Figure 4-23: Example Rate of Change e-mail alert

To set up the ROC limits, launch the device setup option from the Asset Explorer. In the Alarms worksheet, you can set the maximum Rate of Change in ppm/hours for Caution and Alarm, as shown in the example in Figure 4-24.

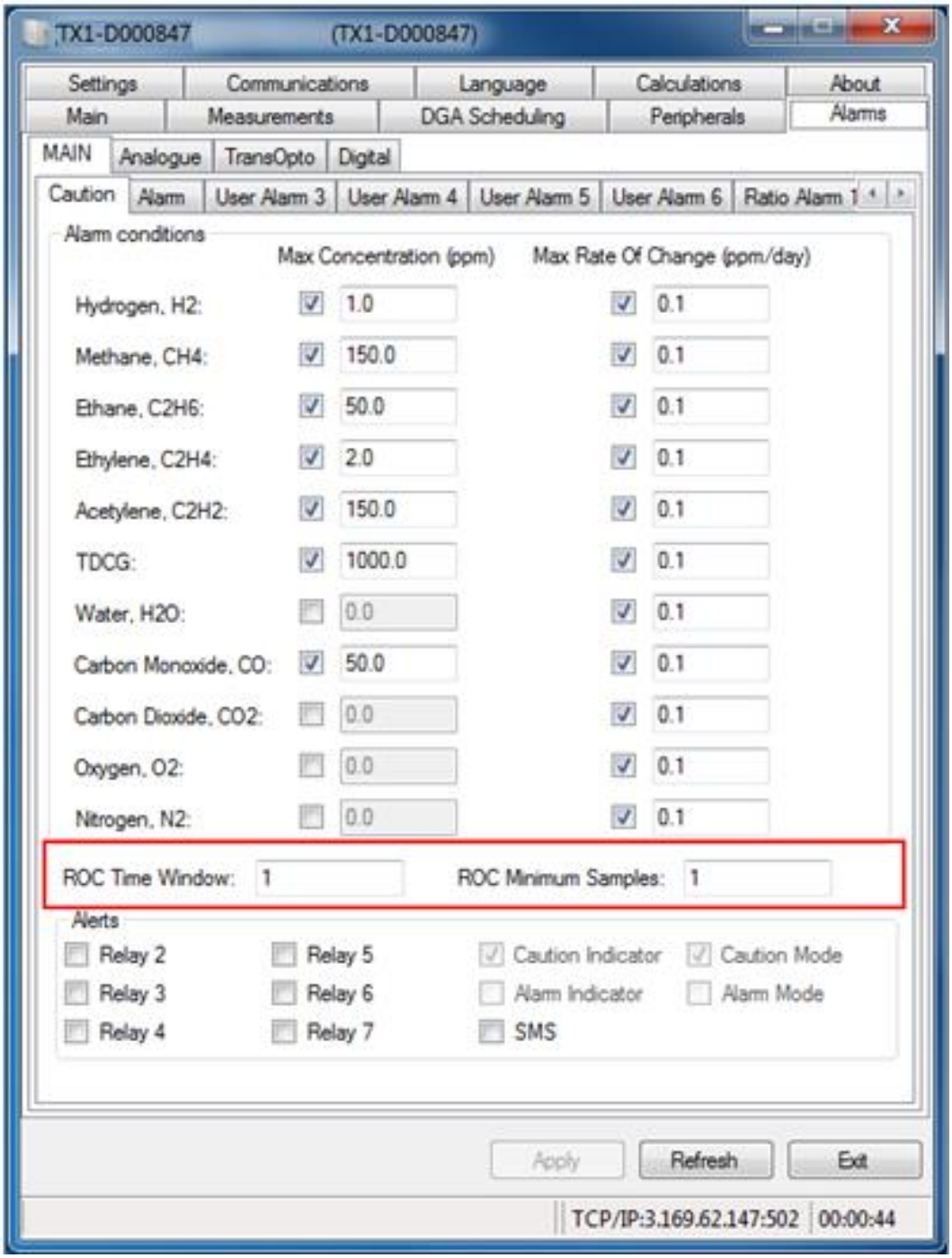


Figure 4-24: ROC settings in TransConnect

The 'ROC Time Window' and 'ROC Minimum Samples' must be defined for the alerts to operate. These values are important as they are used in the ROC calculation. The 'ROC Time Window' can be set between 1 and 96 hours. Over time, the initial measurements are discarded as they fall outside the boundaries of the measurement window and are replaced with more recent results.

To avoid spurious values or dropped measurements (recorded as a zero) from raising an alert, an 'ROC Minimum Samples' parameter is set. When this parameter is met, the unit will calculate the ROC result and, if applicable,

generate an alert. This allows the user to control whether an isolated measurement should raise an alert or whether a more persistent change is required to raise an alert.

4.9 Total Dissolved Combustible Gases (TDCG) Chart

The Total Dissolved Combustible Gases (TDCG) Chart as shown in Figure 4-25 is a pre-set chart with similar controls to the Trend chart for dissolved gases as discussed in Section 0.

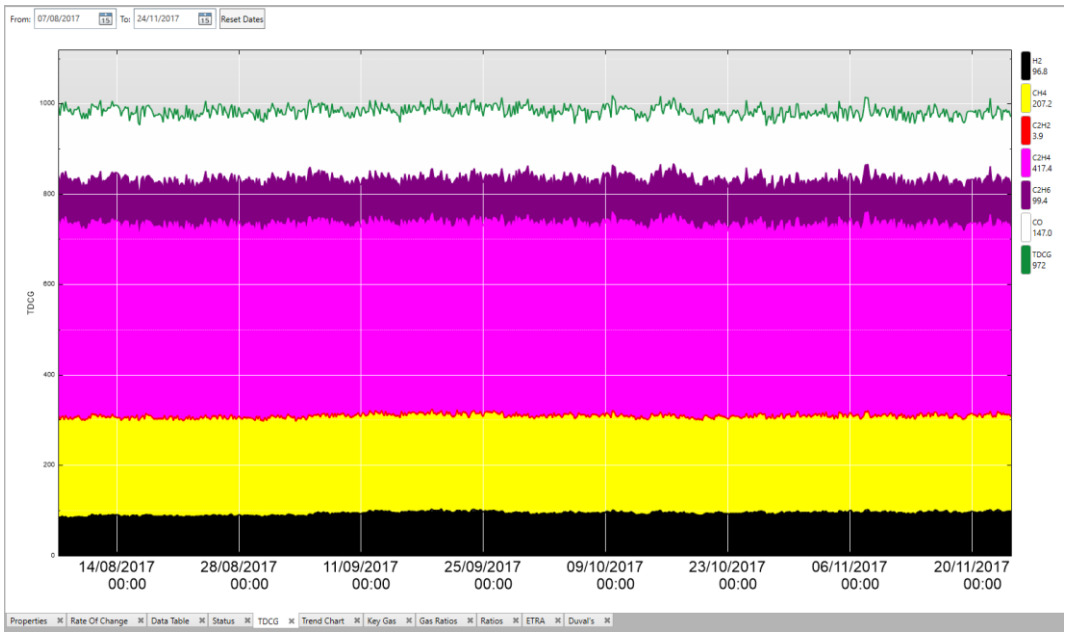


Figure 4-25: TDCG Chart

The key differences are:

- The selection of gases is fixed, so cannot be changed by the user
- The values are stacked upon each other, so it is possible to judge the relative proportions of each gas.
- A **Compartment** option exists to change the phase/compartment of the device being displayed (right click anywhere in the chart to see the option).

Note: Once you have settled on your selection of parameters, it is advisable to rename the chart to indicate which compartment/phase is being displayed.

You can modify the plot dates to identify spikes or adverse trends in the total gas concentrations, for example, as shown in Figure 4-26.

Note: The new plot dates are carried over to the other views so that they are all displaying the same peaks.

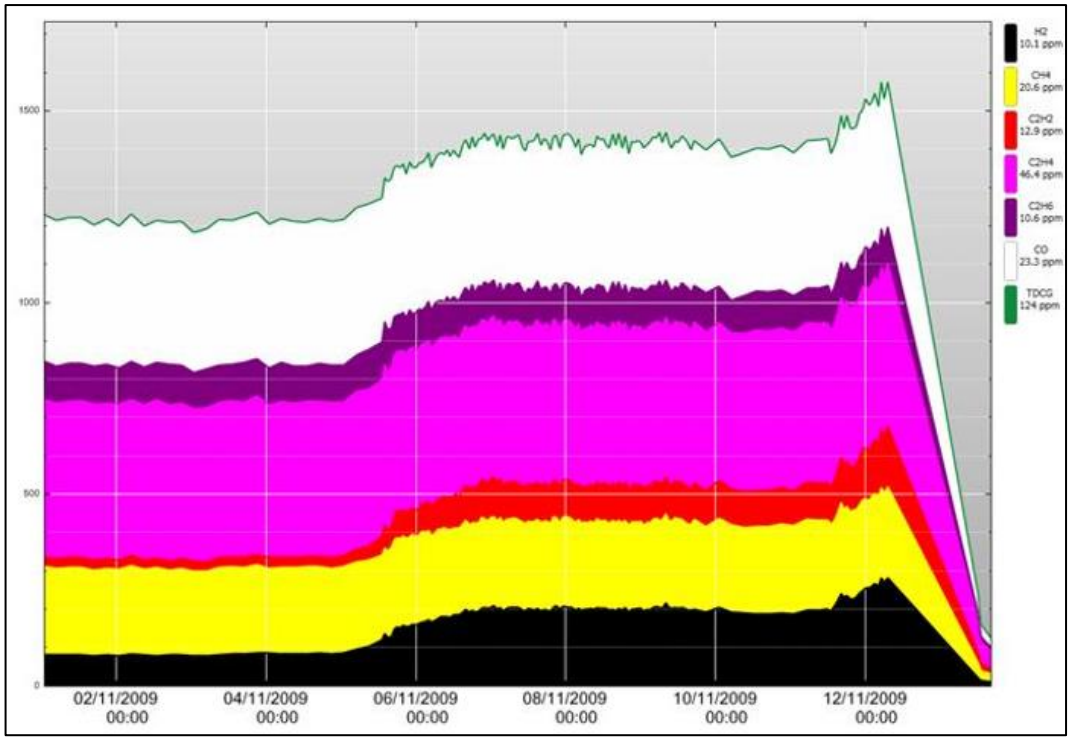


Figure 4-26: TDCG Chart

4.10 Key Gas

The Key Gas worksheet compares the concentrations of key gases against thresholds for four deterioration conditions:

- Arcing from load current
- Corona, Partial discharge
- Overheated oil
- Overheated paper

The set of readings for each condition are rendered graphically (one chart for each condition) using the specified plot dates as shown in the example of Figure 4-27. The date of the readings is also shown in the centre of the four graphs (denoted by the blue rectangle).

Note: The first chart (top left) is replicated below for visibility and description.

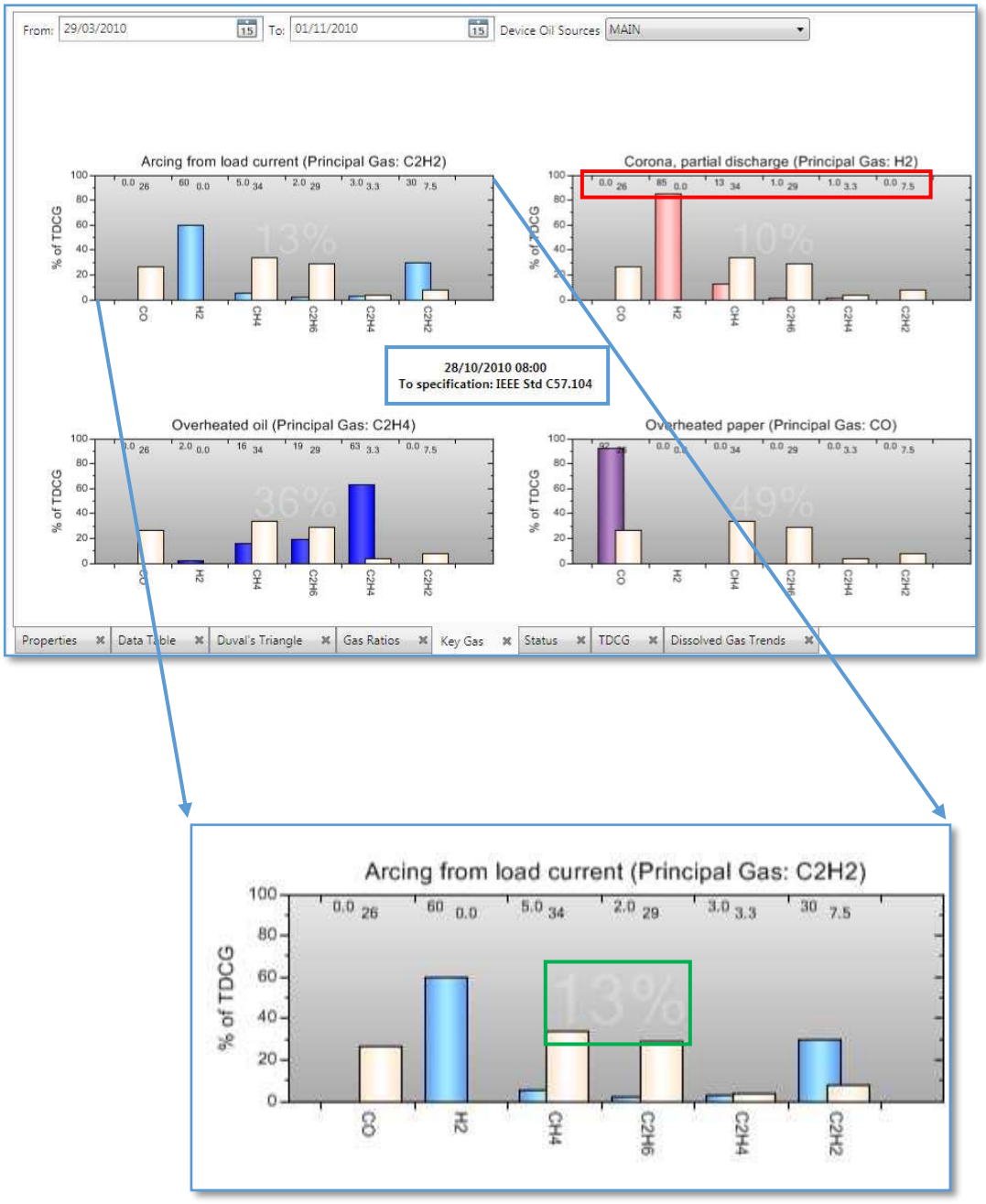


Figure 4-27: Key Gas charts

The bar graphs indicate the percentage of each gas as a proportion of the total of the six gases being presented. For each gas, the coloured bar (blue in this example) indicates the actual percentage and the 'buff' bar indicates the threshold percentage used in the fault condition indication. The numeric values for the percentages are located across the top of the chart, as denoted by the red rectangle, for example, for C2H2.

The percentage figure in the centre of each graph (denoted by the green rectangle) represents the percentage of confidence that it is the most likely fault condition of the four. This is influenced by the number and extent of the parameters exceeding their thresholds.

4.11 Overvoltages

The Overvoltages worksheet is unique to MS 3000 device and plots the characteristics of an overvoltage in Kilovolts over time with the user able to select any date range as shown in Figure 4-28. Any voltage in excess of the normal operating voltage is important to monitor as any surge can disturb electrical equipment.

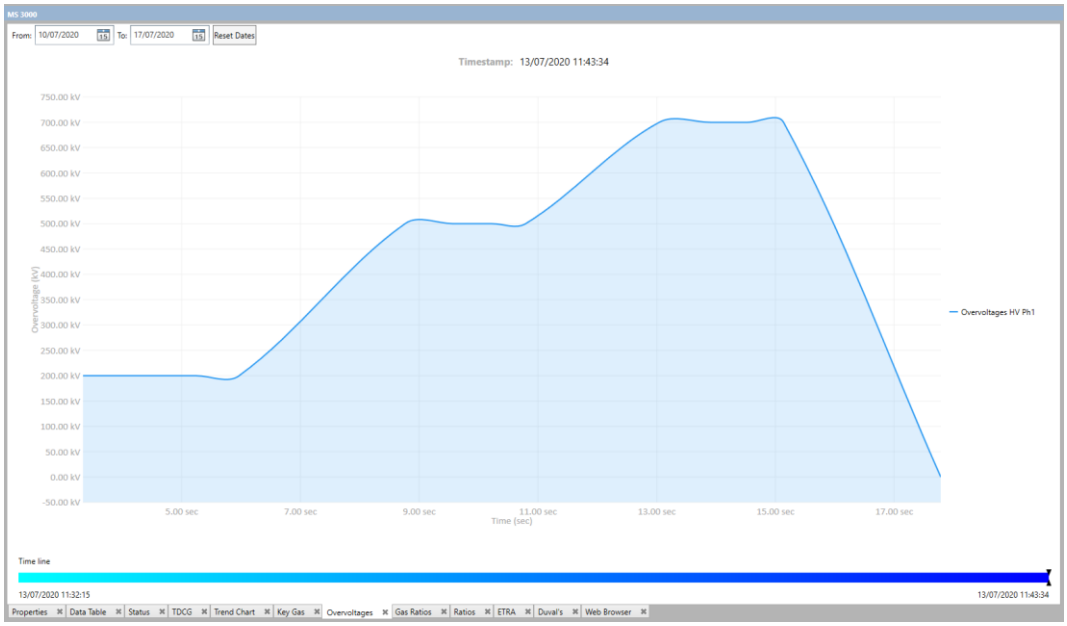


Figure 4-28: Overvoltages worksheet

4.12 Gas Ratios

The Gas Ratios worksheet displays the concentrations of gases in a three-axis cube graph as shown in Figure 4-29. The position of the plot points is indicative of certain fault conditions.

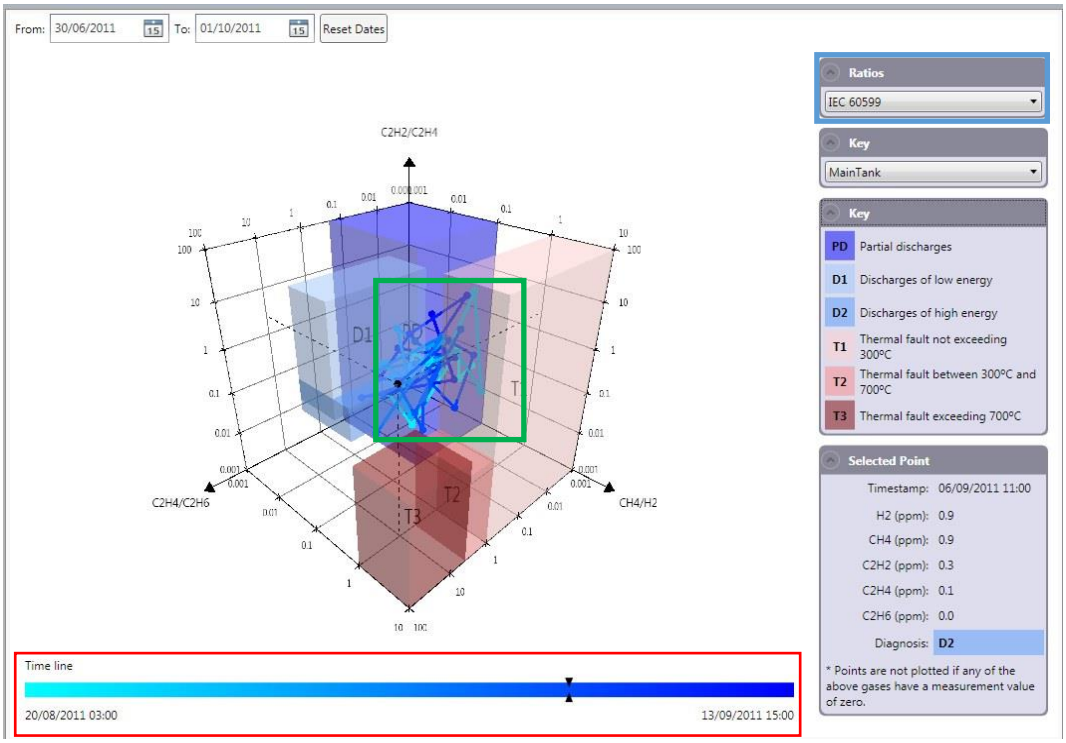


Figure 4-29: Gas Ratios worksheet

The method of plotting the gas ratios can be selected in the **Ratios** dropdown, highlighted by the blue rectangle (top right). The choices are as follows:

- IEC 60599
- IEEE C57.104
- Ratios Table

The **Gas Ratios** worksheet automatically uses the last plot point in the timeline with the selected values listed in the **Selected Point** drop down. The trend range that is plotted from the main date range is shown in the time line bar (denoted by the red rectangle). The plot points (denoted by the green rectangle) are similarly coloured from cyan to dark blue along the time line.

Note: The span of the timeline plotted is the latest available reading within the main date range and the last 50 readings prior to that.

To rotate the cube, hold the left mouse button on one side of the cube and then drag the mouse.

If you select another plot point on the timeline then black dotted lines project its position onto the cube surfaces and the **Selected Point** drop down is updated. The Selected Point information on the legend is also updated. A

diagnosis for the Selected Point is displayed (as highlighted) in the **Selected Point** drop down.

The IEEE C57.104 version of the Gas Ratios is shown in Figure 4-30.

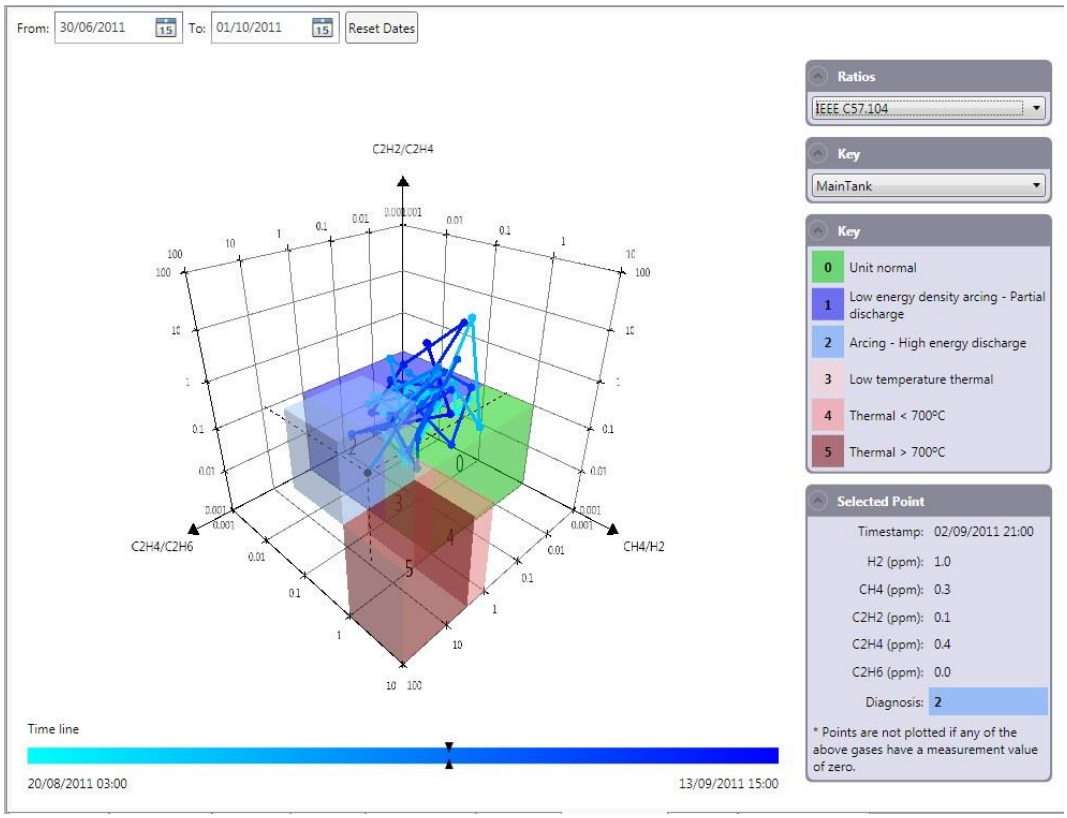
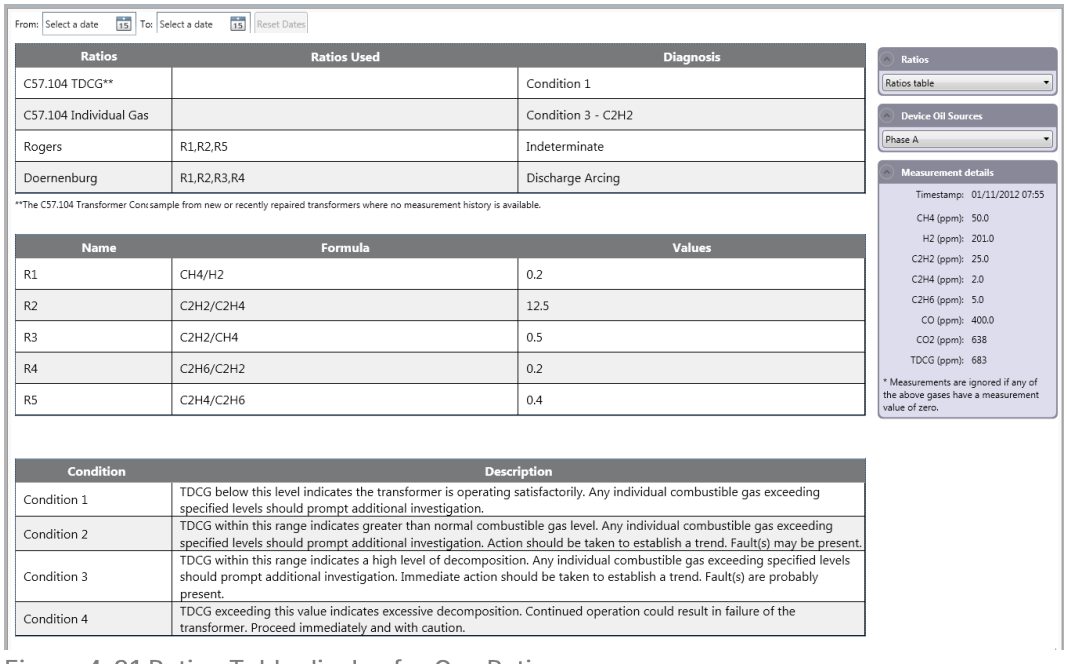


Figure 4-30: IEEE C57.104 version of Gas Ratios

In addition, the 'Ratios Table' option, an example of which is shown in Figure 4-31, indicates the IEC 57.104 Transformer Condition, Rogers Ratio and Doernenburg Ratio, with their resultant diagnoses for the selected point.



From: Select a date To: Select a date Reset Dates

Ratios	Ratios Used	Diagnosis
C57.104 TDCG**		Condition 1
C57.104 Individual Gas		Condition 3 - C2H2
Rogers	R1,R2,R5	Indeterminate
Doernenburg	R1,R2,R3,R4	Discharge Arcing

**The C57.104 Transformer Concsample from new or recently repaired transformers where no measurement history is available.

Name	Formula	Values
R1	CH4/H2	0.2
R2	C2H2/C2H4	12.5
R3	C2H2/CH4	0.5
R4	C2H6/C2H2	0.2
R5	C2H4/C2H6	0.4

Condition	Description
Condition 1	TDCG below this level indicates the transformer is operating satisfactorily. Any individual combustible gas exceeding specified levels should prompt additional investigation.
Condition 2	TDCG within this range indicates greater than normal combustible gas level. Any individual combustible gas exceeding specified levels should prompt additional investigation. Action should be taken to establish a trend. Fault(s) may be present.
Condition 3	TDCG within this range indicates a high level of decomposition. Any individual combustible gas exceeding specified levels should prompt additional investigation. Immediate action should be taken to establish a trend. Fault(s) are probably present.
Condition 4	TDCG exceeding this value indicates excessive decomposition. Continued operation could result in failure of the transformer. Proceed immediately and with caution.

Figure 4-31 Ratios Table display for Gas Ratios

4.13 Ratios

The Ratios worksheet displays any gas ratio on a trend chart (for lab data, a Transfix or DGA 900-family device) and the corresponding alarm limits set on the device as shown in Figure 4-32. The fractional formula line showing how the ratio is calculated is shown below the chart.

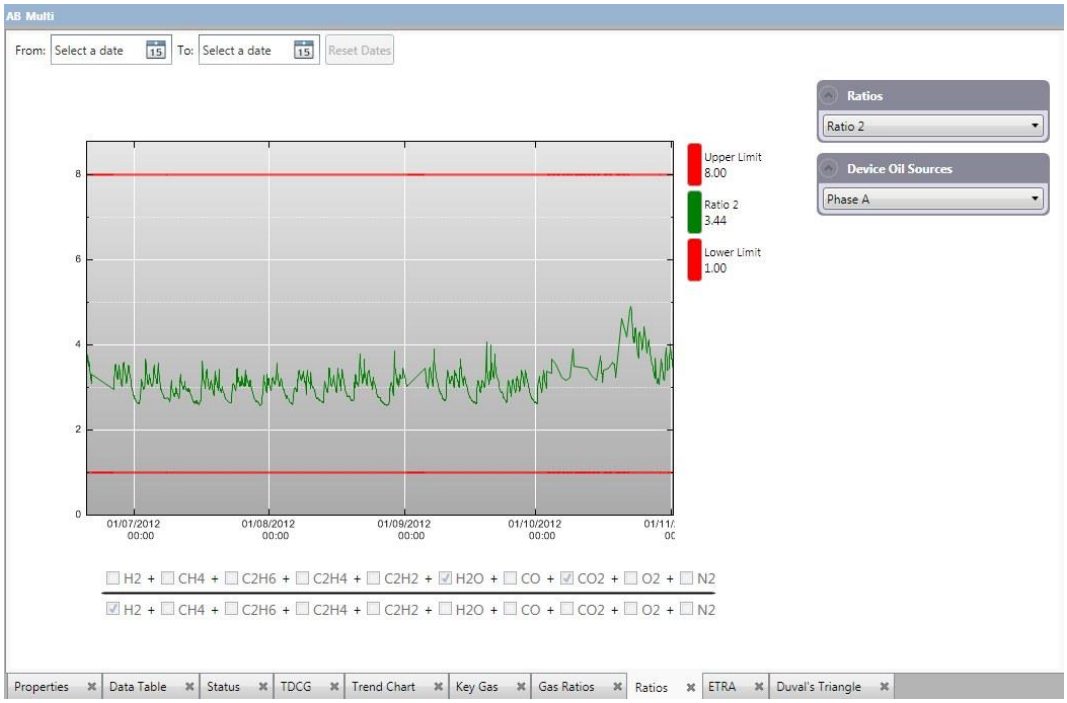


Figure 4-32: Ratios Trend Graph

When displaying a preset ratio retrieved from the device, the fractional formula ratio line is greyed out, as these values are defined on the device and can only be edited via the device setup option.

To create your own custom ratio, use the **Ratios** drop down to select **Custom Ratio**. Select the gases for the numerator and denominator on the fractional formula ratio line. When this is plotted, there are no appropriate alarm limits to plot, so only the ratio trend line is plotted, as shown in Figure 4-33.

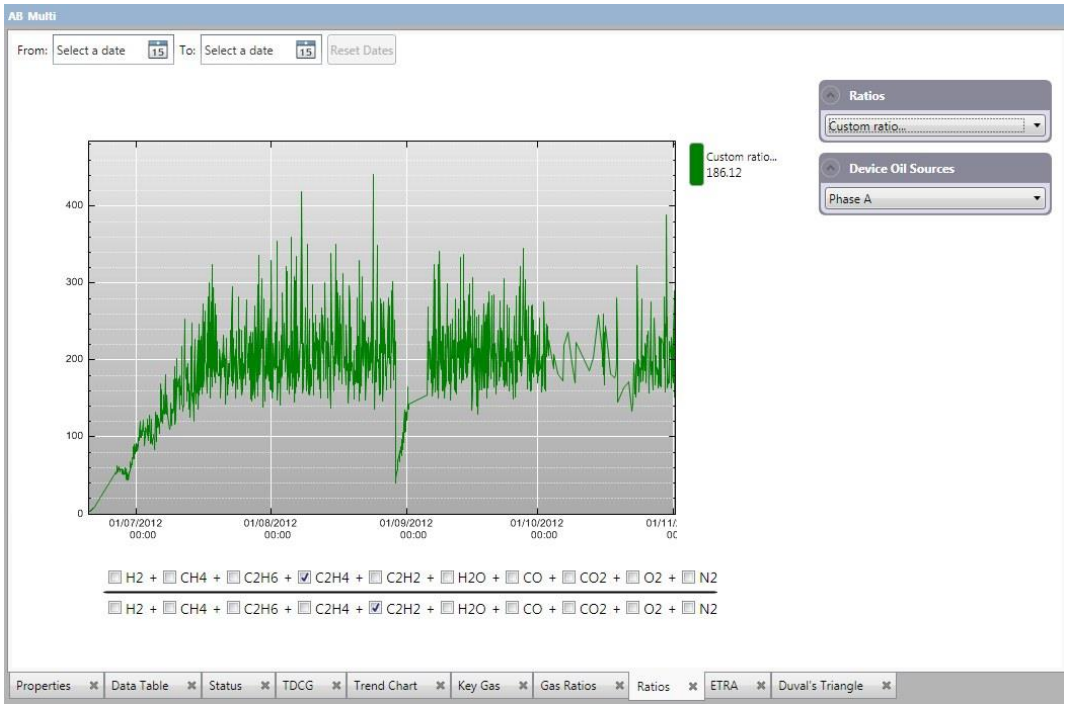


Figure 4-33: Custom ratio trend plot

4.14 ETRA

The ETRA worksheet displays gas ratios according to the Japanese ETRA standards. The **ETRA diagrams** dropdown offers two choices:

- **Diagram A**: classifies overheating and discharges.
- **Diagram B**: categorises the discharges.

The page layout follows the same display and control conventions as the Gas Ratios and Duval's worksheets, namely that the:

- type of diagram is selected from the **ETRA diagrams** dropdown.
- plot points and time line have the earliest plot point represented by a cyan colour ranging to deep blue for the most recent plot point.
- selected plot point has dotted lines to the axes to enable the ratio values to be read off.
- **Selected Point** dropdown has the plot point source data values and the diagnosis.

Figure 4-34 shows ETRA Diagram A for classification of overheating and discharges. The diagnosis in this example is D – Discharges.

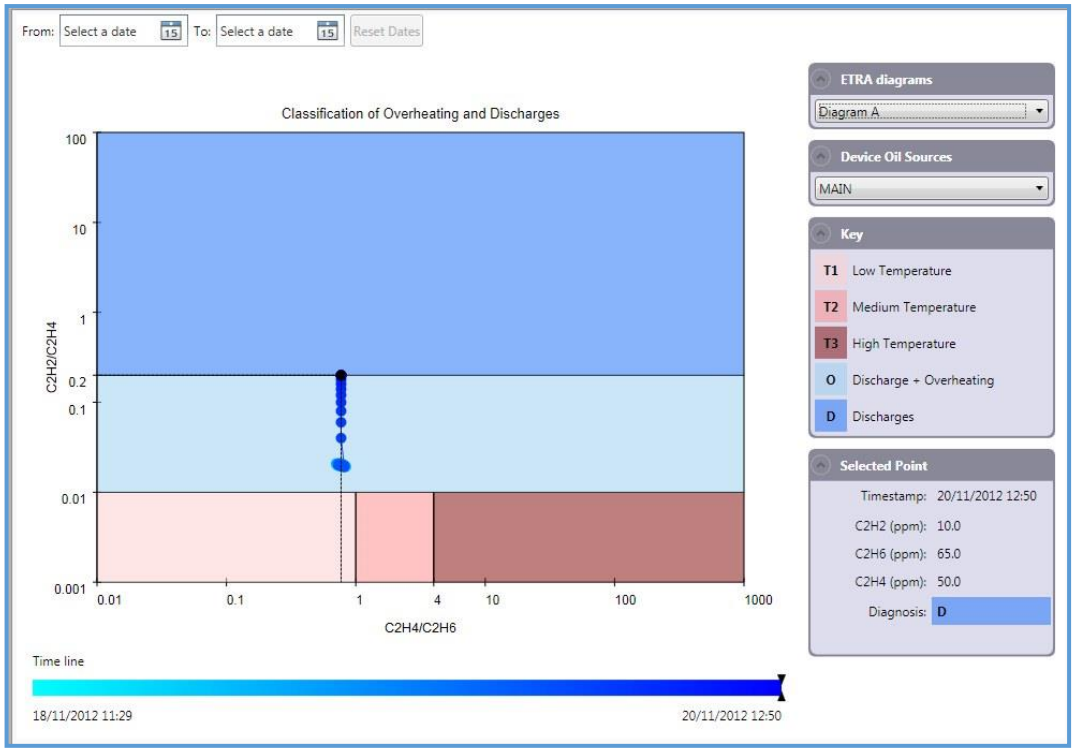


Figure 4-34: ETRA Diagram A

Figure 4-35 shows ETRA Diagram B details of discharges. The diagnosis in this example is PD – Partial Discharges (Low Energy).

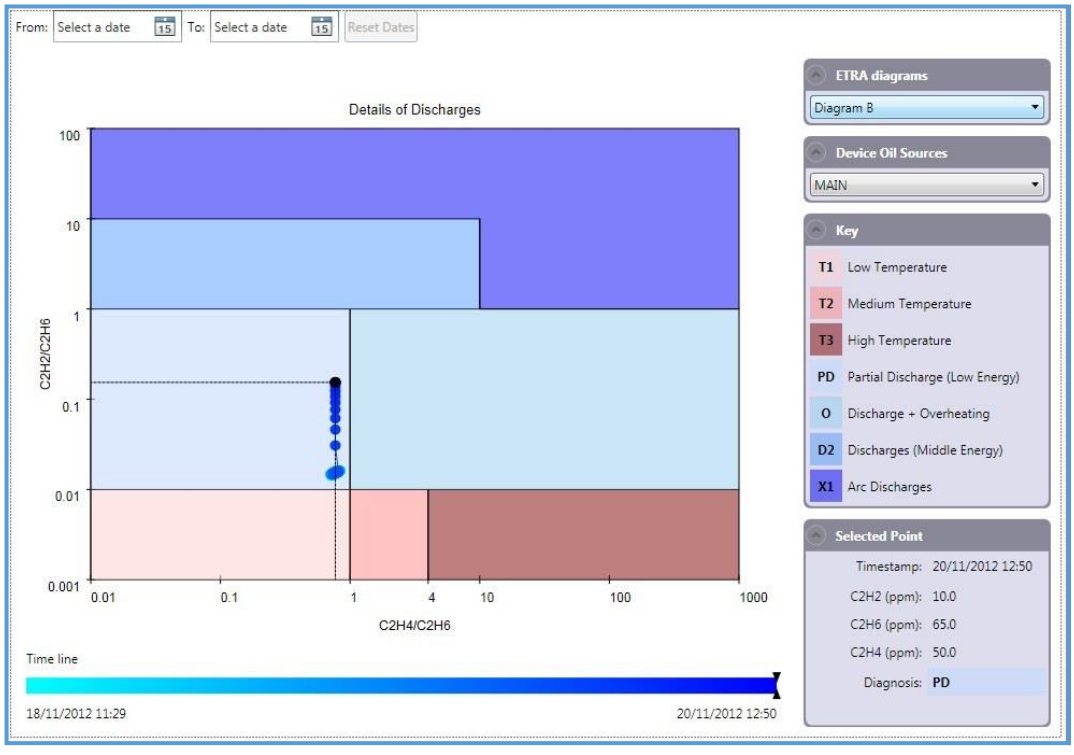


Figure 4-35: ETRA Diagram B

4.15 Duval's

Duval's diagnostics is an alternative method of mapping the gas concentrations to possible fault conditions. The Duval's worksheet as shown

in Figure 4-36 is laid out similarly to the Gas Ratios worksheet described previously. The **Duval's Diagnostics** dropdown offers six available charts:

- Classic
- LTC – the 'Type 2' for Load Tap Changer (mineral oil filled)
- Type 4 – Low temperature faults, using different gases from the 'Classic'
- Type 5 – Low temperature faults, using the same gases as the 'Classic'
- Pentagon 1 – six electrical faults, PD, D1, D2, T3, T2, T1 and stray gassing of mineral oil S
- Pentagon 2 –three electrical faults PD, D1, D2 and four thermal faults T3-H, C, O, and S

Note: The 'Low temperature faults' Duval's triangles should only be applied to faults identified by the Classic Duval triangle as possible faults PD, T1 or T2, and should be viewed only as a complement of information for the Classic Duval triangle.

Figure 4-36 shows a Classic Duval's Triangle. A data point can be selected either from the plot on the Duval's Triangle or by sliding along the time line at the bottom of the display. Both the time line and the plot points are coloured with the earliest plot point represented by a cyan colour ranging to deep blue for the most recent plot point. The **Selected Point** dropdown reveals the plot data and the diagnosis for the selected point, in this example, an electrical and thermal fault. The other versions of the Duval's Triangle for the same data point are shown below.

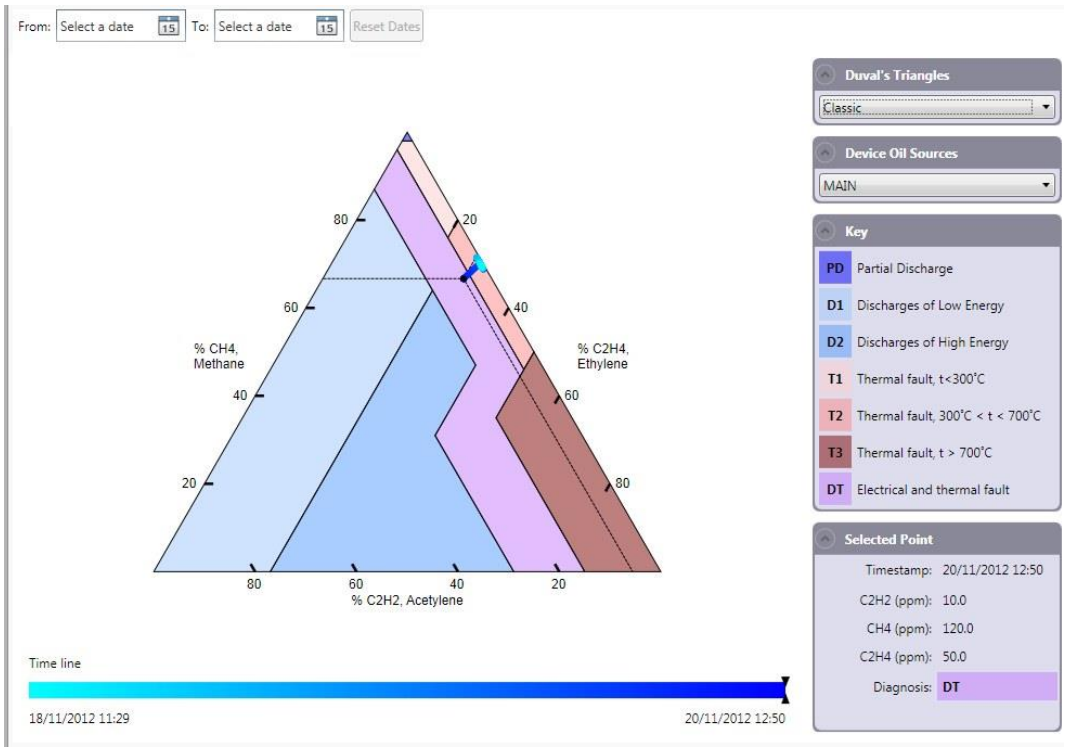


Figure 4-36: Duval's Triangle – Classic

Figure 4-37 shows an LTC example with a T2 diagnosis – severe thermal fault (300<T<700 °C, coking).

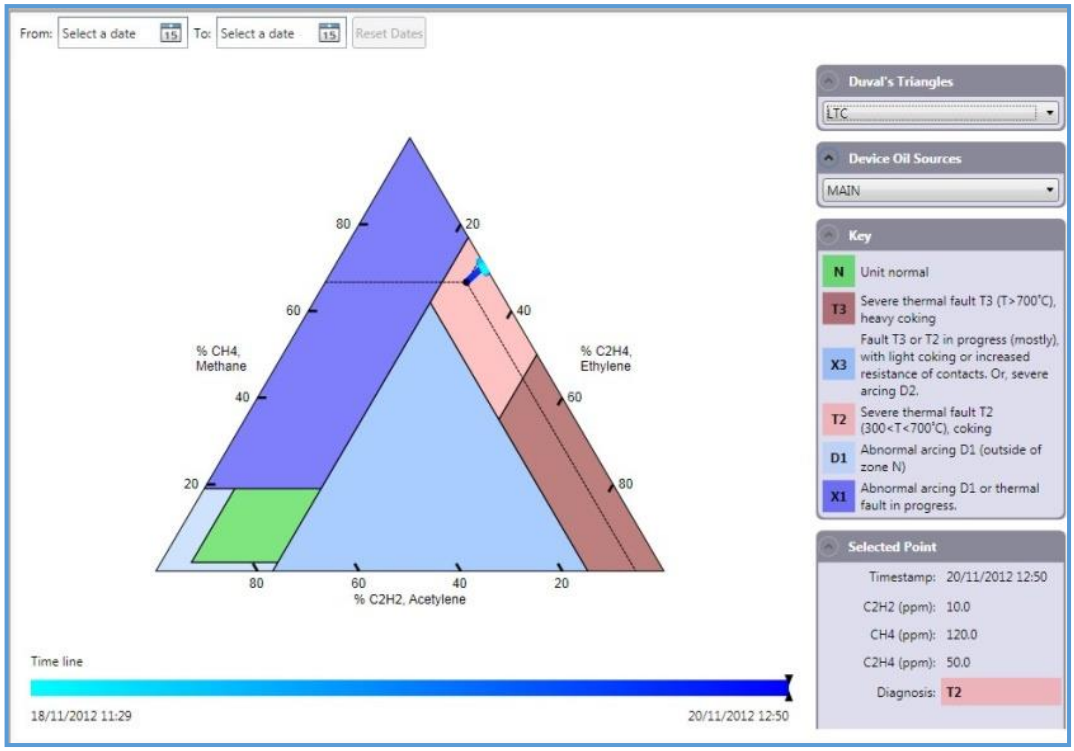


Figure 4-37: Duval's Triangle – LTC example

Figure 4-38 is a Type 4 example – Low Temperature Faults using Hydrogen, Methane and Ethane. Diagnosis S – Stray gassing of mineral oil.

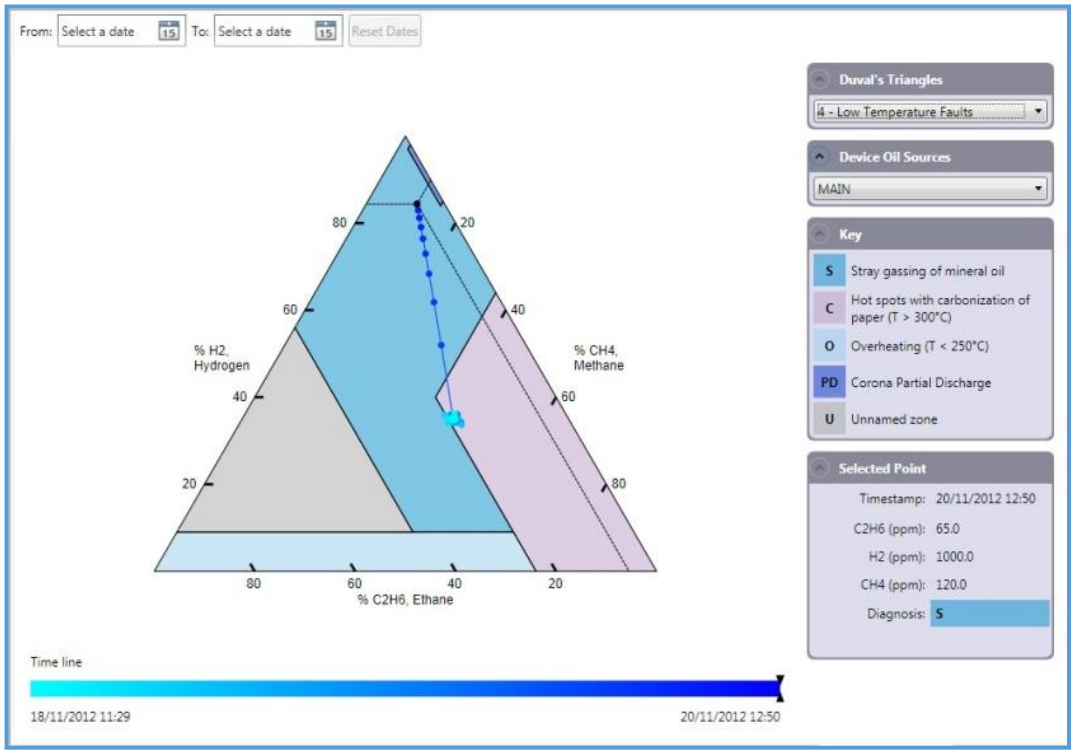


Figure 4-38: Duval's Triangle – Type 4 example

Figure 4-39 is a Type 5 example – Low Temperature Faults using Methane, Ethylene and Ethane. The diagnosis is C – hot spots with Carbonization of paper (T>300 °C).

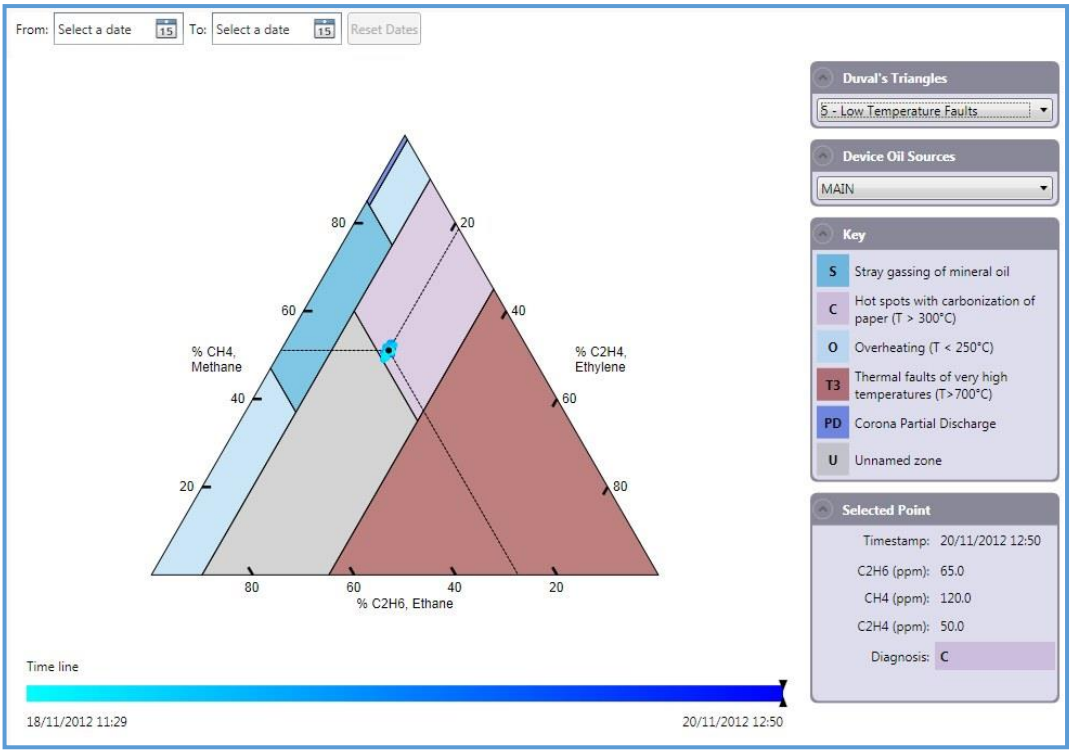


Figure 4-39: Duval's Triangle – Type 5 example

Duval's diagnostics also offers two pentagon representations for 5-gas ratios.

Figure 4-40 is a Pentagon 1 example using hydrogen, acetylene, ethylene, methane and ethane. The diagnosis is S – Stray gassing S of mineral oil at 120 and 200 °C in the laboratory.

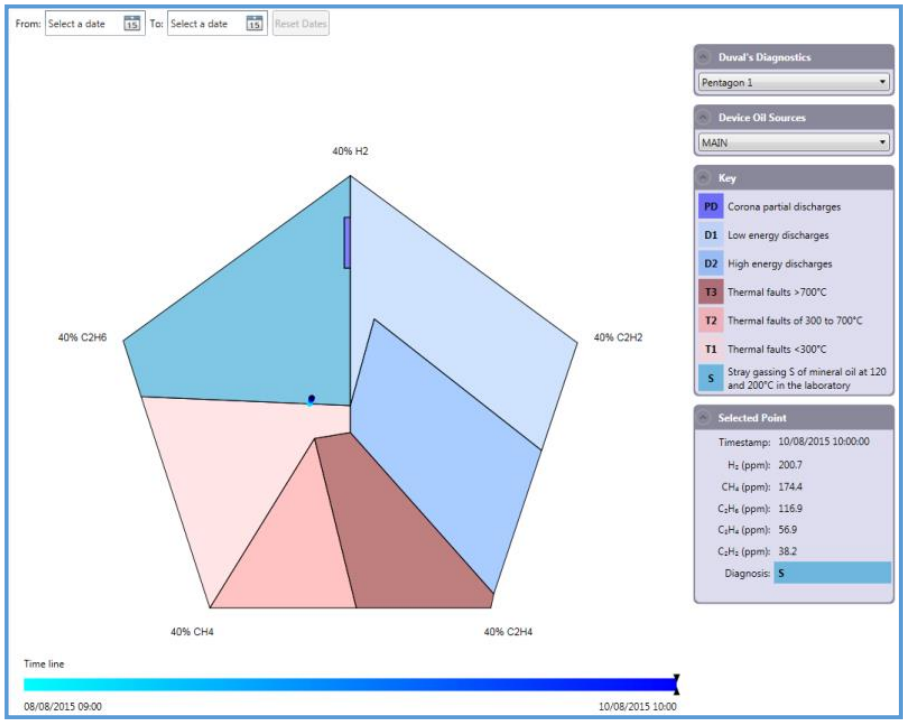


Figure 4-40: Duval's Pentagon 1 for 5 gases

Figure 4-41 is a Pentagon 2 example using hydrogen, acetylene, ethylene, methane and ethane. The diagnosis is S – Stray gassing S of mineral oil at 120 and 200 °C in the laboratory.

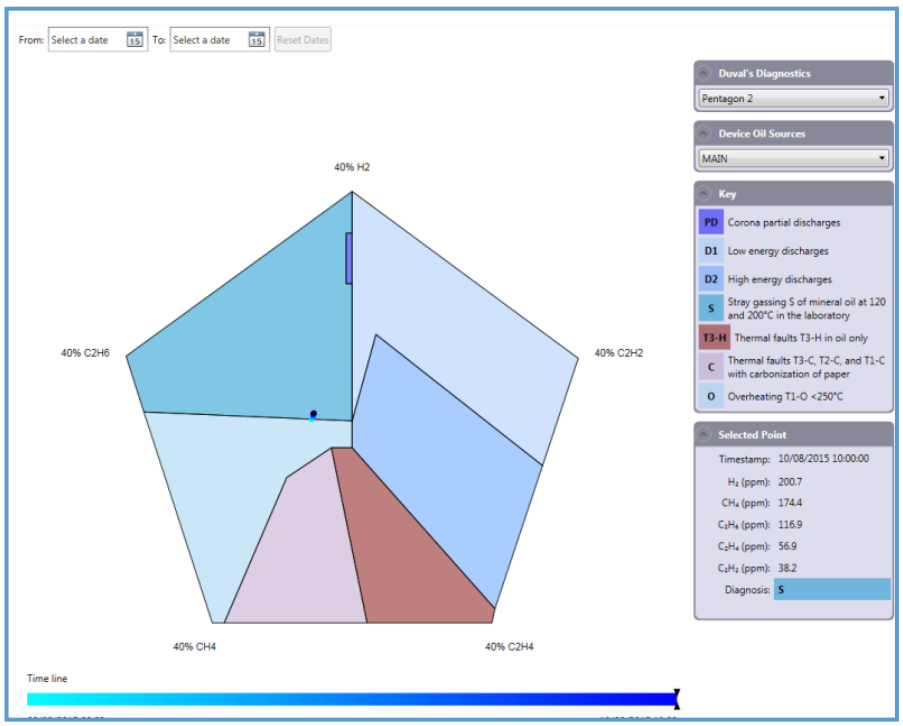


Figure 4-41: Duval's Pentagon 2 for 5 gases

4.16 Models

The Models worksheet is for Intellix MO150, Hydran M2 / M2-X, DGA 900 PLUS and DGA 900 TAPTRANS PLUS devices only. These devices measure an array of parameters (such as current, voltage, temperature and moisture etc) that Perception Desktop utilises in algorithms for graphical models to infer other transformer conditions.

The available models are:

- Dynamic Loading: This model provides the operator with a continuous estimation of the capacity of the transformer to continue safe operation under temporary overloading conditions. See Appendix E.2.1 for a brief description of the model.
- Insulation Ageing: This model monitors the key parameters that lead to the breakdown of the insulation paper in the transformer windings. See Appendix E.2.2 for a brief description of the model.
- Moisture and Bubbling: This model monitors the water content in the oil and the current oil temperature compared to the temperature at which bubbles would form in the oil (dependent upon the atmospheric pressure). See Appendix E.2.3 for a brief description of the model.
- Apparent Power in MVA: This model continuously monitors the load carried by the transformer. See Appendix E.2.4 for a brief description of the model.
- Winding Hot-Spot Temperature (WHST): This model uses several parameters to estimate the temperature of the hottest spot in the winding, as opposed to the general winding temperature. See Appendix E.2.5 for a brief description of the model.
- Cooling Status: This model allows identification of the cooling stage currently in service. This information is also essential to other cooling models, such as Cooling Efficiency and Cooling Control. See Appendix E.2.6 for a brief description of the model.
- Cooling Efficiency: This model computes the top oil temperature that should be expected considering the load current, the ambient temperature, the cooling mode, the oil time constant and the altitude. See Appendix E.2.7 for a brief description of the model.
- On-Load Tap Changer (OLTC) Tap Position: This model provides additional information for monitoring the tap changer driving mechanisms. See Appendix E.2.8 for a brief description of the model.
- OLTC Differential Temperature: This model continuously compares the top oil temperature in the main tank with the tap changer compartment. See Appendix E.2.9 for a brief description of the model.

In addition, there are device-specific sensor reading history graphs:

<u>Hydran M2 Only</u>

- Temperature: Displays the history of various key transformer temperatures: (see Appendix E.2.10 for a brief description of the model.)
  - RH sensor temperature.

- Heater power (in % of full power).
- Top oil temperature.
- RH sensor hourly average temperature.
- Hydran sensor temperature.
- Base plate temperature.

- Hydran Readings: Displays the history of various key Hydran readings: (see Appendix E.2.11 for a brief description of the model.)
  - Hydran reading in ppm.
  - Hydran reading hourly trend, in ± ppm.
  - Hydran reading daily trend, in ± ppm.
  - Hydran sensor temperature.

Intellix MO150 Only

- Transformer Status: *This model provides a display of the main sensors feeding the Intellix MO150. It can accommodate up to six analog and/or digital signals and/or model outputs.* (see Appendix E.2.12 for a brief description of the model).
  - *Temperature sensors*
  - *Current transformers (CT) for load current*
  - *Hydran® intelligent transmitter*
  - *Aquaoil® 400 relative-humidity-in-oil analyser*
  - *Electric or acoustic partial discharge (PD) detectors*
  - *Geomagnetically-induced current detectors.*
- Cooling Control: *This model provides additional cooling control features to improve the performance of the cooling system.* (see Appendix E.2.13 for a brief description of the model).

Figure 4-42 shows a typical format for the Models worksheet for a Hydran device: a trending graph with gauges to indicate the spot values. The individual models are selected using the tabbed list at the top of the screen. In this example, the display is for Hydran Readings.

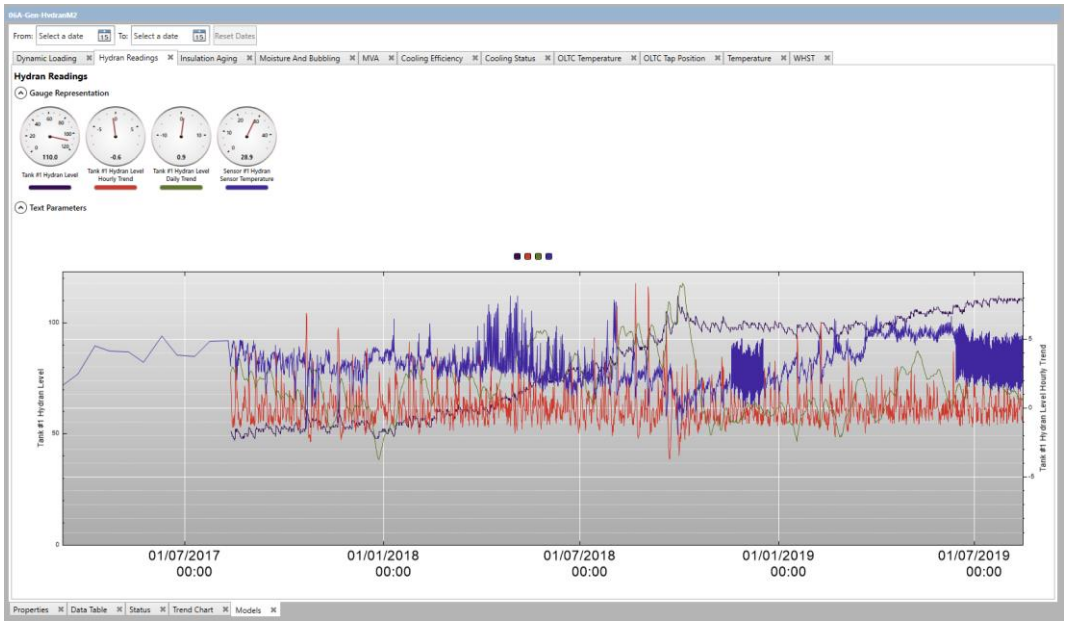


Figure 4-42: Models > Hydran Readings

4.16.1 Display Controls

The Models Trend Graph can be manipulated as follows:

- All the available parameters for a model are plotted on the trend graph, unless they are positively de-selected.
- To de-clutter the trend graph, individual parameters can be de-selected from the plot by clicking the relevant square in the colour-coded legend (it toggles to the large size to indicate deselection). For example, the upper graph in Figure 4-43 shows all parameters plotted, whereas the lower graph shows the purple plot de-selected.

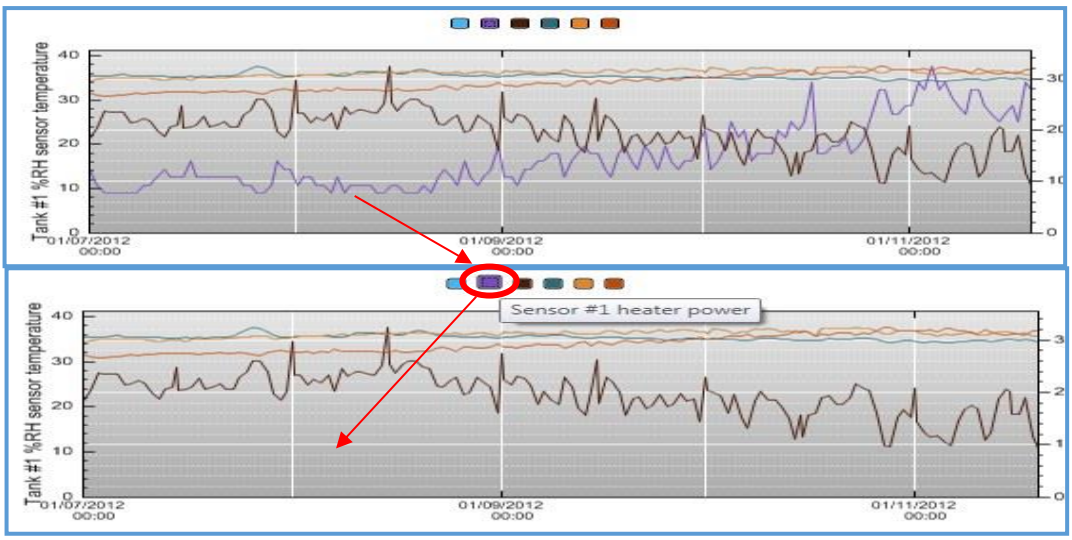


Figure 4-43: Example of deselecting a parameter

Note: Rest the mouse over a square in the colour-coded legend to see a description of the parameter.

- The respective parameter colour also underlines each gauge. The gauges indicate the most recent reading in the selected date range. If the cursor is

within the graph area, then the gauges represent the value at the cursor position.

- The gauges show an analogue reading on a dial with an appropriate scale. The value is also shown in digital form at the 6 o'clock position. If there is no digital number, then there are no values (as opposed to the value zero).
- Some gauges may have green, yellow and red borders on their circumference as shown in Figure 4-44. This indicates that normal, low and high operating ranges are set on the Hydran M2 / Intellix MO150 device.

Figure 4-44: Gauge Representation – examples

- Some models have a user-selected averaging period (at the source device). If that is the case, the Text parameters between the Gauges and the Graph Plot show the settings for the averaging period.

4.17 Bushing Monitor

This feature is available on all BMT devices and as an option on DGA 900 PLUS and DGA 900 MULTITRANS. The Bushing Monitor and Partial Discharge (PD) worksheets use polar plots to better identify and quantify which bushing (C1 and PF%) or phase (PD) is being affected with respect to the others. External factors such as temperature affect all three bushings (and thus all three phases) equally. When data is plotted on the polar plots, variations due to common effects are negated and have no effect on the output that is displayed on the polar plots. Each plot point represents the sum of all three phases. The radius of the plot gives its magnitude (e.g. % change) and the angle on the polar plot gives a visual indication of which bushing(s) are affected.

The Bushing Monitor worksheet presents two polar plots by default displaying the following parameters as shown in Figure 4-45.

- The relative change of Capacitance (C1) for a set of three bushings over time.
- The relative change of Power Factor (PF%) for a set of three bushings over time.

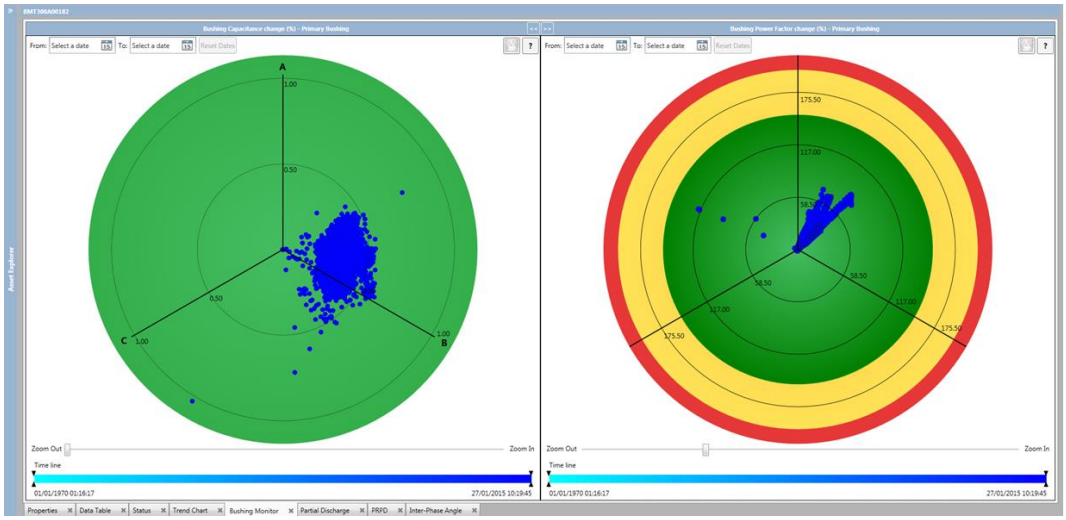


Figure 4-45: Bushing Monitor polar plot

Devices with bushing monitoring are shipped from the factory with default alarm settings. Note: Alarms are user configurable; refer to the relevant product Operator Guide. If the alarms are enabled on the device, the alarms are displayed in the polar plot as colour-coded boundaries as shown in Figure 4-46. Green denotes that the amplitude of the polar plot is within the acceptable given limits; yellow a warning and red an alarm.

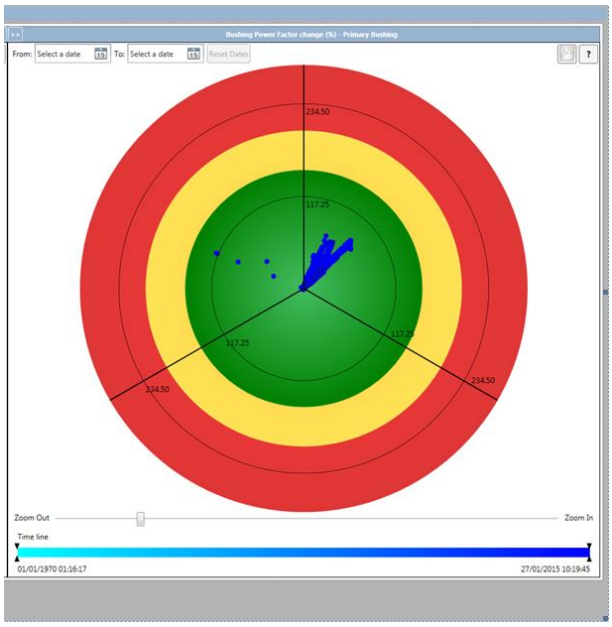


Figure 4-46: Bushing Monitor polar plot — alarms

Rest the mouse pointer over any data point on the polar plot to display a tooltip with the data point information.

Right click inside the pane for a shortcut menu with several graphing options as shown in Figure 4-47.

- The Plot option offers a choice of a Polar or Histogram view.
- The Bushings option offers a choice of Primary, Secondary or Tertiary bushings.

- The Measurement option offers a choice of measurement parameter either percentage change in either Capacitance or Power Factor.

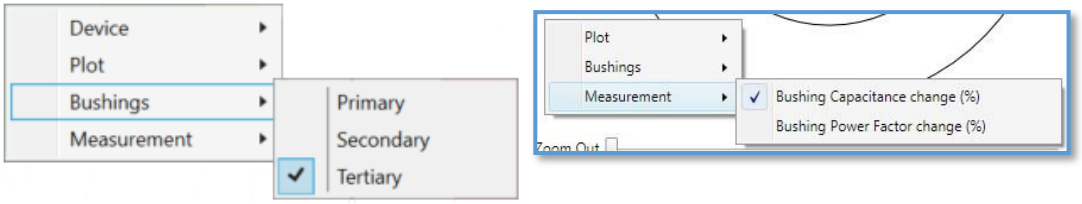


Figure 4-47: Bushing Monitor graphing options

4.17.1 Display Controls

The worksheet offers several controls as shown in Figure 4-48.

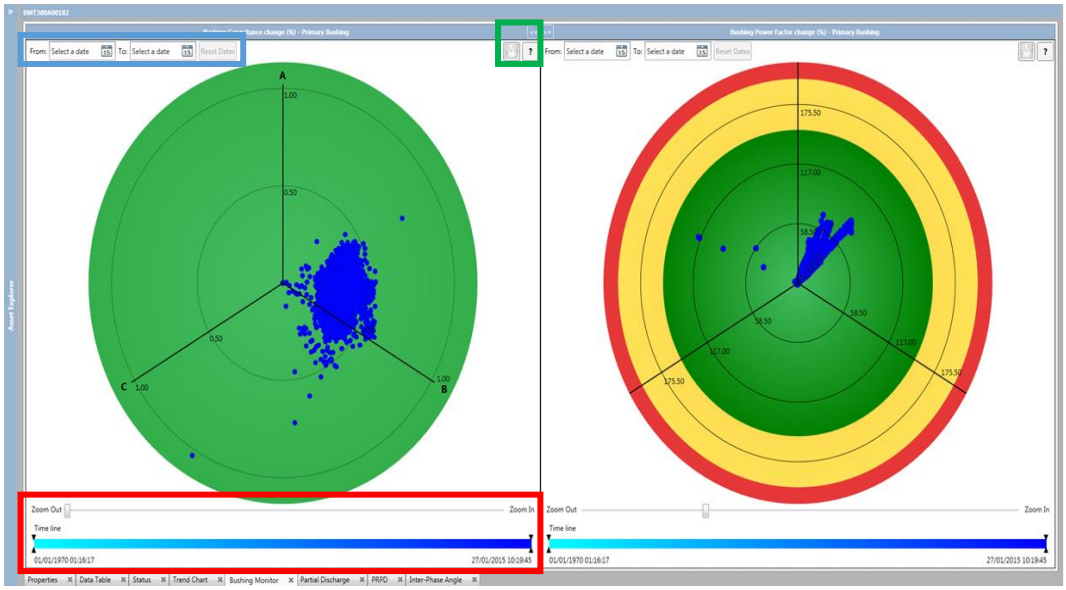


Figure 4-48: Bushing Monitor polar plot – controls

4.17.1.1 Date controls

The blue rectangle in Figure 4-48 highlights the Date controls.

- The **Date** picker is used to set the date range to display. The range is also shown on the Timeline below with the earliest plot point represented by a cyan colour ranging to deep blue for the most recent plot point.
- **The Reset Dates** button resets the date range to include all available data, ending in the most recent.

4.17.1.2 Zoom and Range controls

The red rectangle in Figure 4-48 highlights the Zoom and Range controls.

- The **Zoom** slider controls the radial scale to allow zooming in and out of the polar plot. When the polar plot is zoomed in, click and drag with the left mouse button to pan the zoomed region within the polar plot.
- The **Range** selector within the timeline allows the user to display a subset of the available data filtered by time. Drag the black markers on the far left

and right of the timeline accordingly to define a time-bound range of data. Drag the time-bound data range to update the polar plot in real time.

The effects of zooming and restricting the date range are shown in Figure 4-49. Zooming in and restricting the date range makes tracking a parameter over time more visible.

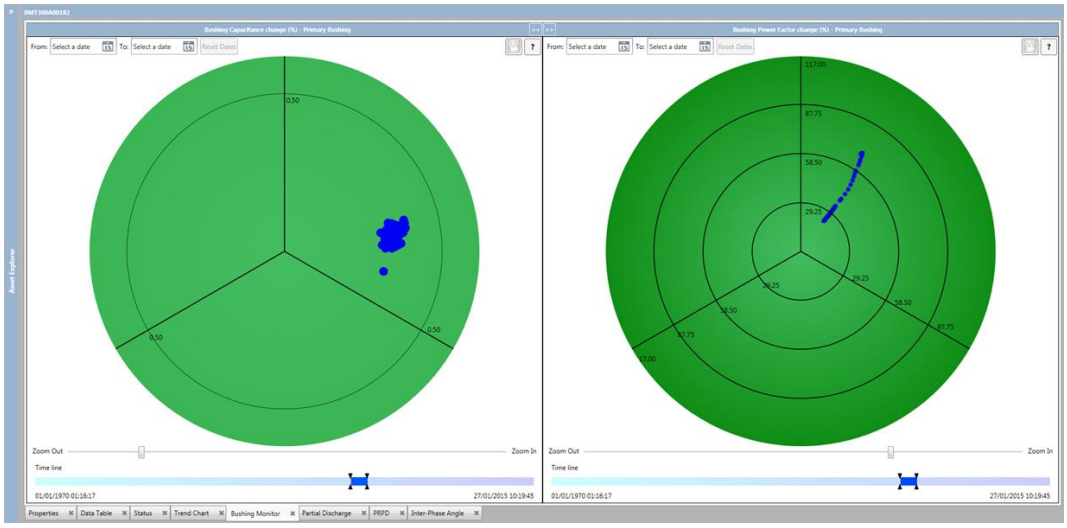


Figure 4-49: Bushing Monitor polar plot – zooming

4.17.1.3 Other controls

The green rectangle in Figure 4-48 highlights the other controls. These are also shown in Figure 4-50.

Figure 4-50: Other controls

- The '<<' or '>>' buttons hide and restore the graphs respectively.
- The 'graph' button (left most) toggles the view between a trend chart and a polar plot.
- The '?' button gives a short description of the graph.

The controls on one pane are independent of the other pane allowing the same dataset to be viewed differently alongside each other. For example in Figure 4-51, the left pane has been changed to a histogram view, while the right pane shows the same data selection and zoom, but using a plain polar view.

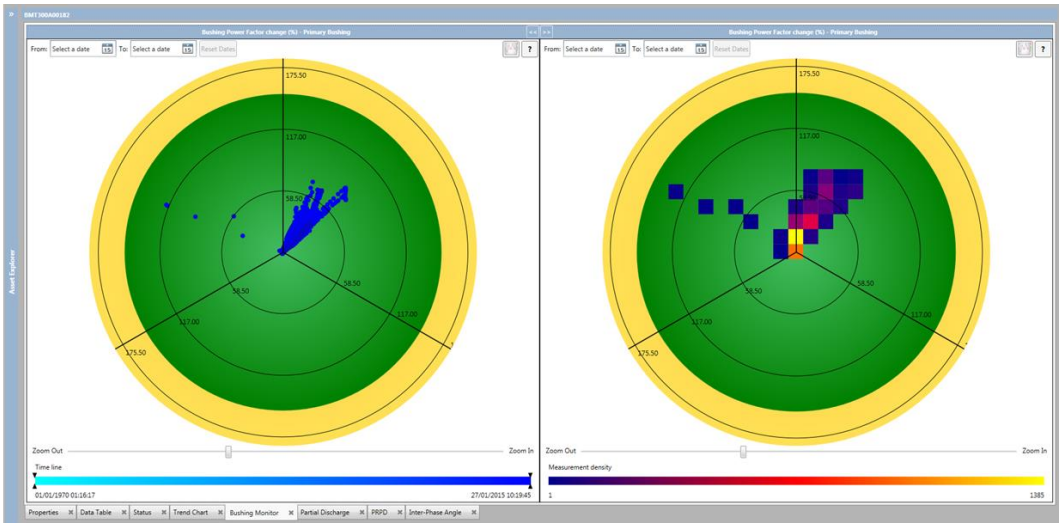


Figure 4-51: Histogram (left) and polar plot (right) using the same dataset

The colour of the histogram pixels denote the density of measurements at that point. Resting the mouse pointer on a pixel opens a tooltip showing the numerical value associated with the pixel's colour. This is useful when there are a large number of plot points: the plain polar view indicates the range of values, while the histogram indicates the commonality of the values. The histogram view can also be zoomed to give greater density detail.

4.17.2 Multiple BMT devices

The Asset Explorer allows multiple Intellix BMT 300/330 devices to be added to a single transformer to support the monitoring of multiple sets of bushings as shown in Figure 4-52. This makes it possible to visualize the monitoring data for multiple sets of bushings and easily switch between devices within a single worksheet, such as the Bushing Monitor worksheet. Right click the plot area on the worksheet and select the relevant BMT device from the shortcut menu as shown in Figure 4-53.

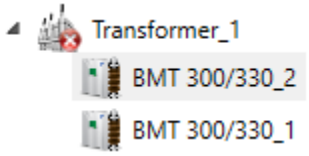


Figure 4-52: Asset Explorer

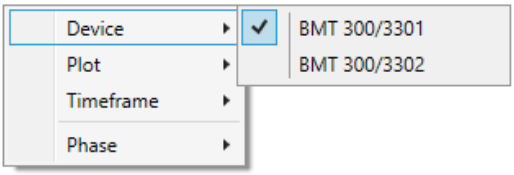


Figure 4-53: Shortcut menu to choose BMT device

4.18 Partial Discharge

This feature is available on all BMT devices and as an option on DGA 900 PLUS and DGA 900 MULTITRANS. The Partial Discharge worksheet renders polar plots displaying the statistical partial discharge parameters as measured by the device. The layout consists of three polar plots — one in a 'major' pane and two in 'minor' panes as shown in Figure 4-54.

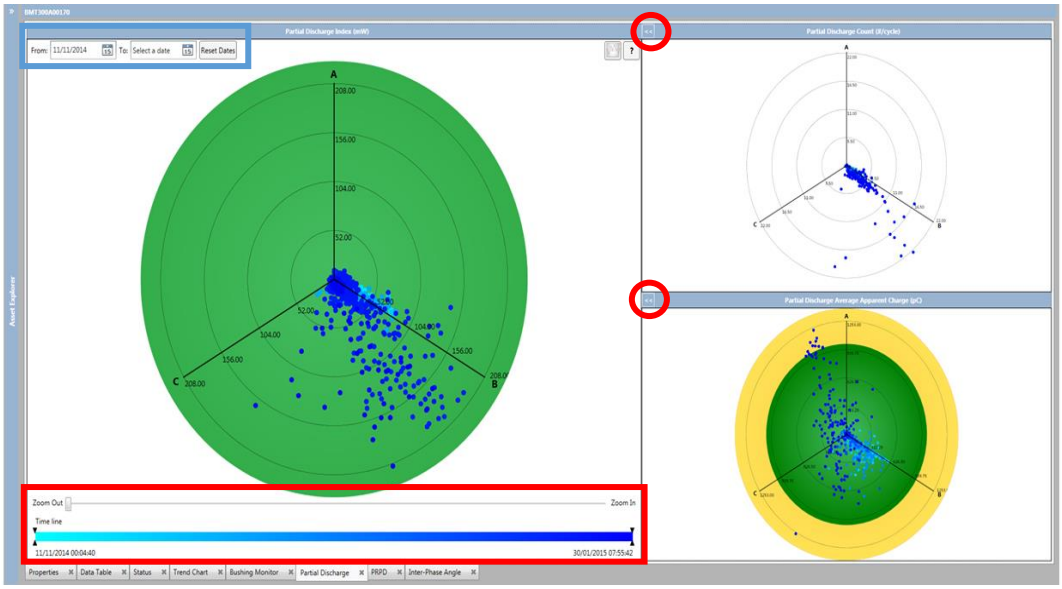


Figure 4-54: Partial Discharge polar plots

The three polar plots are as follows:

- Partial Discharge Count.
- Partial Discharge Index (PDI) – measured in mW.
- Partial Discharge Value – measured in picocoulombs (pC).

Rest the mouse pointer over any data point on the major polar plot to display a tooltip showing the data point information.

Right click inside the major pane for a shortcut menu to change the Plot to either Polar or Histogram view as shown in Figure 4-55.

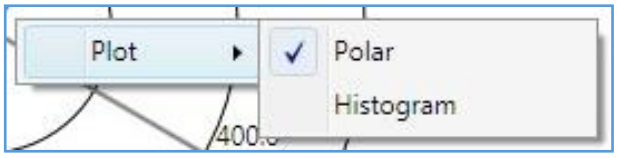


Figure 4-55: Partial Discharge graphing options

Either of the polar plots in the minor panes can be brought into focus by moving it to the major pane. Click the relevant 'double arrow' << button (denoted by the red circles on the top left corner of the minor panes in Figure 4-54) to move a minor polar plot to the major pane.

The worksheet offers similar controls to the Bushing Monitor polar plot to define the date range and zoom as described previously in Section 4.17.1.

Click the 'trend graph' button (left most on the major pane) to display a trend chart using the values with which the polar plot is built, an example of which is shown in Figure 4-57.

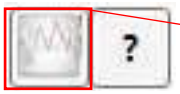


Figure 4-56: Toggle charts

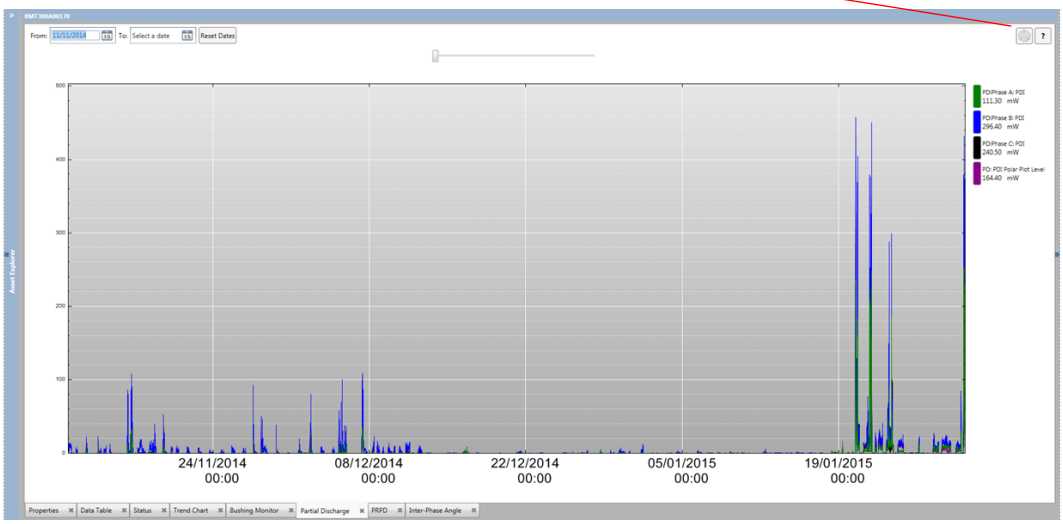


Figure 4-57: Partial Discharge trend chart

The device “High” and “High-High” alarms thresholds are plotted as amber and red lines respectively.

Click the ‘polar plot’ button as shown in Figure 4-58 to return to the polar plot view.

Figure 4-58: Return to Polar view

4.19 PRPD

This feature is available on Intellix BMT 330 devices, BMT 430 and as an option on DGA 900 PLUS and DGA 900 MULTITRANS. The PRPD polar plot visualises the Phase Resolved Partial Discharge data patterns (if available). The PRPD worksheet shows the PD pattern of a grid voltage cycle. This pattern can be used to analyse and potentially identify the PD sources. The PRPD tab is only available for the Intellix BMT 330, BMT 430 & DGA 900 PLUS devices. The worksheet displays PRPD data from the device on a standard 2-D chart, which can also be configured as a histogram.

Summary information as shown in Figure 4-63 and Figure 4-64 for the PRPD is displayed on the ‘PD event info’ panel (top right). If the 2D chart is active, the lower panel (‘Selected PD event’) lists the PRPD coordinates of the selected PD event (if selected); or the selected pixel density in the case of a histogram.

4.19.1 Display Controls

The worksheet offers similar controls e.g. to manipulate the date range as described previously in Sections 4.17 and 4.17.1.

Rest the mouse pointer on any data point (or pixel) to display a tooltip with the data point (or pixel) information.

Right-click inside the pane for a shortcut menu with several graphing options.

- The Plot option offers a choice of a 2D chart or Histogram as shown in Figure 4-59.

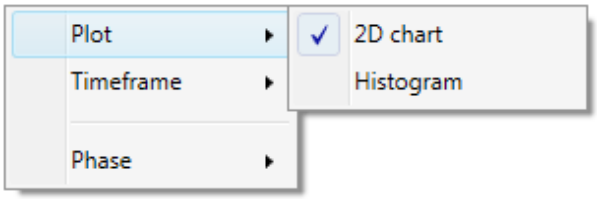


Figure 4-59: Plot shortcut menu

- The Timeframe option offers a choice of a single PRPD view (one record) or daily view as shown in Figure 4-60.

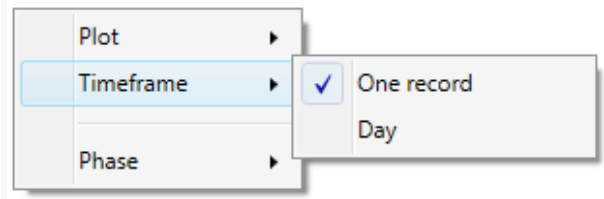


Figure 4-60: Appearance shortcut menu

- The Phase option offers a choice of phases A, B or C as shown in Figure 4-61.

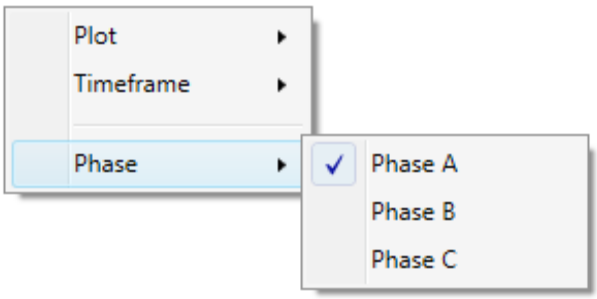


Figure 4-61: Phase shortcut menu

The **Zoom** slider controls the scale and allows you to zoom in and out of the PRPD. When zoomed in, it is possible to drag the PRPD to pan across the chart.

To set the PRPD vertical range and the histogram density range, double click the plot to open the PRPD Range dialog as shown in Figure 4-62.

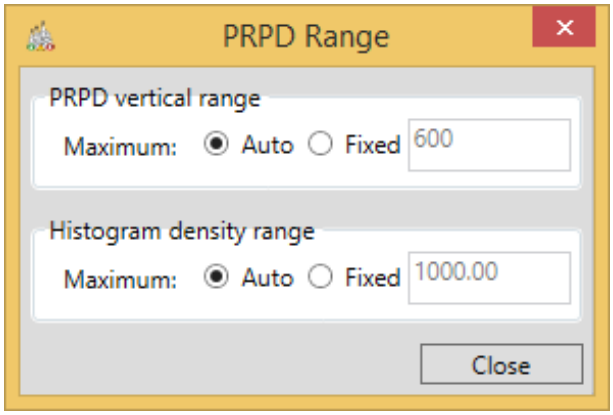


Figure 4-62: PRPD Range dialog

4.19.2 2D Chart

The standard 2D chart shown in Figure 4-63 plots the PD events as per the phase angle of the grid voltage in degrees (X-axis) and the apparent charge (pC) (Y-axis).

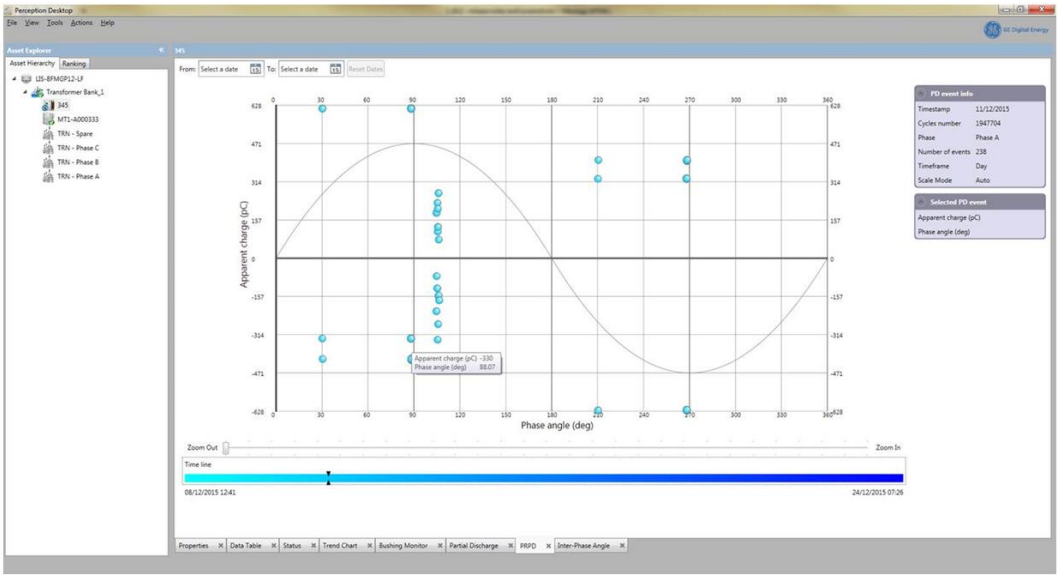


Figure 4-63: PRPD standard 2-D chart

4.19.3 Histogram

The histogram shown in Figure 4-64 uses the same axes as the 2D chart to plot the same data, but adds the PD event density as colour. The colour scheme for the histogram is shown in the legend at the bottom of Figure 4-64 where the density (the number of events per one thousand cycles) is depicted by a particular colour.

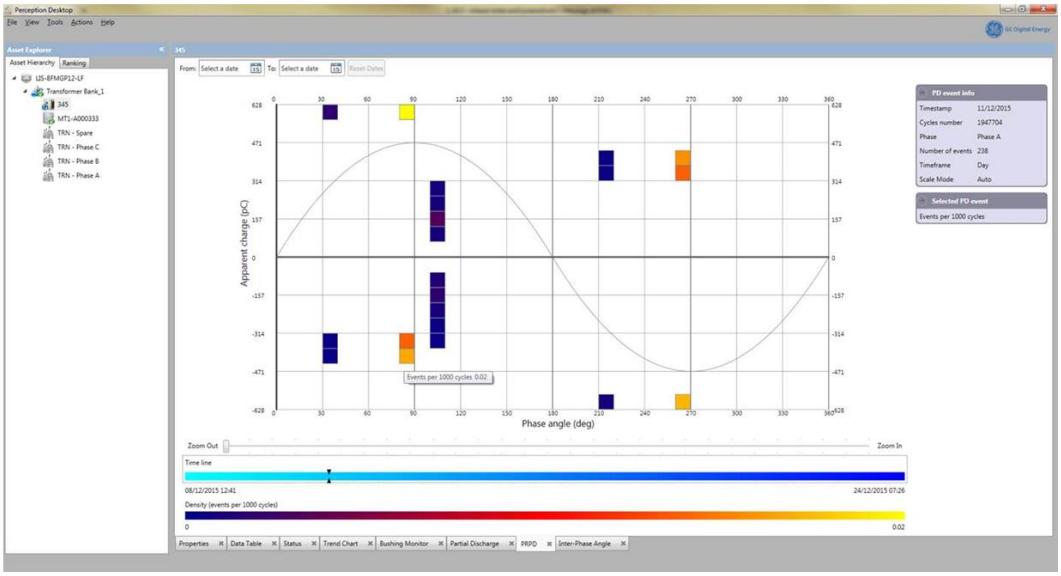


Figure 4-64: PRPD histogram

4.20 Inter-Phase Angle

This feature is available on all BMT devices and as an option on DGA 900 PLUS and DGA 900 MULTITRANS. The Inter-Phase Angle worksheet as shown in Figure 4-65 uses an Inter-Phase Angle plot to display the temporal evolution of angles, with the time increasing radially. The Inter-Phase Angle polar plot displays the measured angles in a more intuitive way than could otherwise be achieved with a trend chart. The worksheet displays the measured Angle A-B and Angle A-C against the expected respective angles. The Phase Angle Caution and Alarm limits as configured on the device are also shown.

Figure 4-65: Inter-Phase Angle

4.20.1 Display Controls

The worksheet offers similar controls e.g. to manipulate the date range as described previously in Sections 4.17 and 4.17.1.

Move the mouse pointer on the plot area and a tooltip displays the date and timestamp of the Marker Line, while the legend (top right) displays the angle values.

Right-click inside the pane for a shortcut menu with several graphing options.

The Bushings option offers a choice of Primary, Secondary or Tertiary Bushings as shown in

Figure 4-66.

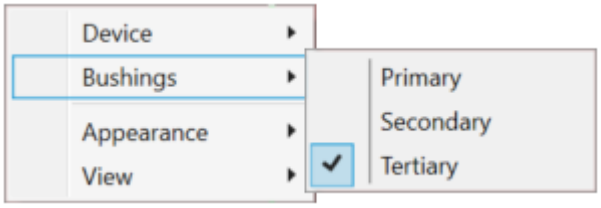


Figure 4-66: Bushings shortcut menu

- The Appearance option toggles the Marker Line On or Off as shown in Figure 4-67.

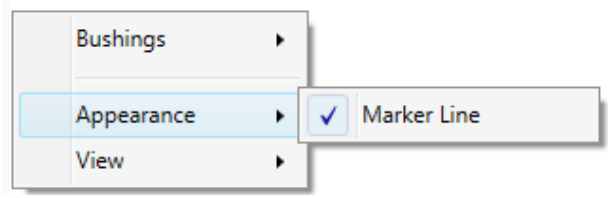


Figure 4-67: Appearance shortcut menu

- The View option toggles the Legend On or Off as shown in Figure 4-68.

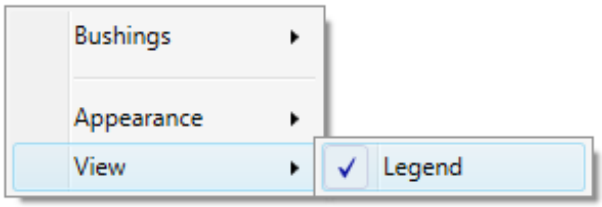


Figure 4-68: View shortcut menu

The Zoom slider allows you to change the magnification of the Inter-Phase Angle plot.

The Phase Angle Caution and Alarm limits are also available on the Data Table worksheet as shown in Figure 4-69. Rest the mouse pointer on any Angle point value to obtain a tooltip that includes phase angle caution and alarm limits.

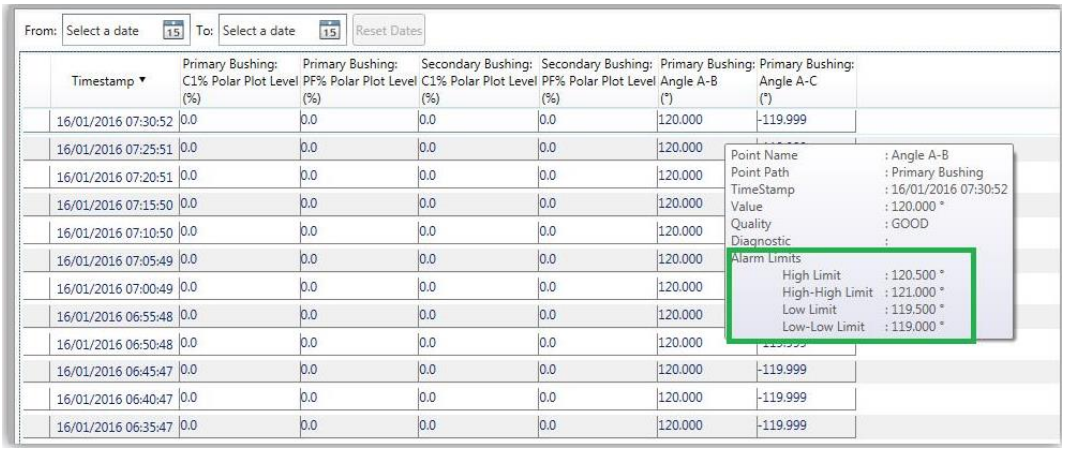


Figure 4-69: Data Table with Caution and Alarm limits tooltip

The Phase Angle Caution and Alarm limits are also available on the Status worksheet as shown in Figure 4-70.

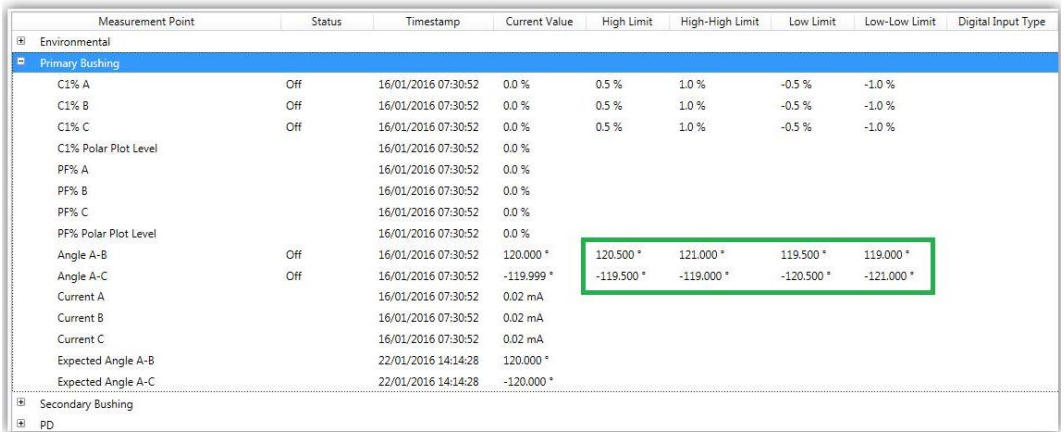


Figure 4-70: Status worksheet with Caution and Alarm limits

4.21 Web Browser

The Web Browser worksheet displays web content as rendered on the remote HMI of an MS 3000, CBWatch or DGA 900-family device. An example is shown in Figure 4-71.

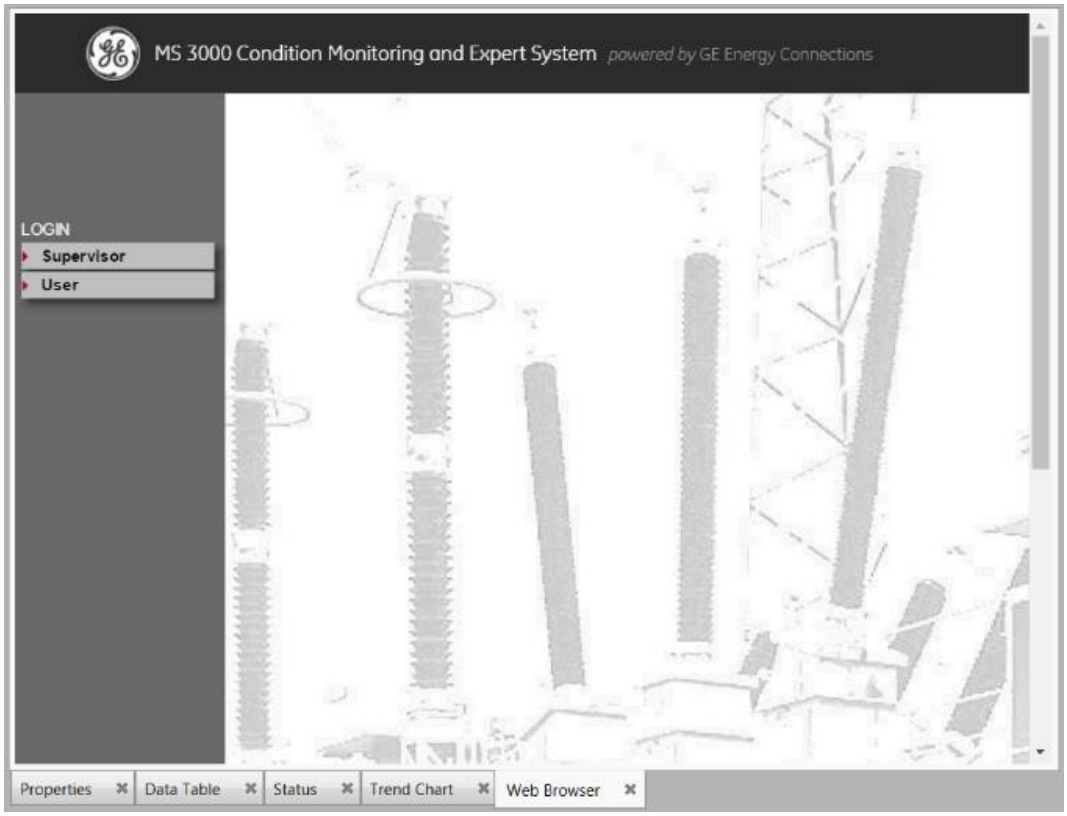


Figure 4-71: MS 3000 Log-in screen

The HMI uses an integrated frameless browser for interacting with the products. To open the web browser, click the tab or select the **Setup** context menu item from the appropriate asset in the Perception fleet tree (left pane). The web browser state is saved while navigating between worksheets of the same asset, but is reset after switching to another asset. To access web content, ensure that a valid Host name or IP address for the product is specified in the Communications section of the Properties worksheet as shown in Figure 4-72.

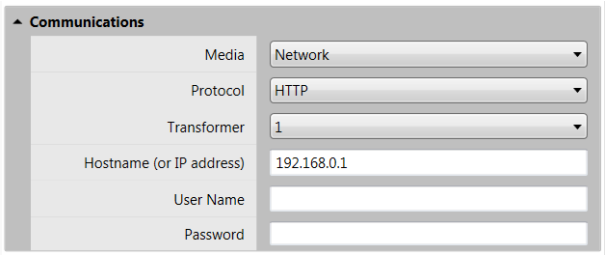


Figure 4-72: Properties – Communications – IP address

4.22 COMTRADE History

This feature is only available on CB Watch3, 845 and 869 Relays. The COMmon format for TRAnsient Data Exchange is a standard digital file format for recording transient fault data identified from sampling electrical characteristics and stored as a series of files. These files can be downloaded and stored within the Microsoft SQL Perception database. They can also be saved to a local location on the PC for later analysis to provide insight on the magnitude and effect of faults over time using third-party tools.

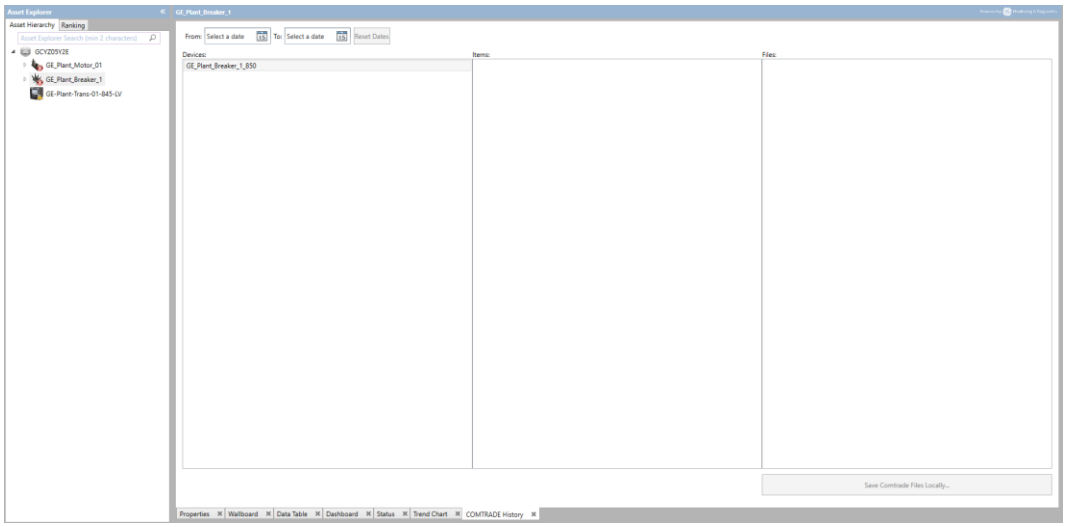


Figure 4-73: COMTRADE History

4.23 Breaker Trend Chart

This feature is only available on 869 Relay devices. The Breaker Trend Chart renders the breaker records retrieved from the 869 relay in a predefined way as shown in Figure 4-74.

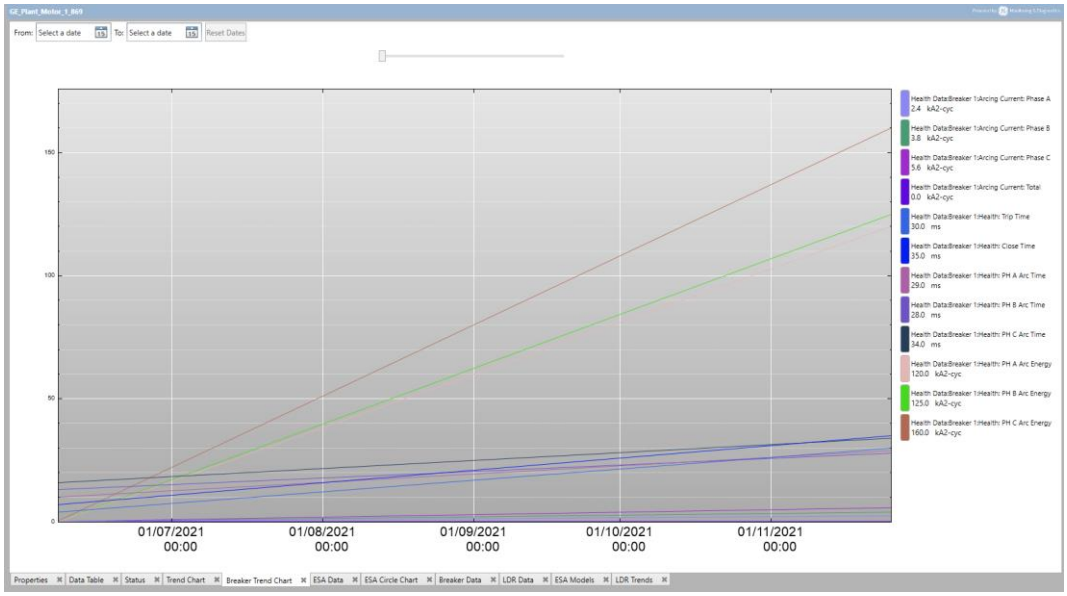


Figure 4-74: Breaker Trend Chart

Event data is represented on the chart as solid vertical lines to correlate with breaker data. This includes breaker arcing parameters and breaker health records. The resulting trend chart plots the available historical data in accordance with the custom selected date/time range. See Section 4.4 for details on the controls to manipulate trend charts.

4.24 ESA Data

This feature is only available on 869 Relay devices. ESA (Electrical Signature Analysis) is the monitoring of stator current or voltage in a rotating machine. Various electrical and mechanical fault conditions can cause a modulation of the current and/or voltage signal. Proven ESA algorithms are implemented in the 8 Series relays to detect mechanical abnormalities in the motor and this 'signature' allows motor faults, such as a broken rotor bar, bearing failure, static & dynamic eccentricity, foundation looseness and misalignments to be identified early and their severity assessed.

The ESA Data table lists the raw electrical signature analysis data retrieved from the 869 relay in a predefined way as shown in Figure 4-75.

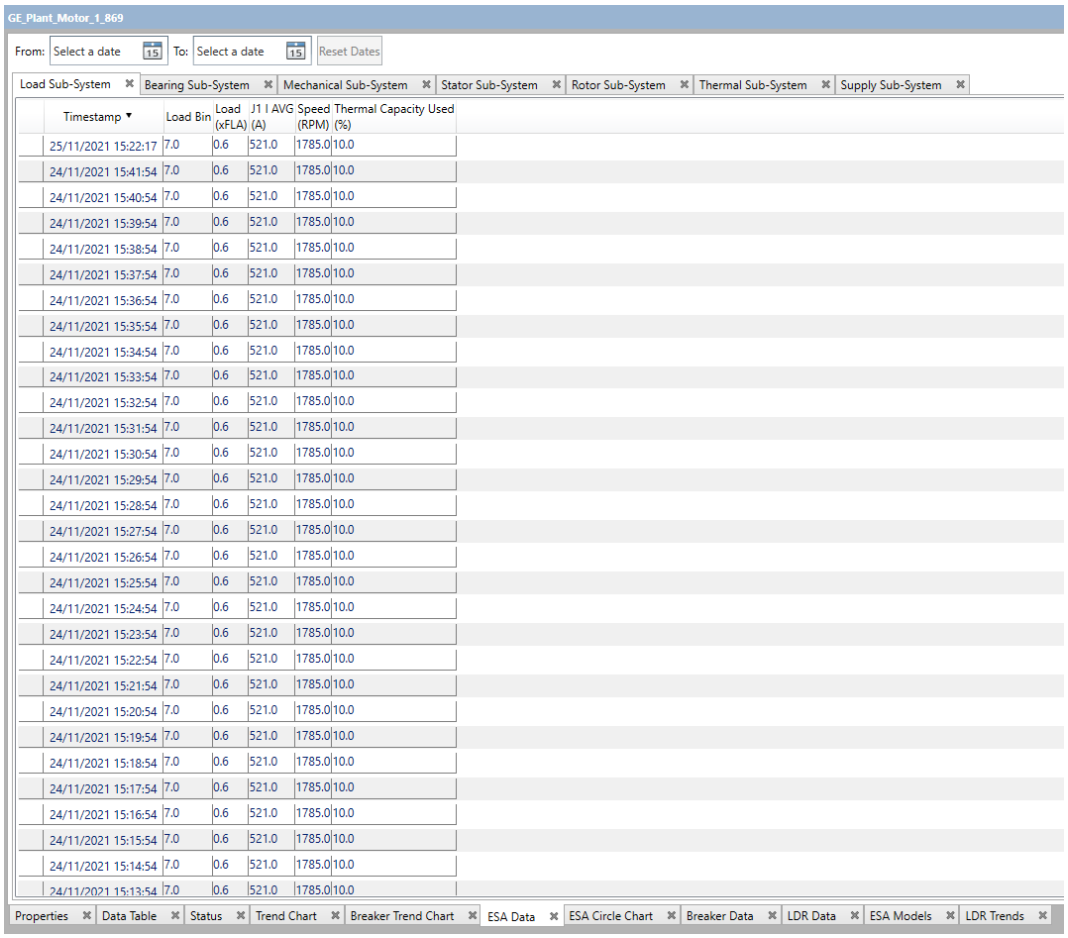


Figure 4-75: ESA Data

Data is grouped across a series of subtabs with timestamps to represent the various subassemblies of the machine being monitored – Load-Sub-System,

Bearing Sub-System, Mechanical Sub-System, Stator Sub-System, Rotor Sub-System, Thermal Sub-System and Supply Sub-System.

4.25 ESA Circle Chart

This feature is only available on 869 Relay devices. The ESA Circle Chart is a fault diagnostic tool that plots the last fifty historical data records retrieved from the 869 relay in a circle format as shown in Figure 4-76.

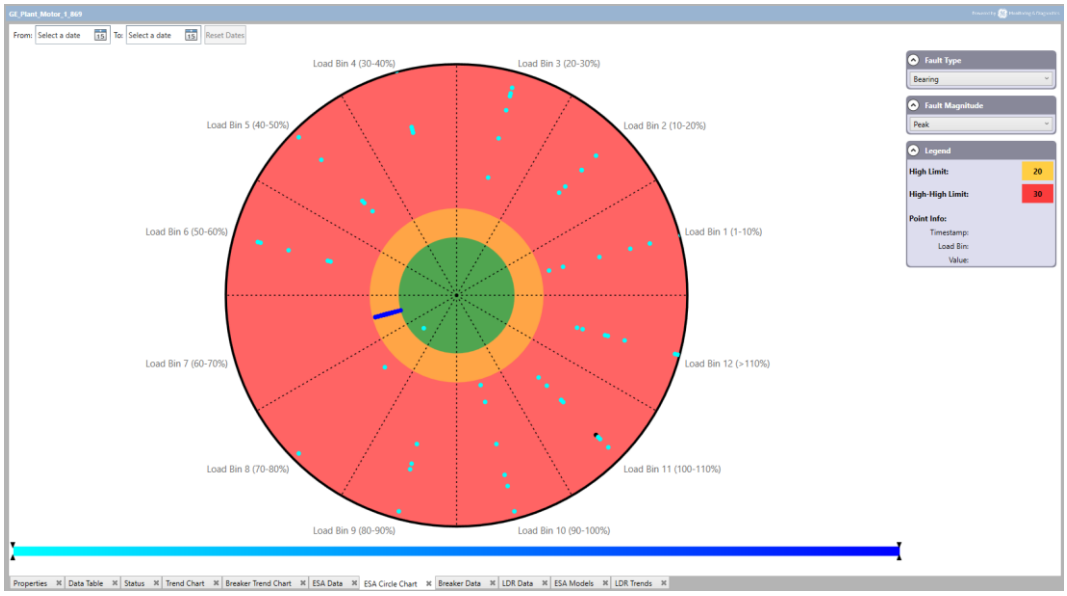


Figure 4-76: ESA Circle Chart

This is a useful visualization aid as to the motor status (normal, caution or alarm). The ESA circle is divided into twelve load bins with concentric circles to show if a historical record is within a baseline or has breached an alarm level set on the 869 relay. This can be used to identify mechanical, bearing and stator faults. Refer to the 869 Motor Protection System – Instruction Manual for more details.

4.26 Breaker Data

This feature is only available on 869 Relay devices. The Breaker Data table lists the breaker records from the 869 relay in a predefined data table as shown in Figure 4-77.

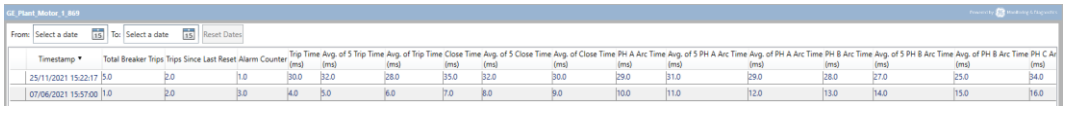
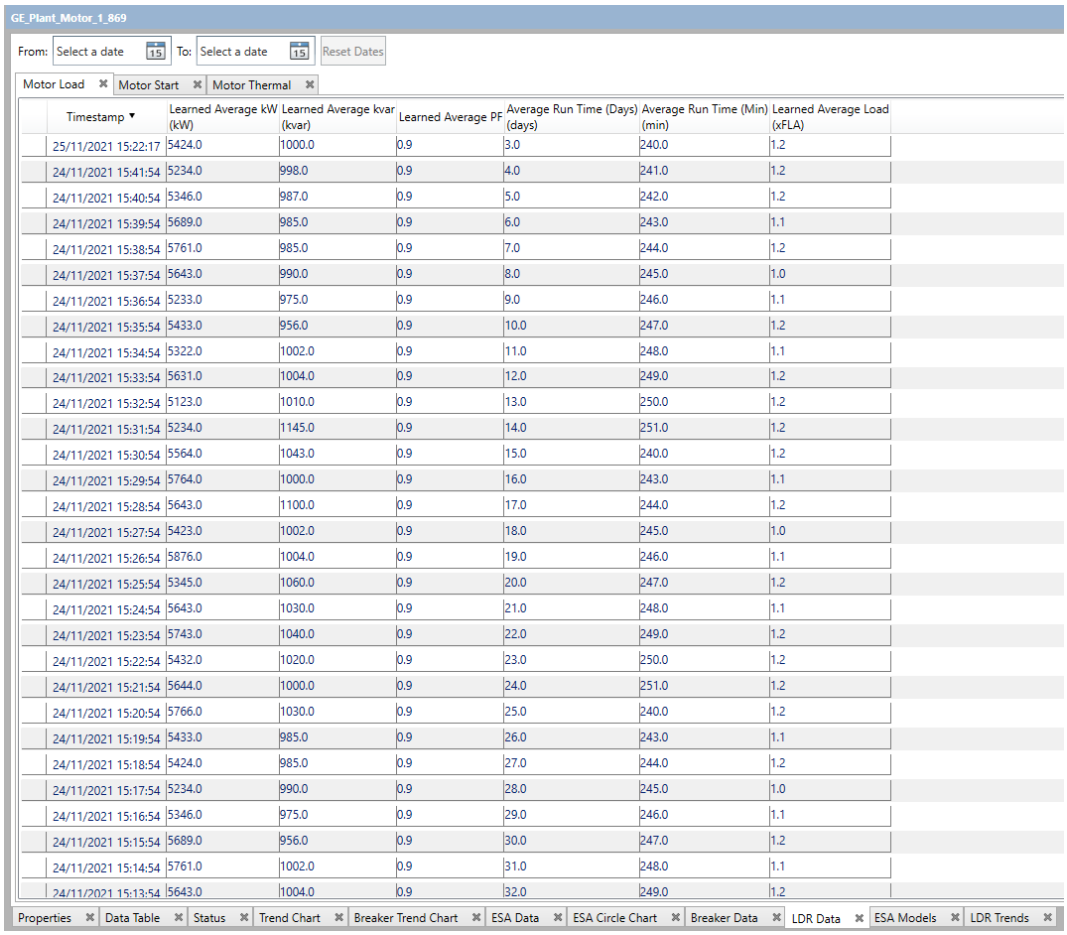


Figure 4-77: Breaker Data

The breaker records include the breaker arcing parameters and breaker health records. Refer to the 869 Motor Protection System – Instruction Manual for more details.

4.27 LDR Data

This feature is only available on 869 Relay devices. The Learned Data Recorder (LDR) Data table lists the learned data records retrieved from the 869 relay as shown in Figure 4-78.



Timestamp	Learned Average kW (kW)	Learned Average kvar (kvar)	Learned Average PF	Average Run Time (Days) (days)	Average Run Time (Min) (min)	Learned Average Load (xFLA)
25/11/2021 15:22:17	5424.0	1000.0	0.9	3.0	240.0	1.2
24/11/2021 15:41:54	5234.0	998.0	0.9	4.0	241.0	1.2
24/11/2021 15:40:54	5346.0	987.0	0.9	5.0	242.0	1.2
24/11/2021 15:39:54	5689.0	985.0	0.9	6.0	243.0	1.1
24/11/2021 15:38:54	5761.0	985.0	0.9	7.0	244.0	1.2
24/11/2021 15:37:54	5643.0	990.0	0.9	8.0	245.0	1.0
24/11/2021 15:36:54	5233.0	975.0	0.9	9.0	246.0	1.1
24/11/2021 15:35:54	5433.0	956.0	0.9	10.0	247.0	1.2
24/11/2021 15:34:54	5322.0	1002.0	0.9	11.0	248.0	1.1
24/11/2021 15:33:54	5631.0	1004.0	0.9	12.0	249.0	1.2
24/11/2021 15:32:54	5123.0	1010.0	0.9	13.0	250.0	1.2
24/11/2021 15:31:54	5234.0	1145.0	0.9	14.0	251.0	1.2
24/11/2021 15:30:54	5564.0	1043.0	0.9	15.0	240.0	1.2
24/11/2021 15:29:54	5764.0	1000.0	0.9	16.0	243.0	1.1
24/11/2021 15:28:54	5643.0	1100.0	0.9	17.0	244.0	1.2
24/11/2021 15:27:54	5423.0	1002.0	0.9	18.0	245.0	1.0
24/11/2021 15:26:54	5876.0	1004.0	0.9	19.0	246.0	1.1
24/11/2021 15:25:54	5345.0	1060.0	0.9	20.0	247.0	1.2
24/11/2021 15:24:54	5643.0	1030.0	0.9	21.0	248.0	1.1
24/11/2021 15:23:54	5743.0	1040.0	0.9	22.0	249.0	1.2
24/11/2021 15:22:54	5432.0	1020.0	0.9	23.0	250.0	1.2
24/11/2021 15:21:54	5644.0	1000.0	0.9	24.0	251.0	1.2
24/11/2021 15:20:54	5766.0	1030.0	0.9	25.0	240.0	1.2
24/11/2021 15:19:54	5433.0	985.0	0.9	26.0	243.0	1.1
24/11/2021 15:18:54	5424.0	985.0	0.9	27.0	244.0	1.2
24/11/2021 15:17:54	5234.0	990.0	0.9	28.0	245.0	1.0
24/11/2021 15:16:54	5346.0	975.0	0.9	29.0	246.0	1.1
24/11/2021 15:15:54	5689.0	956.0	0.9	30.0	247.0	1.2
24/11/2021 15:14:54	5761.0	1002.0	0.9	31.0	248.0	1.1
24/11/2021 15:13:54	5643.0	1004.0	0.9	32.0	249.0	1.2

Figure 4-78: Breaker Data

The Learned Data Recorder measures operational parameters and records up to 250 data record 'sets' from the actual motor operation. LDR Data is grouped across three tabbed pages – **Motor Load**, **Motor Start** and **Motor Thermal**. This data is used to identify changes to key motor operations and evaluate those trends over time. Refer to the 869 Motor Protection System – Instruction Manual for more details.

4.28 ESA Models

This feature is only available on 869 Relay devices. The Electrical Signature Analysis (ESA) Models tabbed page presents a series of sub-system models using a combination of predefined graphical gauges and trend charts as shown in Figure 4-79.

This data is grouped using a series of subtabs – **Load**, **Supply**, **Thermal**, **Bearing**, **Mechanical**, **Stator** and **Rotor**.

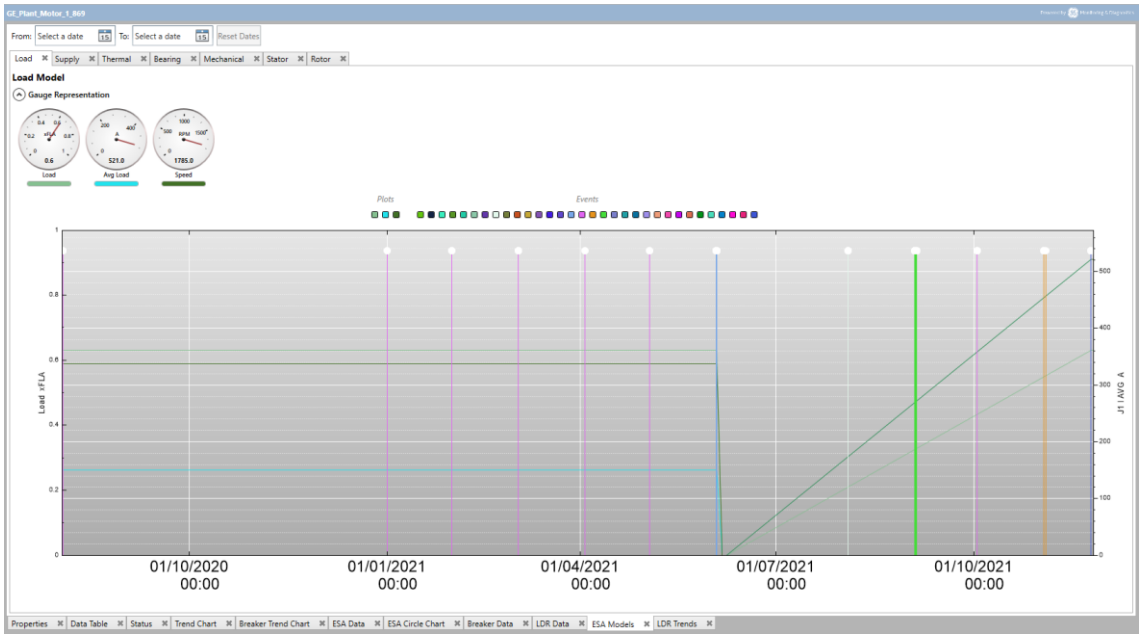


Figure 4-79: ESA Models

ESA trend charts plot the available historical data according to the custom selected date/time range. Event data is represented on the chart as solid vertical lines to correlate with ESA data. See Section 4.4 for details on the controls to manipulate trend charts.

4.29 LDR Trends

This feature is only available on 869 Relay devices. The Learned Data Records (LDR) Trends tabbed page presents a series of sub-system models using a combination of predefined graphical gauges and trend charts as shown in Figure 4-80.

This data is grouped using a series of subtabs – **Motor Start**, **Motor Electrical** and **Motor Thermal**.

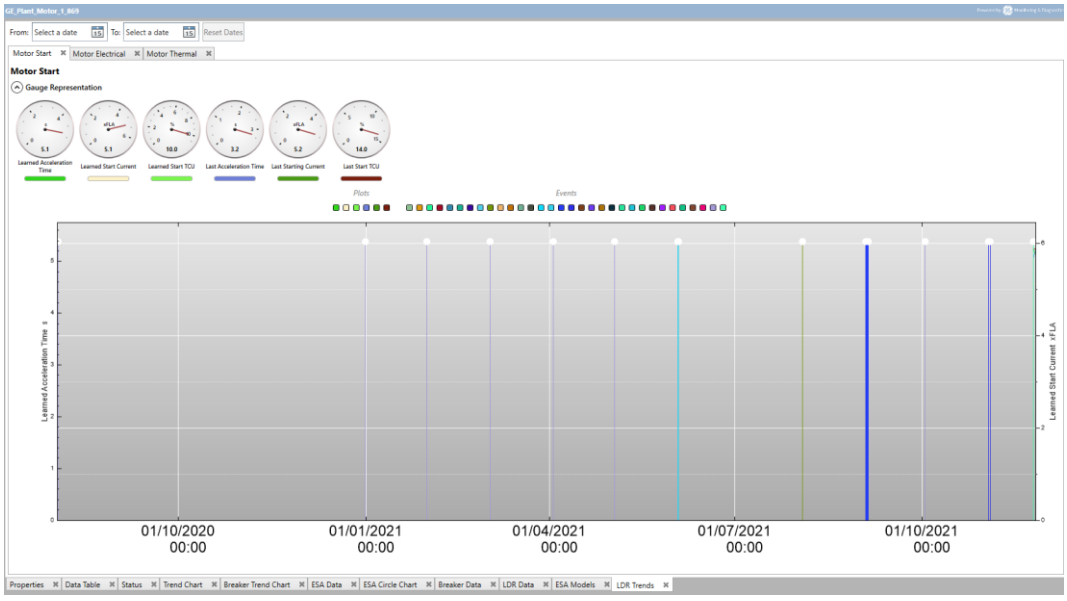


Figure 4-80: LDR Trends

LDR Trends plot the available historical data according to the custom selected date/time range. Event data is represented on the chart as solid vertical lines to correlate with LDR data. See Section 4.4 for details on the controls to manipulate trend charts.

5 OTHER TOOLS & FUNCTIONALITY

5.1 Downloading Data...

5.1.1 ...Via Perception

To download data from a device, right click on the device in the Asset Explorer and select **Download** as shown in Figure 5-1. This starts the manual download. The device node in the Asset Explorer gains a spinning blue icon to show that the download is in progress.

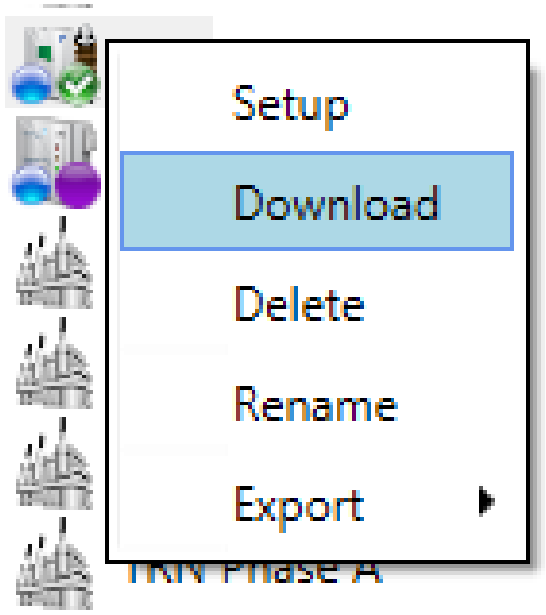


Figure 5-1: Download

If the Properties worksheet is open, the progress bar in the Device Connection section will show the download progress as shown in Figure 5-2.

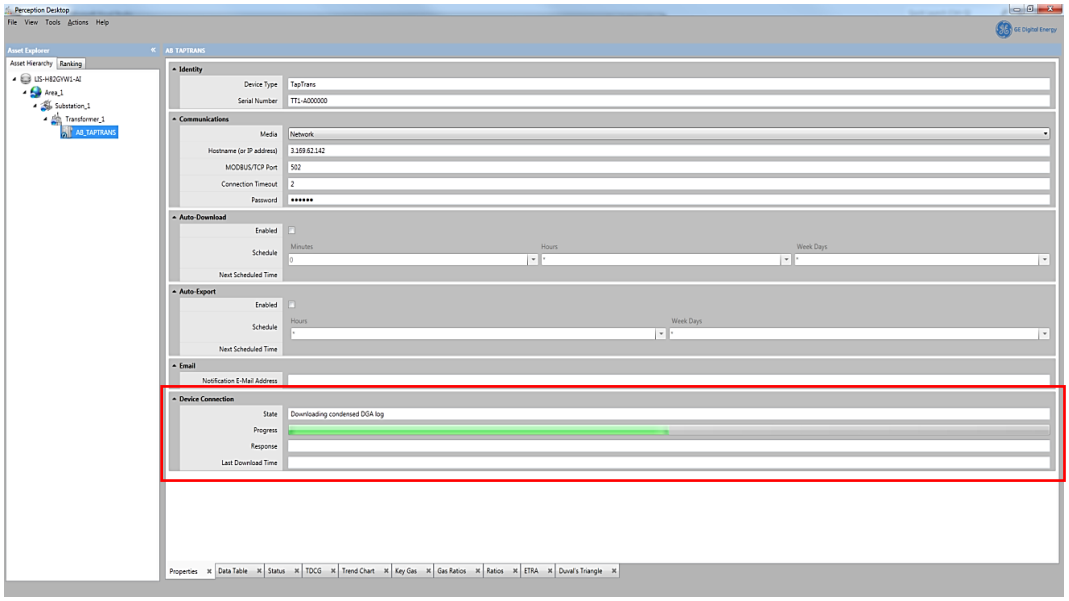


Figure 5-2: Download progress

To cancel the download, right click on the device and select **Cancel Download** as shown in Figure 5-3.

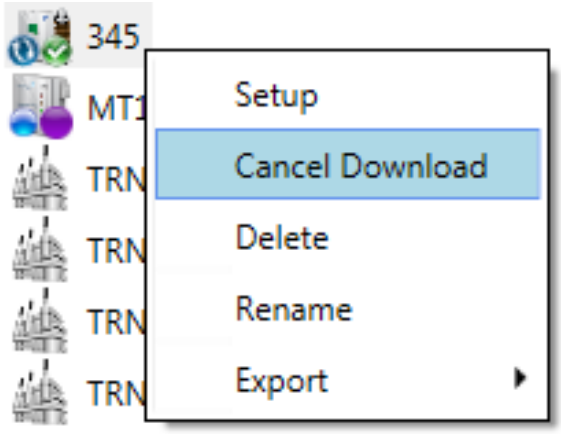


Figure 5-3: Cancel Download

When used in conjunction with Perception Server, the download of data can also be scheduled to occur automatically (see Section 3.9.5.3). Note: Data can also be manually downloaded during scheduled download intervals.

5.1.2 ...Via USB

Data download from a Transfix device using the USB communications support must be performed via the TransConnect application as shown in Figure 5-4.

Note: The TransConnect application is automatically installed with Perception Desktop. The default location is 'Programs/GE Energy'.

The steps are as follows:

- Close Perception Desktop.
- Select **Start > All Programs > GE Energy > Perception > TransConnect** to open the TransConnect application.

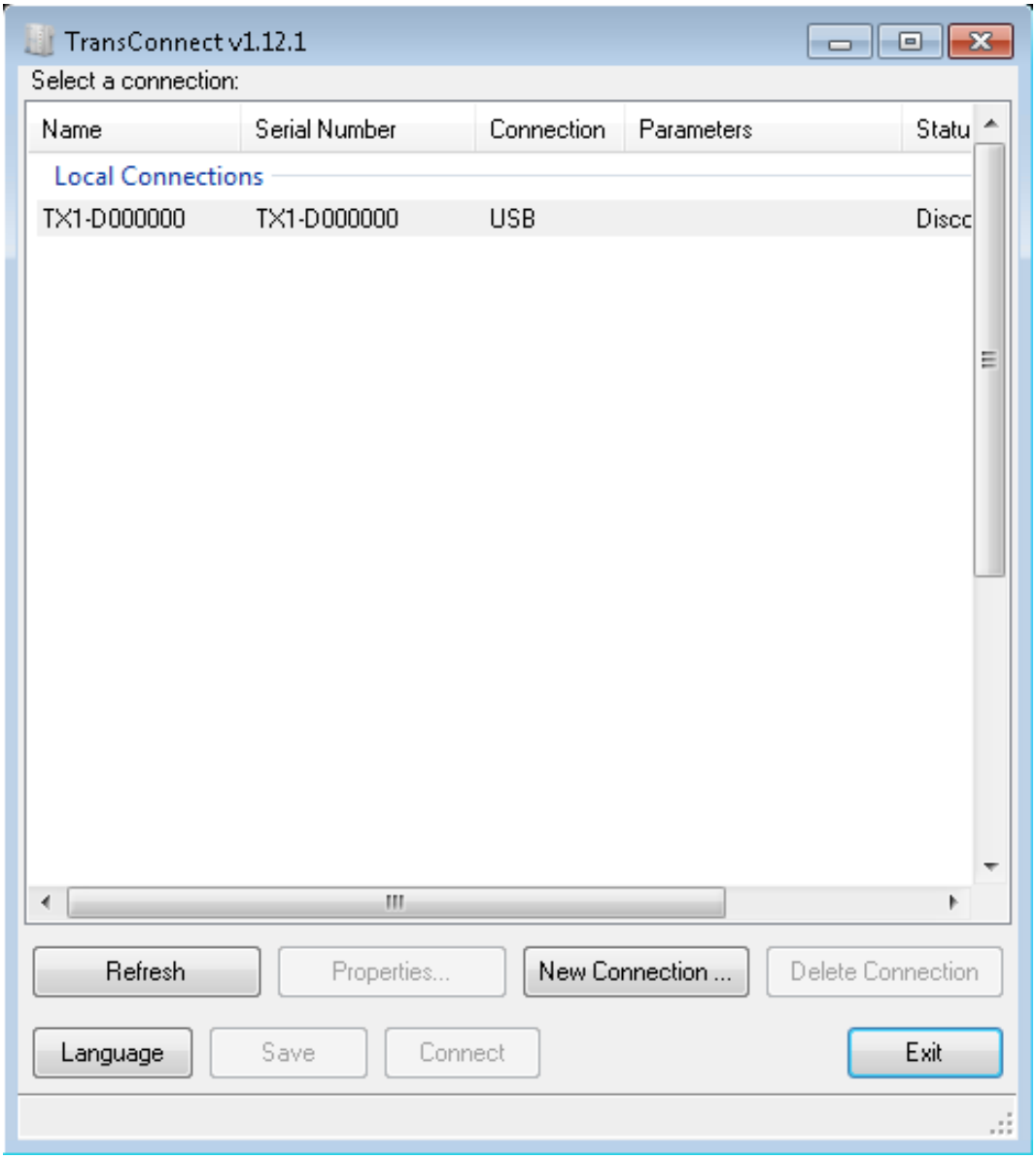


Figure 5-4: TransConnect

- Connect your PC to the Transfix via a USB port.
- The Transfix device should be listed under Local Connections. Select this device, connect to it and then choose the option to download the latest records.

Note: The data is stored in a temporary folder called “FileWatcher”.

- Exit the TransConnect application.

Upon next starting Perception Desktop, the downloaded data will be automatically imported from the FileWatcher folder to the database that Perception Desktop is connected to on launch.

Note: If you have a copy of Perception Express on your PC and launch that before Perception Desktop, then the downloaded data will be imported to the Perception Express database. Since Perception Desktop already includes all the features of Perception Express, it is

recommended that any prior copies of Perception Express be removed.

5.2 Exporting and Importing Data

Perception provides several options for configuring the export and import of data using a CSV file. This includes alarm information for all device types, measurement diagnostics and quality status information. In addition, the Perception Server Configuration tool allows you to define any custom CSV format. However, Perception recognises three CSV formats out of the box:

- Perception
- TransConnect
- TOA4

5.2.1 Export

You can export assets (transformers and/or devices) to a Perception format standalone CSV file at the database, parent or device-node level. This is useful if you want to copy data to another system to perform, for example, custom analysis. Other export options are listed in Table 5-1.

Table 5-1: Export options

Properties	Export all the attributes specified on the Properties page along with the corresponding asset hierarchy.
Measurements	Export device measurement data plus the corresponding asset hierarchy only. 'Uncertain' and 'Bad data' are attributed with diagnostic information for each data point. Uncertain data values are appended with '**!U**'. Bad data values are appended with '**!B**'.
Ranking History	Export the ranking history data as described in Section 3.11.
All Data	Export everything – all the Properties, Measurements and Alarms as defined above.

Right click the asset in the Asset Hierarchy or select **Actions** > **Export** to see the available export options as shown in Figure 5-5. Select an option e.g. **All Data**.

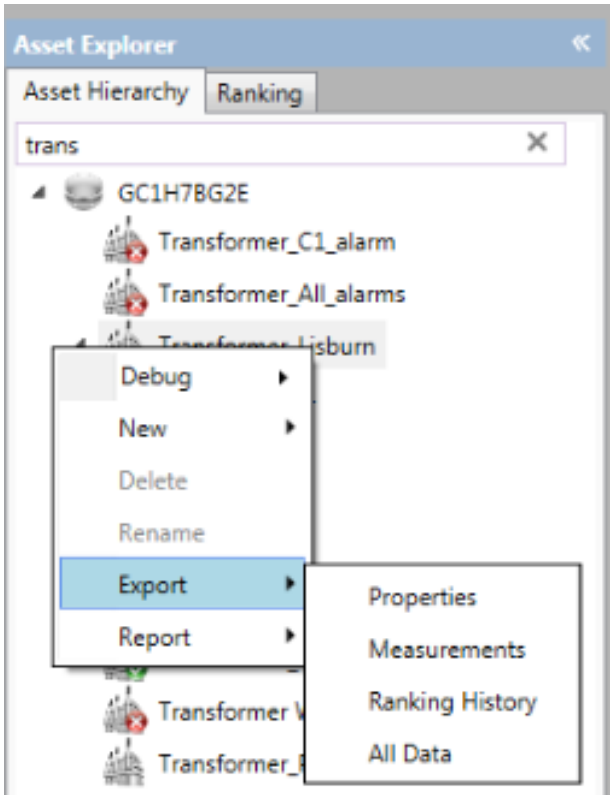


Figure 5-5: Export options

The 'Save Exported File As' dialog as shown in Figure 5-6 allows you to save the data to a Perception format CSV data file. To do this, navigate to a suitable location, specify a name for the CSV file or select an existing file to overwrite, and then click **Save** to export the data using this format.

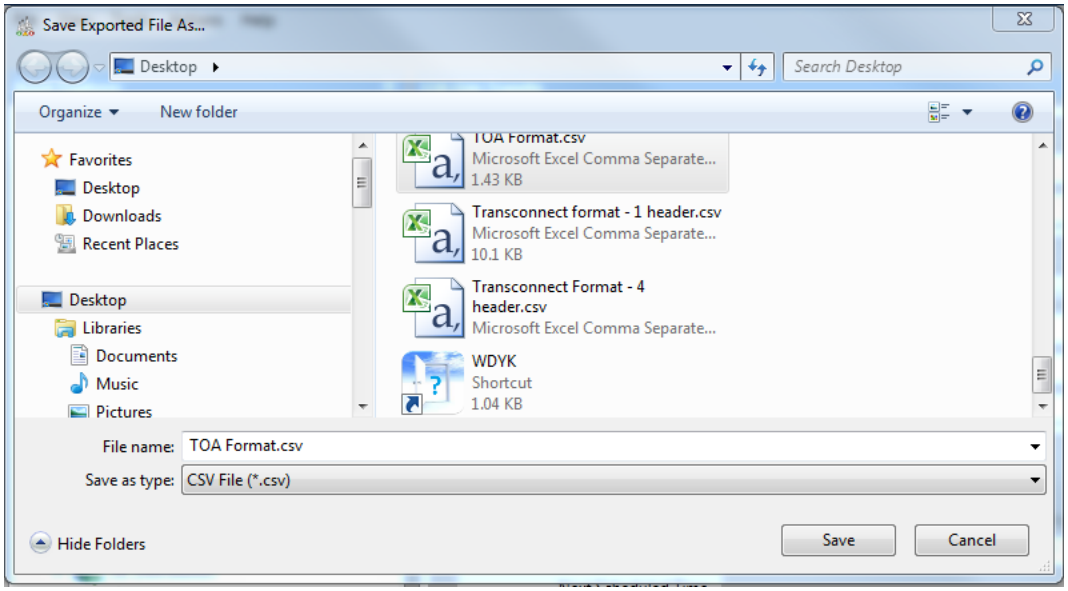


Figure 5-6: Save as a CSV file

The parent-child relationship depicted in the Asset Hierarchy is also included as part of every export. During an import, this allows assets to be recreated on the recipient machine in the same structured way as the source machine. The metadata for the hierarchy of assets is represented in the CSV file in the following way: A parent column is created in the CSV file and that is used to

store the value of the parent node against each asset value in the 'Equipnum' column. If there is no parent node for an asset, then the value of the parent column is left blank against the respective asset value. On import, this asset will be created at the highest level in the asset hierarchy i.e. directly under the database node.

5.2.2 Import

You can import assets (transformers and/or devices) from a CSV file that adheres to one of the formats listed in Section 5.1. The CSV file may include asset properties, device measurement data, ranking history and the corresponding asset hierarchy, depending on the options chosen at the time of export.

In Perception Desktop, select **Actions** > **Import** > **Import File...** as shown in Figure 5-7.

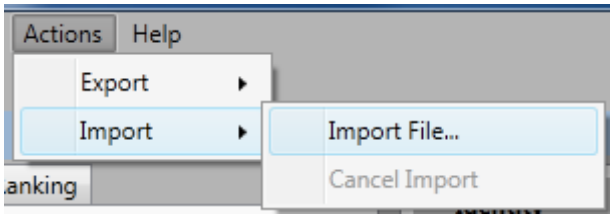


Figure 5-7: Import a file

The Open dialog allows you to select a CSV file. Click **Open** to import the contents of the file to the database as shown in Figure 5-8.

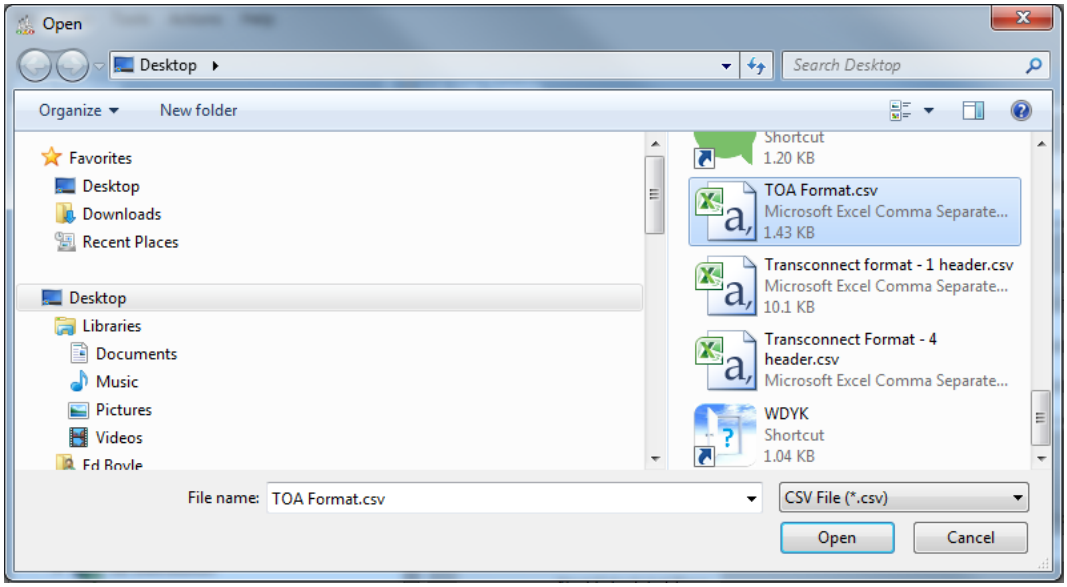


Figure 5-8: Open a CSV file

A progress bar is displayed during the import. The diagnostic information that accompanies 'Uncertain' and 'Bad data' is also included as part of the import, along with the metadata to reconstruct the parent-child node structure in the Asset Explorer.

Note: The import may take several minutes (depending on the size of the file) during which time you cannot manipulate the asset hierarchy.

Note: Alarms are also imported, including those from Transport X units that use firmware v1.12.6.567 or later.

Note: Nameplate information that is imported to the database is not time stamped. If a TOA file contains several rows of nameplate information for one device, only the first row for each compartment is imported. See Section 3.9.1.

If the data values of the following fields in the CSV file match all the asset attributes on the Properties pages, then the asset already exists in the database and is updated accordingly with any new data from the CSV file. These fields are:

- *Equipnum*: the name of the transformer
- *Serialnum*: the serial number of the transformer
- *Apprtype*: device type (TRN for transformer)

If any one of the fields does not match, then the asset is considered to be new. A new asset node will then be created in the Asset Hierarchy at the desired level as per the data value listed in the parent column of the CSV file for the asset. The position of new assets can be rearranged as required. See Section 3.2.4.

The import summary dialog is displayed, and if the import is problematic, it will also include a link to the corresponding log file. The log file records details of the import including any errors and is saved in the same location as the imported CSV file.

5.3 Downloading Service Logs

Service and factory logs can be downloaded from some devices, either remotely over a network, or directly from a Transfix via a USB connection. To configure the download, use the menu option **Tools > Download Service Logs...**. Note: You can also right click the device to access a shortcut menu option.

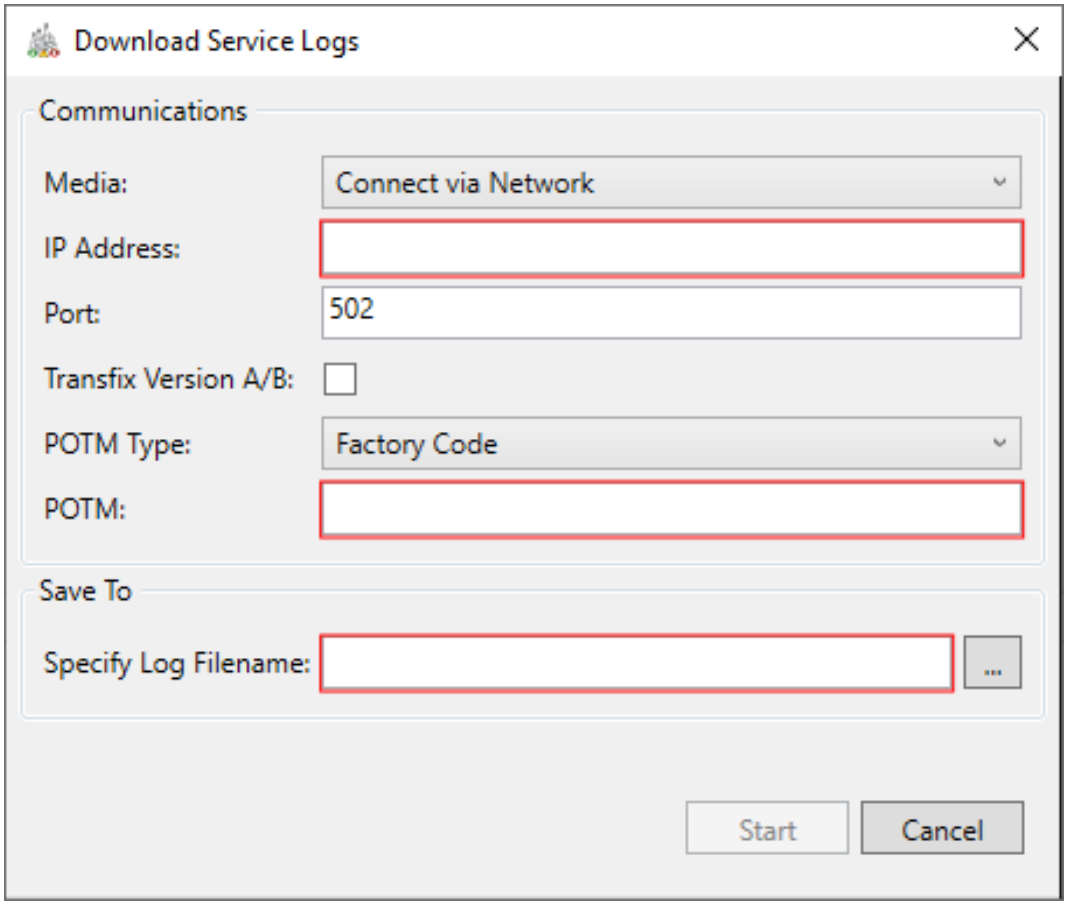


Figure 5-9: Download Service Logs - Network

The Media field defaults to a Network source as shown in Figure 5-9. For a network source, you must supply the IP address and enter the secure POTM code. To obtain the POTM code, please contact GE. Finally, enter the destination folder on your PC or use the Browse (...) button to navigate to the destination folder.

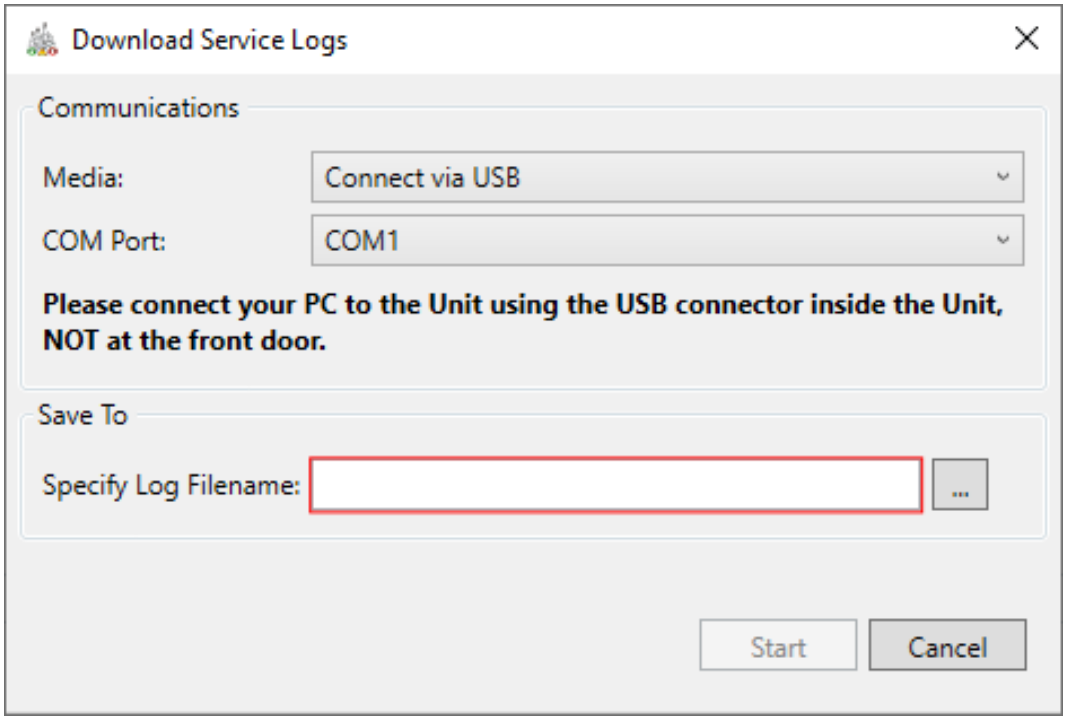


Figure 5-10: Download Service Logs - USB

If you are onsite at the Transfix, select **USB** in the Media field. The dialog changes to reflect the setup as shown in Figure 5-10. For a USB direct connection, you need only supply the destination folder on your laptop.

Note: You must use the USB port inside the Transfix (located behind the Control panel).

This resulting file can then be sent to GE for analysis.

5.4 Data Viewing Options

Select **Tools** > **Options** > **View** to examine a couple of options for viewing the data as shown in Figure 5-11.

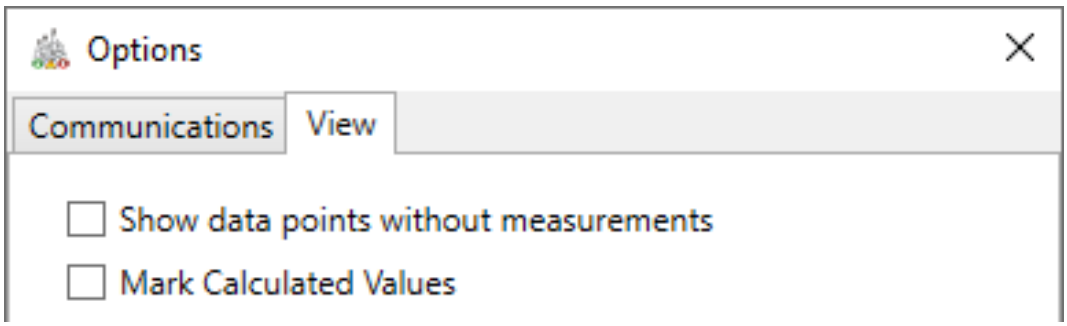


Figure 5-11: Tools > Options > View

- *Show data points without measurements*: By default, any data points without measurement values are excluded to aid the identification of trends and ensure a smooth plot. To include these data points irrespective of their null values, select **Show data points without measurements**.
- *Mark Calculated Values*: Select **Mark Calculated Values** to identify all values that result from a calculation of other measurements. By default, this option

is not selected since many values are obviously calculations e.g. TDCG, but not all are obvious, so it may on occasion be useful to explicitly identify them. For example, the nitrogen value comes not from a direct nitrogen measurement, but a calculation using other directly measured parameters. Calculated values are marked with an asterix '*' at the end of the display name e.g. Nitrogen*.

5.5 Transformer Report

The Transformer Report is a multi-page report that contains key overview details of the transformer using Perception-based data.

Note: The report is generated as a Microsoft Word document and can be found in the Documents folder of the local machine.

To generate the report, right click on a Transformer asset in the asset tree as shown in Figure 5-12.

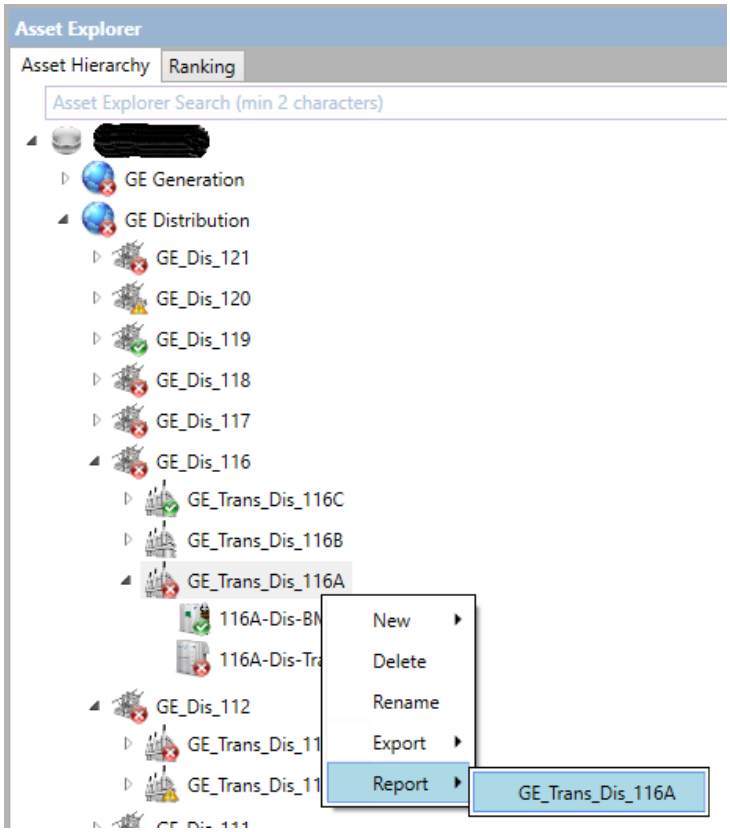


Figure 5-12: Transformer Status report context menu

The **Report** option lists the selected transformer with any qualifying child assets below. Select an asset to launch the Report Configuration Wizard as shown in Figure 5-13.

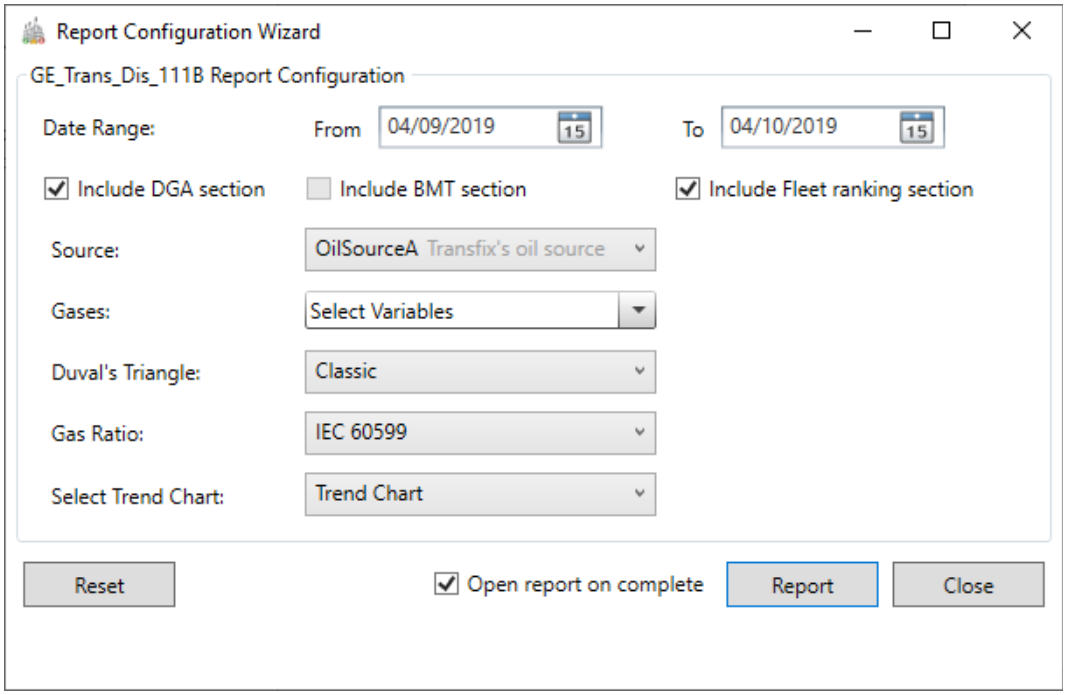


Figure 5-13: Report Configuration Wizard

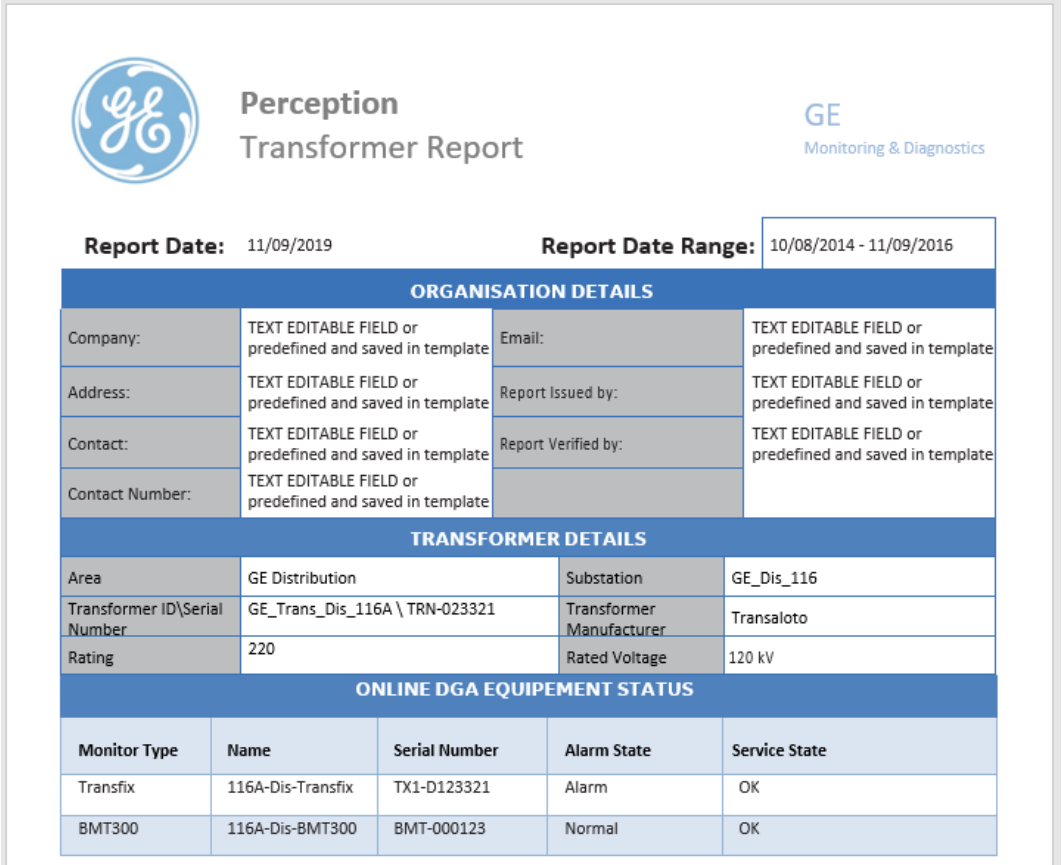
The Report Configuration Wizard allows the report content to be customized as follows:

- The **Date Range** sets the range of dates that the report will span.
- The **Include section** – choose from **DGA**, **BMT** and **Fleet ranking**.
- The **Source** dropdown allows you to select the relevant oil source.
- The **Gases** dropdown allows you to select multiple variables.
- The **Duval's Triangle** dropdown allows you to select which of the six Duval's diagnostics options to display on the report.
- The **Gas Ratio** dropdown allows you to select which of the two gas ratio diagnostics to display on the report.

Note: The diagnostic information provided by the Gas Ratio is displayed on the report (above the conclusion). However, the Gas Ratio diagram is not displayed.

- The **Select Trend Chart** dropdown contains a list of the trend charts available for the report. If you have multiple trend charts in the device workbook area, these will appear here. You can choose to use one of the predefined trend charts or you can create a custom trend chart. To create a custom trend chart, select from the available variables to display as shown in Figure 5-13.
- The **Reset** button resets all options back to the default settings.
- The **Report** button generates the report on the local machine and the adjacent checkbox opens the report on completion.

A sample first page of the Transformer report is shown in Figure 5-14.



Perception
Transformer Report

GE
Monitoring & Diagnostics

Report Date: 11/09/2019 **Report Date Range:** 10/08/2014 - 11/09/2016

ORGANISATION DETAILS			
Company:	TEXT EDITABLE FIELD or predefined and saved in template	Email:	TEXT EDITABLE FIELD or predefined and saved in template
Address:	TEXT EDITABLE FIELD or predefined and saved in template	Report Issued by:	TEXT EDITABLE FIELD or predefined and saved in template
Contact:	TEXT EDITABLE FIELD or predefined and saved in template	Report Verified by:	TEXT EDITABLE FIELD or predefined and saved in template
Contact Number:	TEXT EDITABLE FIELD or predefined and saved in template		

TRANSFORMER DETAILS			
Area	GE Distribution	Substation	GE_Dis_116
Transformer ID\Serial Number	GE_Trans_Dis_116A \ TRN-023321	Transformer Manufacturer	Transaloto
Rating	220	Rated Voltage	120 kV

ONLINE DGA EQUIPEMENT STATUS				
Monitor Type	**Name**	**Serial Number**	**Alarm State**	**Service State**
Transfix	116A-Dis-Transfix	TX1-D123321	Alarm	OK
BMT300	116A-Dis-BMT300	BMT-000123	Normal	OK

Figure 5-14: Transformer Status Report

The first pages contain the:

- Report Date and Date Range of the data contained in the report
- Organisation Details
- Transformer Details
- List of online DGA equipment and Status (in alarm or not)

The following pages lists the DGA alarm information for each Source. The report also contains three free-text entry boxes – Introduction, Summary and Conclusion, which the user can populate before printing.

The remaining pages relate to the DGA analysis with trend charts, DGA diagnostics (Duval, Key Gas, Gas Ratio, TDCG, CO2\CO with hot metal gases), Bushing analysis and Risk and Rank analysis (if selected in the Report Configuration Wizard).

5.6 Workflow Scheduler

Workflows can be scheduled from Perception Desktop via the Tools menu as shown in Figure 5-15.

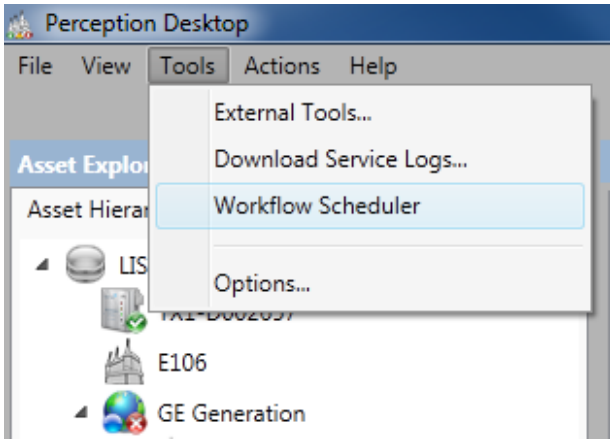


Figure 5-15: Tools menu

Click the **Workflow Scheduler** option to launch the 'Workflow Scheduler' dialog as shown in Figure 5-16.

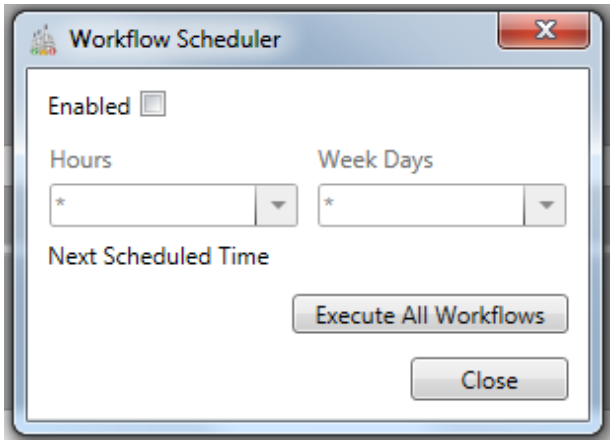


Figure 5-16: Workflow Scheduler dialog

To manually execute all workflows, click the **Execute All Workflows** button to instantly perform a data evaluation.

To enable scheduling, select the **Enabled** checkbox and then specify when the workflow should run. For example, every 6 hours of every day is specified as shown in Figure 5-17.

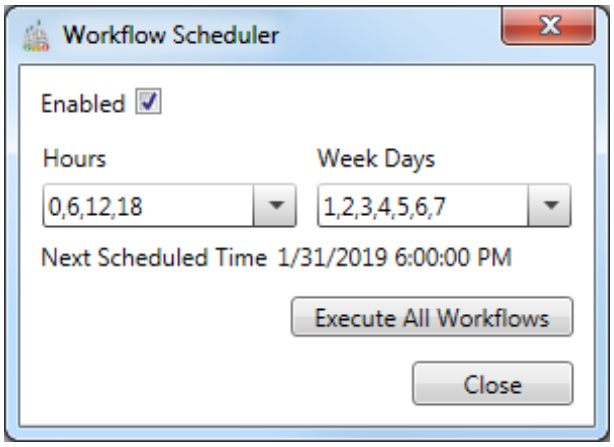


Figure 5-17: Workflow Scheduler enabled

5.7 Launching External Applications

External applications can be launched from Perception Desktop via the Tools menu as shown in Figure 5-18.

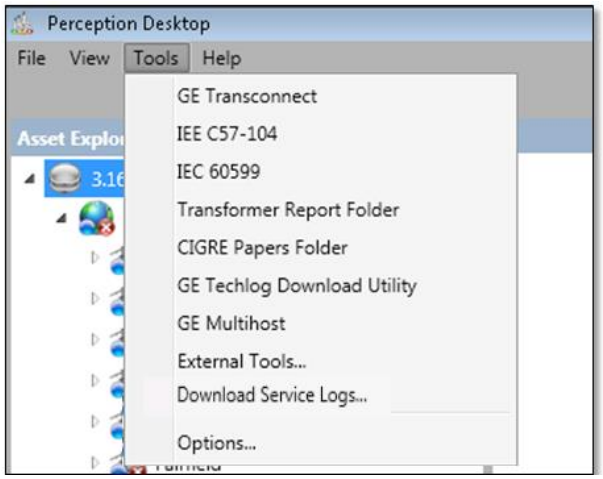


Figure 5-18: External Tools Menu Option

Select the **External Tools** option to launch the 'External Tools' dialog as shown in Figure 5-19.

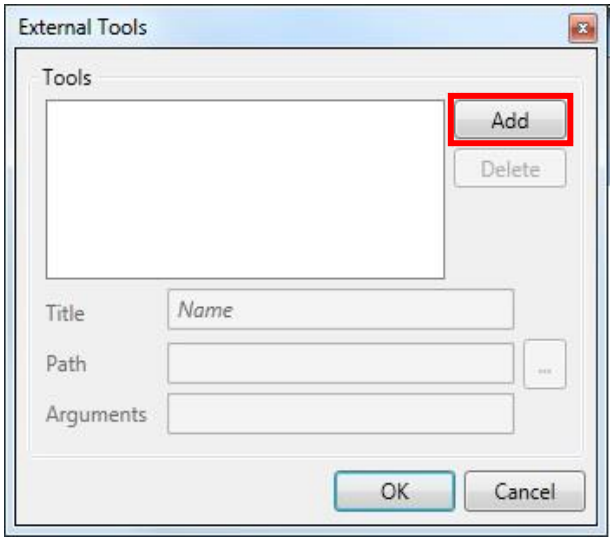


Figure 5-19: External Tools dialog

To create a new entry, click the **Add** button as shown in Figure 5-20. The Title and Path fields become available and must be populated.

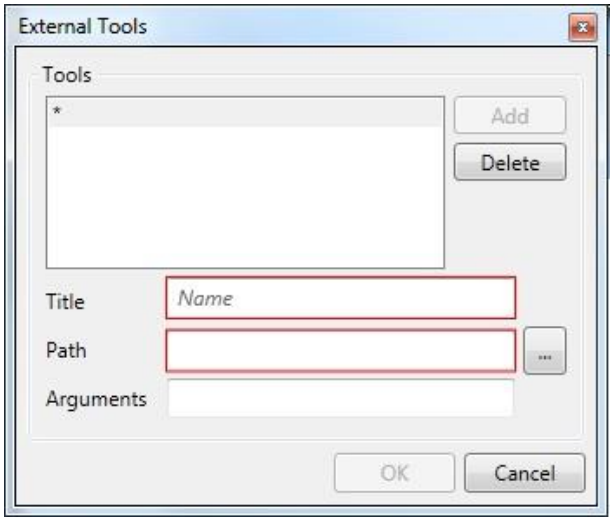


Figure 5-20: External Tools dialog – after clicking 'Add'

Enter the name of the external tool and the path of the executable file in the respective fields.

Note: A (...) browse button to the right of the path field allows you to browse to the executable location.

Figure 5-21 shows an example of adding Windows 'Notepad' as a tool.

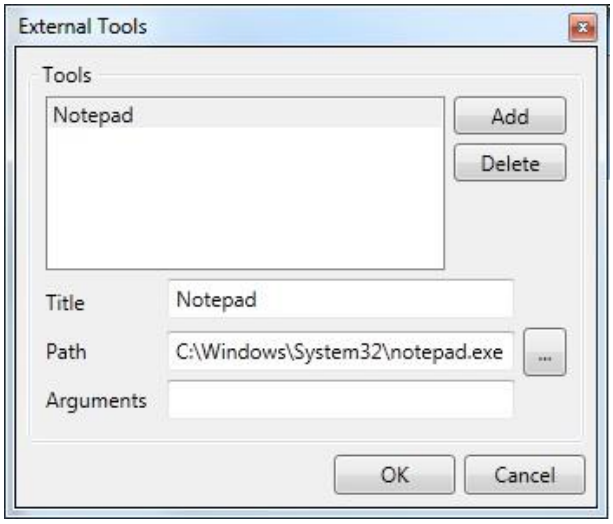


Figure 5-21: External Tools – Notepad example

You can also add an argument parameter to the external tool. The argument can be a command or file to open when the external application is launched. An example is shown in Figure 5-22.

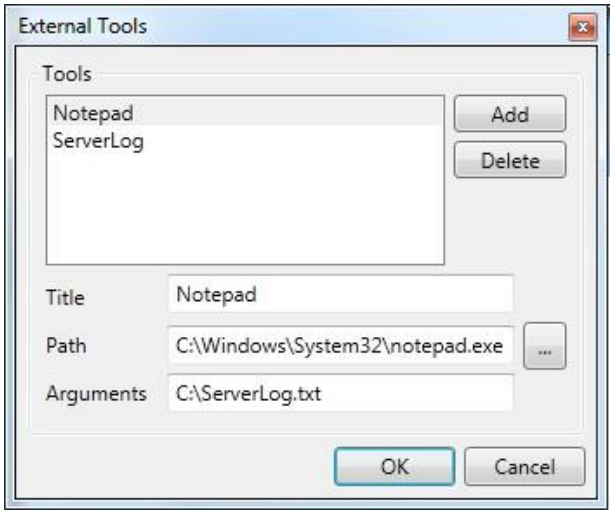


Figure 5-22: External Tools – Notepad example with an argument

Click **OK** to add the configured external tool to the Tools menu as shown in Figure 5-23.

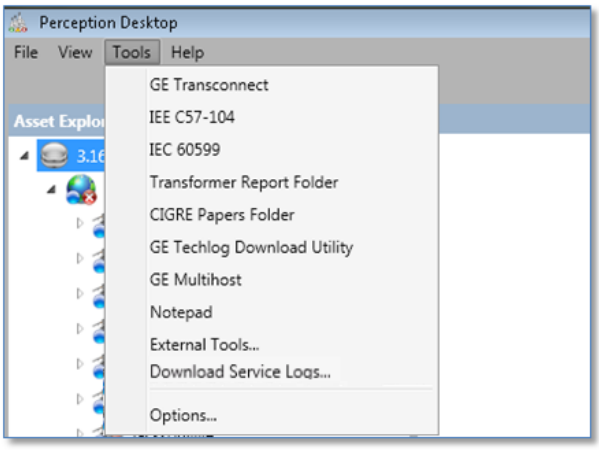


Figure 5-23: Tools Menu option with Notepad added to external tools

Any of the listed externals tools can be launched independently from Perception Desktop, if configured correctly.

To delete an external tool:

- Select **Tools** > **External Tools** to launch the 'External Tools' dialog.
- Select the external tool entry to delete and click **Delete**.
- Click **Yes** to the prompt as shown in Figure 5-24.

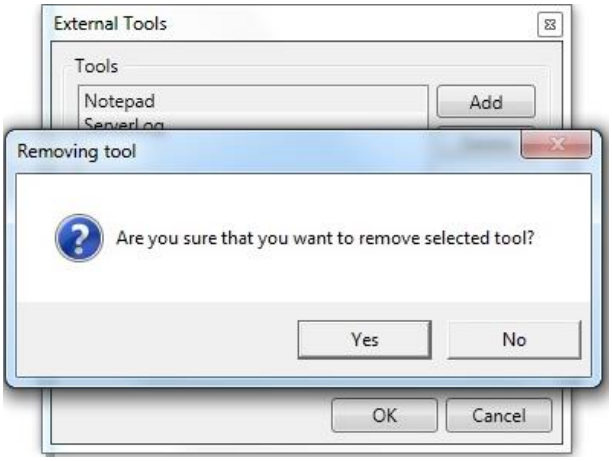


Figure 5-24: Deleting an External Tool

The external tool is no longer listed on the Tools menu as shown in Figure 5-25.

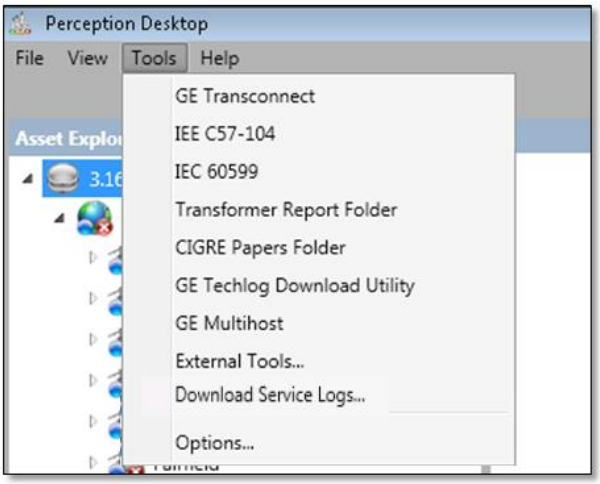


Figure 5-25: Tools Menu with Notepad removed

5.8 Transport X^2 Options

The Transport X^2 device is represented in the Asset Hierarchy and appears above the root node as shown in Figure 5-26.

Note: The asset is automatically detected about 30 seconds after the device is connected to a PC with Perception Desktop.

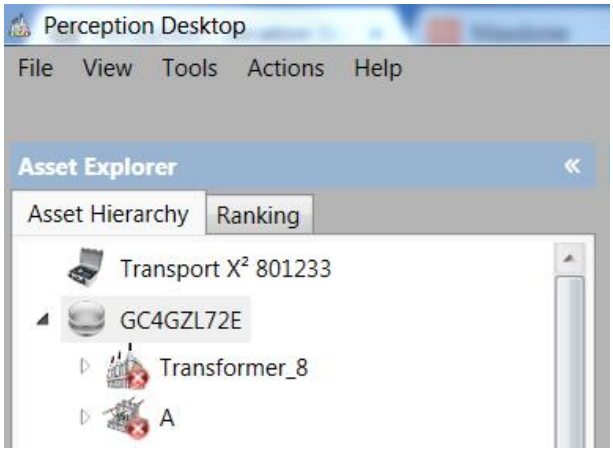


Figure 5-26: Transport X² Asset hierarchy

The Properties worksheet contains some basic information about the device, such as the serial number as shown in Figure 5-27. To establish communication with the device, the connection needs to be confirmed on the device side. From the Transport X² touchscreen Main Menu, press **PC Sync**.

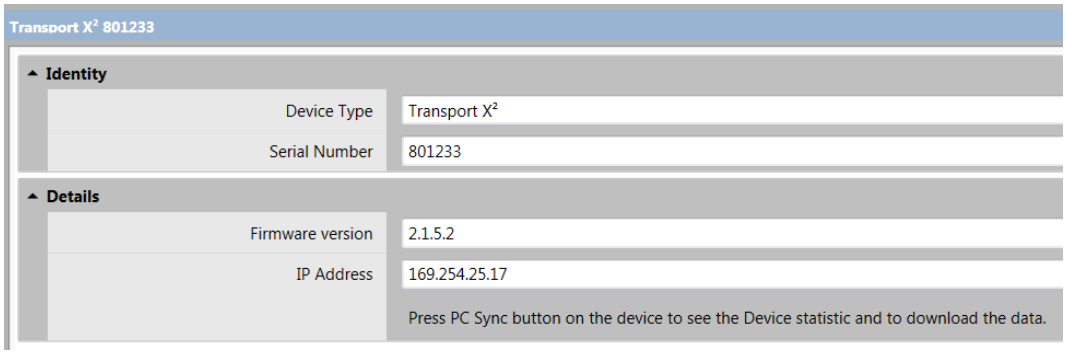


Figure 5-27: Transport X² Properties worksheet – before connection

The Properties worksheet details additional sections (Statistics & Measurements) as shown in Figure 5-28.

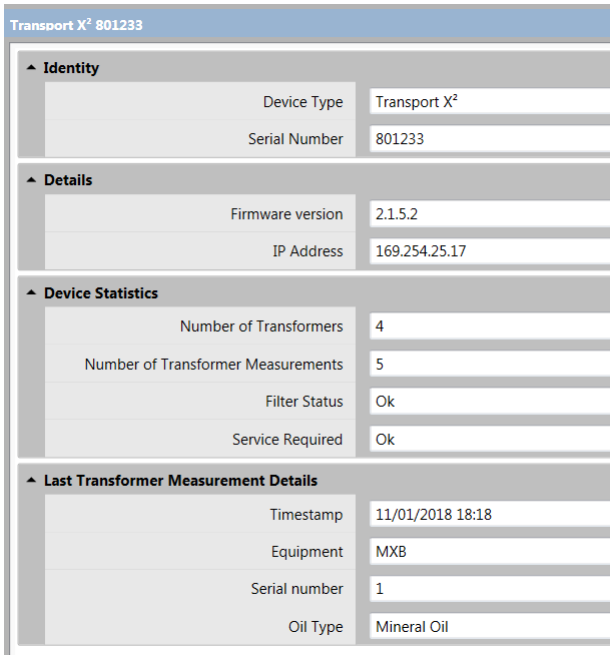


Figure 5-28: Transport X² Properties tab – after connection

If new measurements are detected after successful connection to a PC, the user is advised to download the data as shown in Figure 5-29 (or this action can be performed later as described below).

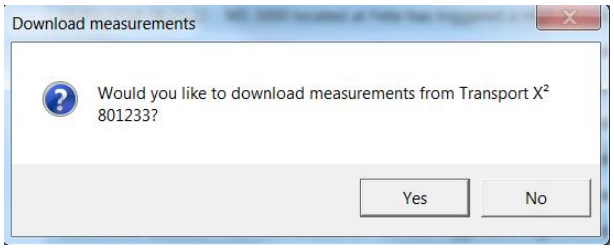


Figure 5-29: Transport X² Download measurements message

Right click on the Transport X² asset to see the available options as shown in Figure 5-30.

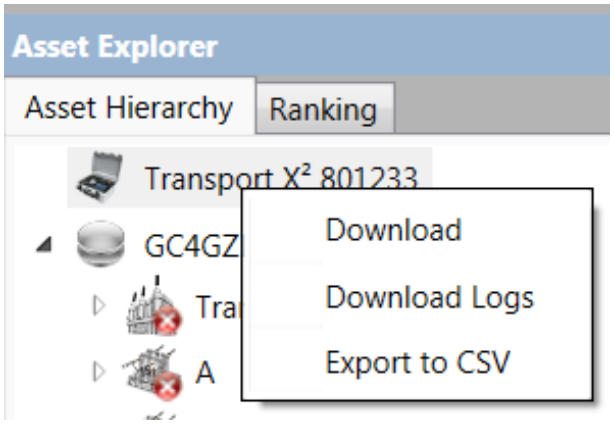


Figure 5-30: Transport X² options

- **Download**: retrieves all measurements stored on the device and creates appropriate transformer nodes in the asset tree (or adds additional information to existing nodes based on serialnum / equipnum id).
- **Download Logs**: retrieves debugging and sustaining information from the device to be used by service engineers.
- **Export to CSV**: export all Transport X² data to a CSV file to maintain compatibility with a legacy requirement. Note: When exporting to CSV, the file is automatically adjusted to the regional settings on the local machine.

Appendix AInstalling the Transport X driver in Windows 7

Transport X is a portable device that can be used onsite to sample oil by direct connection to the assets. The Transport X device is then brought back to the office and connected via USB to your PC. The data collected from the assets is then transferred to your PC and Perception will then load the data into the server database.

The Transport X device is installed in the same manner as any plug and play device attached to a PC.

A.1 Installing Mobile Device Center

The generic Microsoft Mobile Device Center must be downloaded from the Microsoft website.

For Windows Vista/7 x86 (32-Bit):

http://www.microsoft.com/download/en/details.aspx?displaying=en&id=14

For Windows Vista/7 x86 (64-Bit):

http://www.microsoft.com/en-us/download/details.aspx?id=3182

As part of the download process, you will have to allow the Microsoft Validation to take place. More information about the Validation requirements can be obtained by a 'click here' link as shown in Figure A-1.

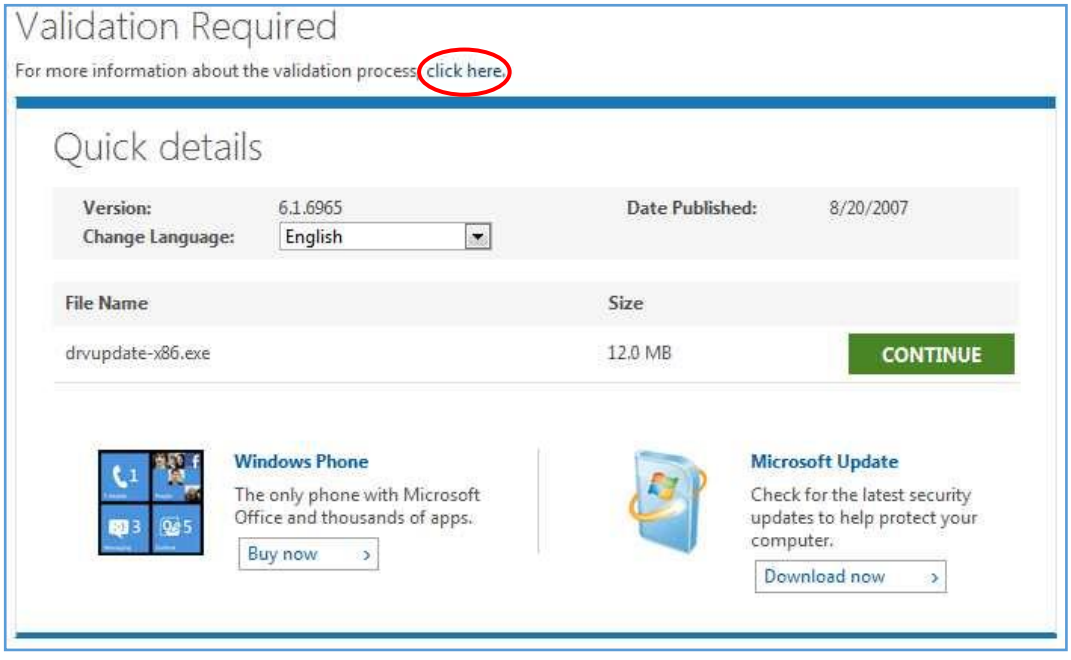


Figure A-1: Validation

After the validation process click **Download** as shown in Figure A-2.

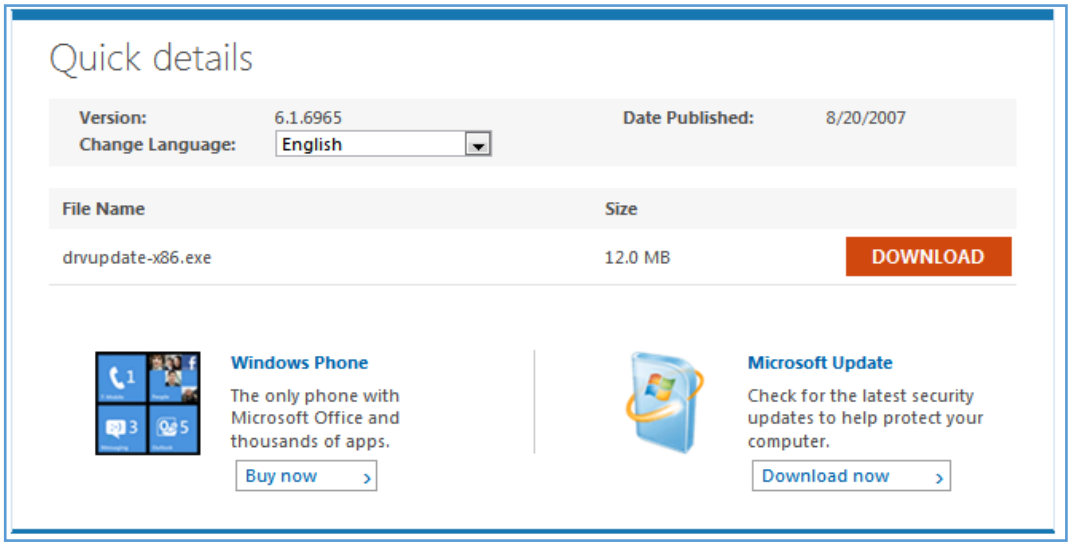


Figure A-2: Download

Then click **Run** on the File Download - Security Warning dialog as shown in Figure A-3.

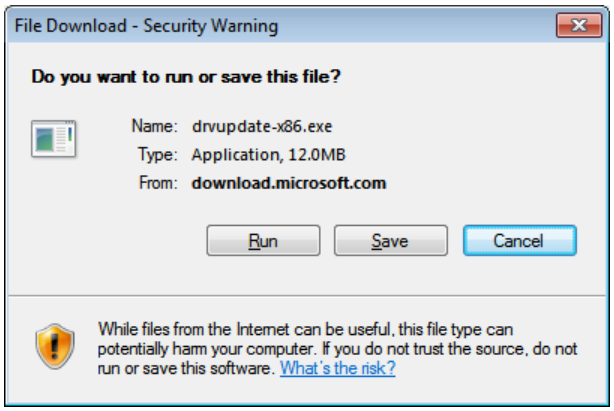


Figure A-3: Security Warning

And click **Run** again on the Internet Explorer – Security Warning dialog as shown in Figure A-4.

Figure A-4: Browser Security Warning

The software prepares to install and displays the following series of dialogs as shown in Figure A-5.

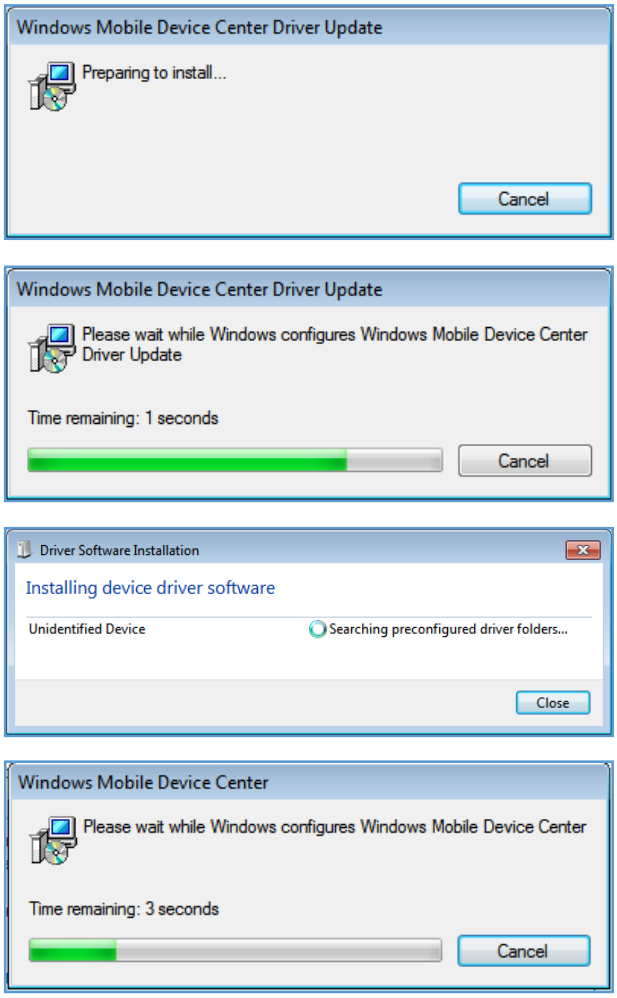


Figure A-5: Installation dialogs

If Figure A-6 appears during the process or at the end, then the installation has been unsuccessful. Click the **Close** button and install the Transport X device manually as outlined in Section A.2.

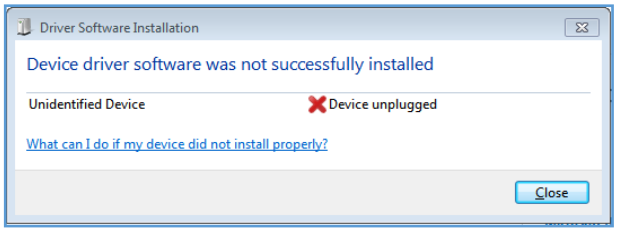


Figure A-6: Unsuccessful device driver installation

A.2 Installing Transport X

To connect the Transport X (running Windows CE 5.0 or 4.2) to a computer running Windows 7, follow the steps below:

- Power up the device.
- Connect the device to your computer with the supplied USB cable.

- You will see a ‘Found New Hardware’ screen.
- If you had already installed or attempted installing a driver, you can right-click **Computer**, choose **Manage** and go to **Device Manager**.
- If the device appears under ‘Mobile Devices’, then use the ‘Update Device Driver’ utility.
- Select the option to locate and install software as shown in Figure A-7.

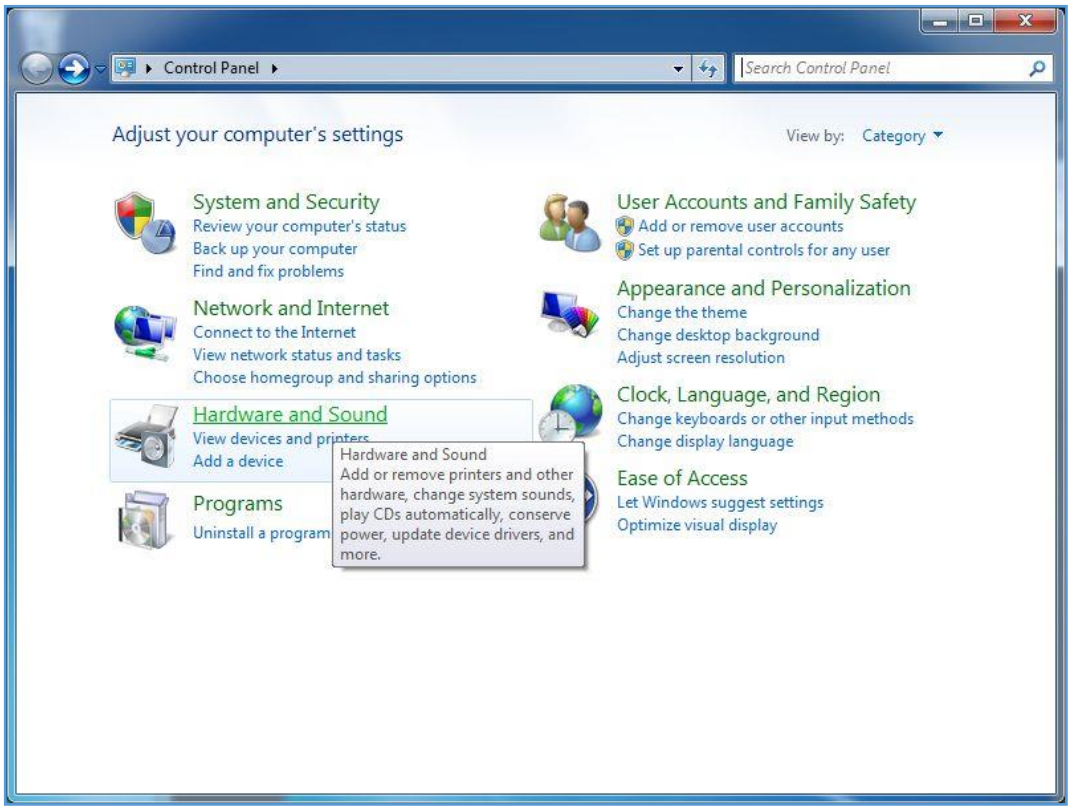


Figure A-7: Control Panel

- Under **Devices and Printers**, select **Device Manager** as shown in Figure A-8.

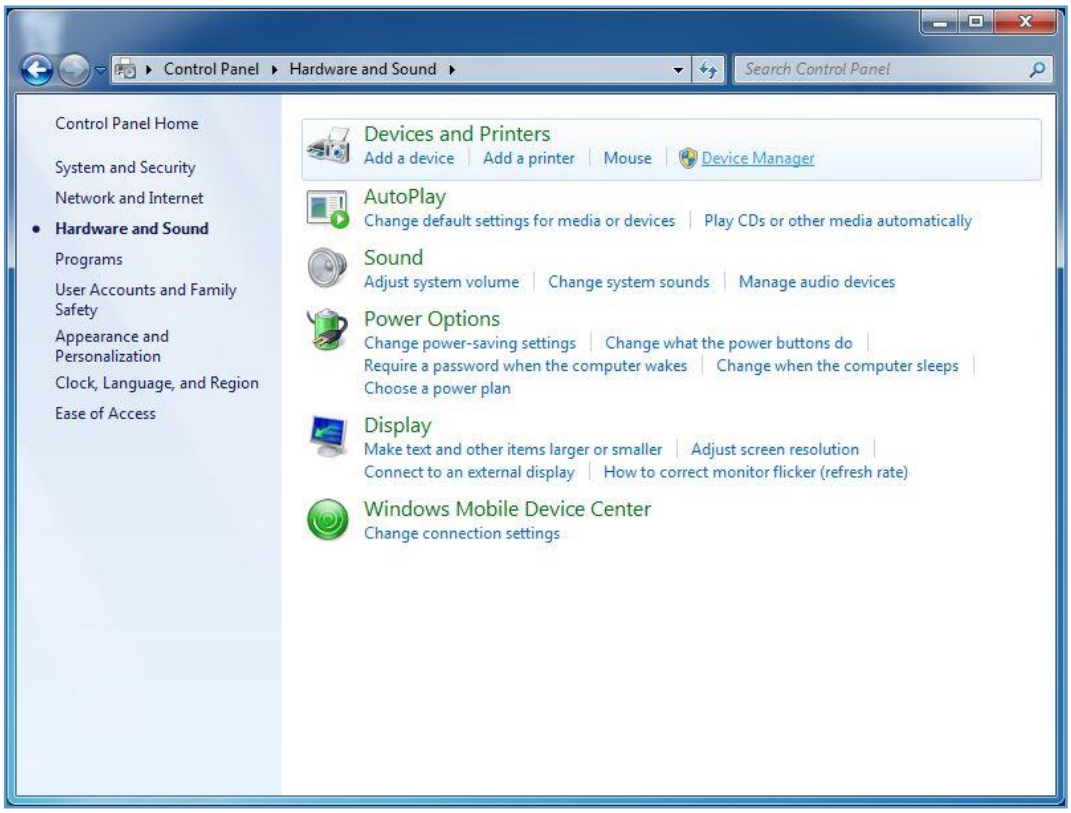


Figure A-8: Devices and Printers

- Expand **Other devices** to display **Kelman Transport X** as shown in Figure A-9.

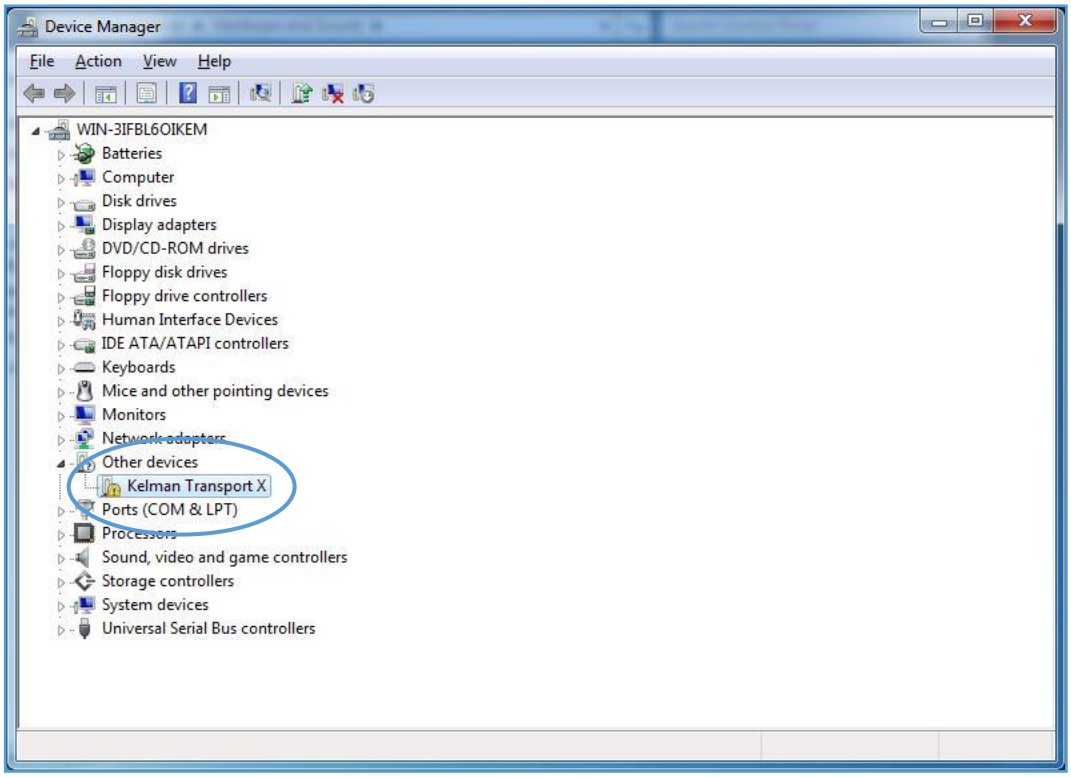


Figure A-9: Device Manager

- Right-click **Kelman Transport X** and select **Update Driver Software** as shown in Figure A-10.

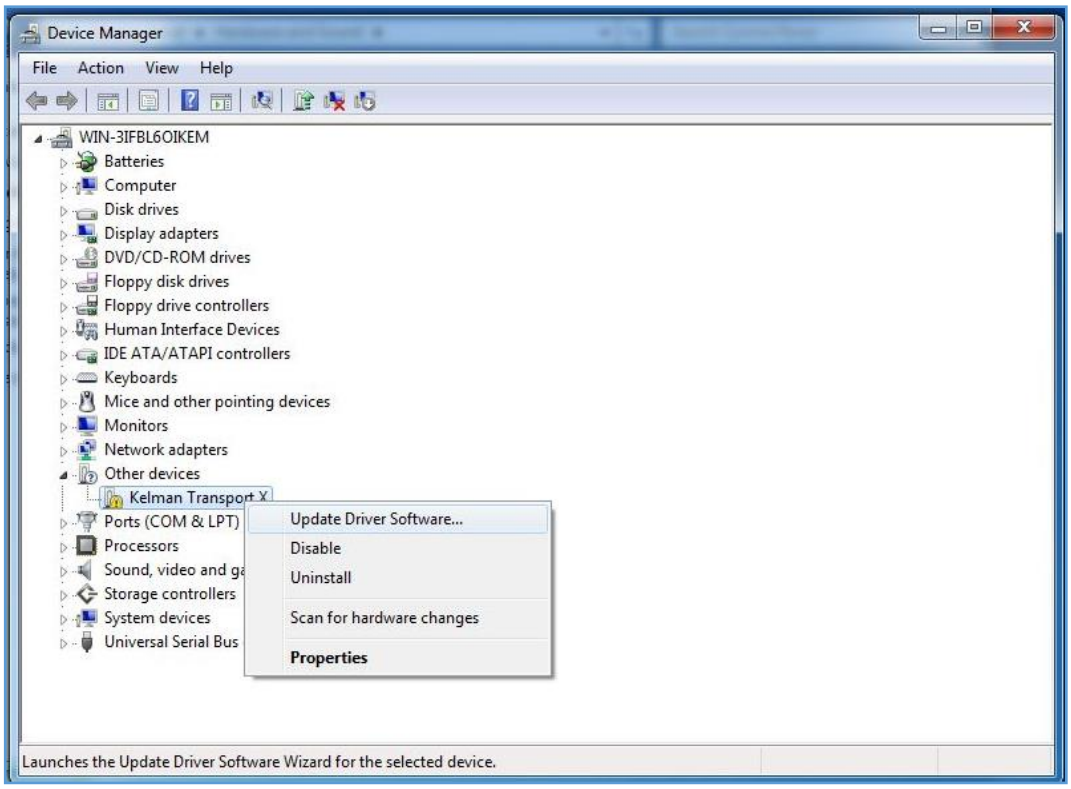


Figure A-10: Device Manager – Update Driver Software

- On the Windows Permission Request screen, click **Continue**.
- On the next screen, select **Browse my computer for driver software** as shown in Figure A-11.

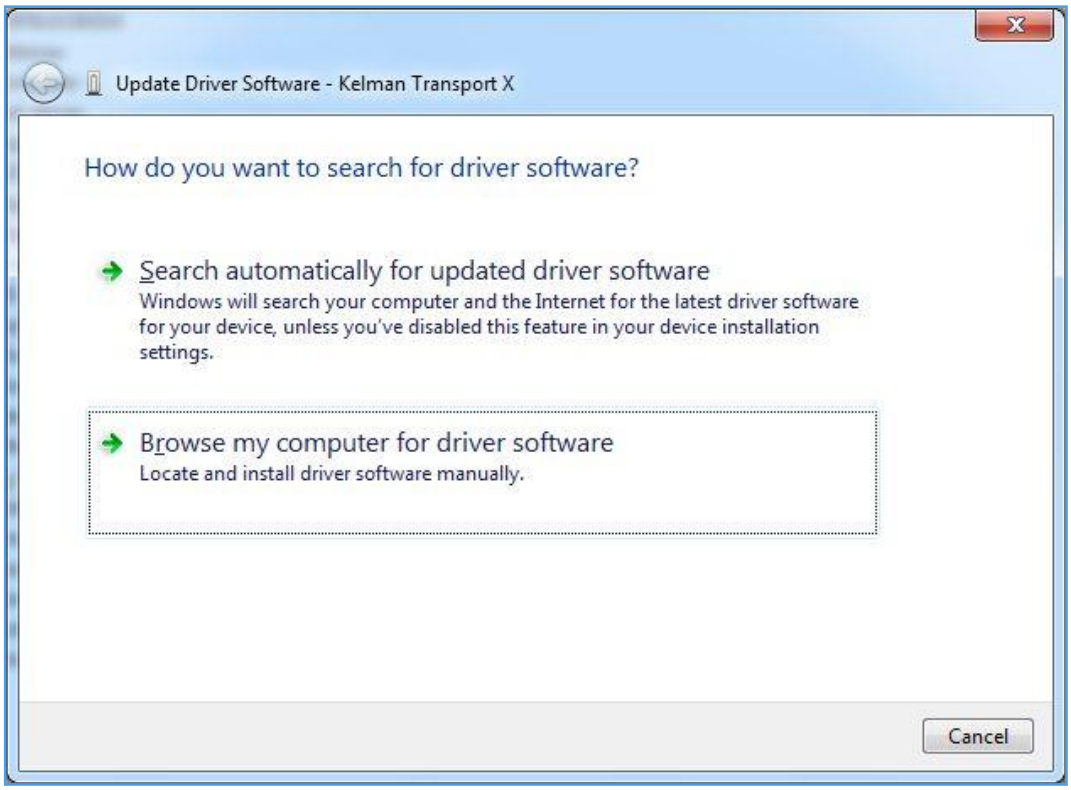


Figure A-11: Update Driver Software - Kelman Transport X

- Select **Let me pick from a list of device drivers on my computer** as shown in Figure A-12.

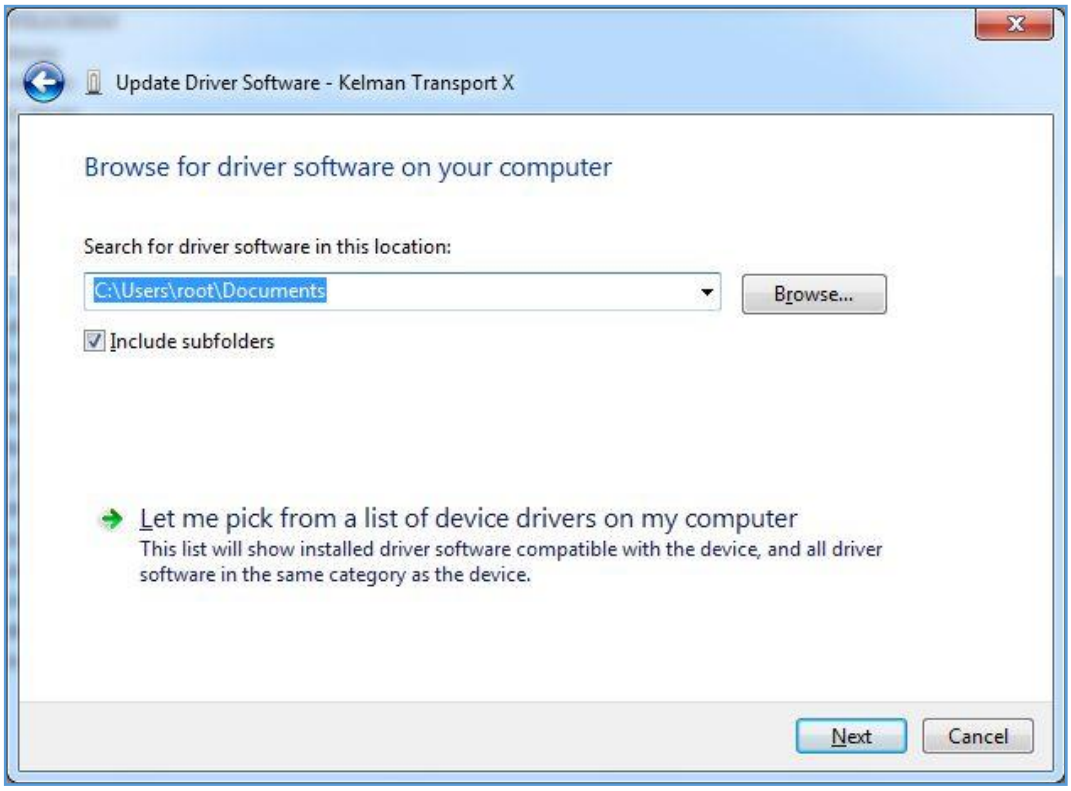


Figure A-12: Browse for driver software

- Select **Mobile devices**, then click **Next** as shown in Figure A-13.

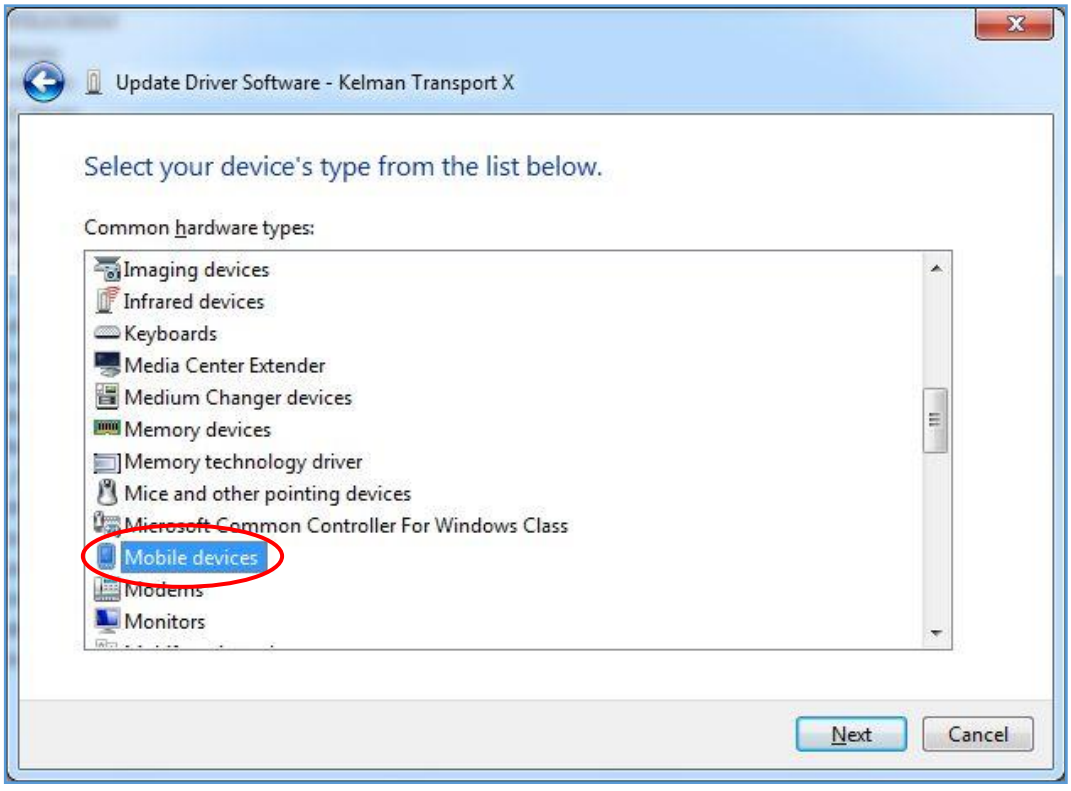


Figure A-13: Choose the device type

- Clear the **Show compatible hardware** checkbox.

- In the Manufacturer column, choose **Microsoft** as shown in Figure A-14.
- In the Model column, choose **Microsoft USB Sync**.
- Click **Next**.

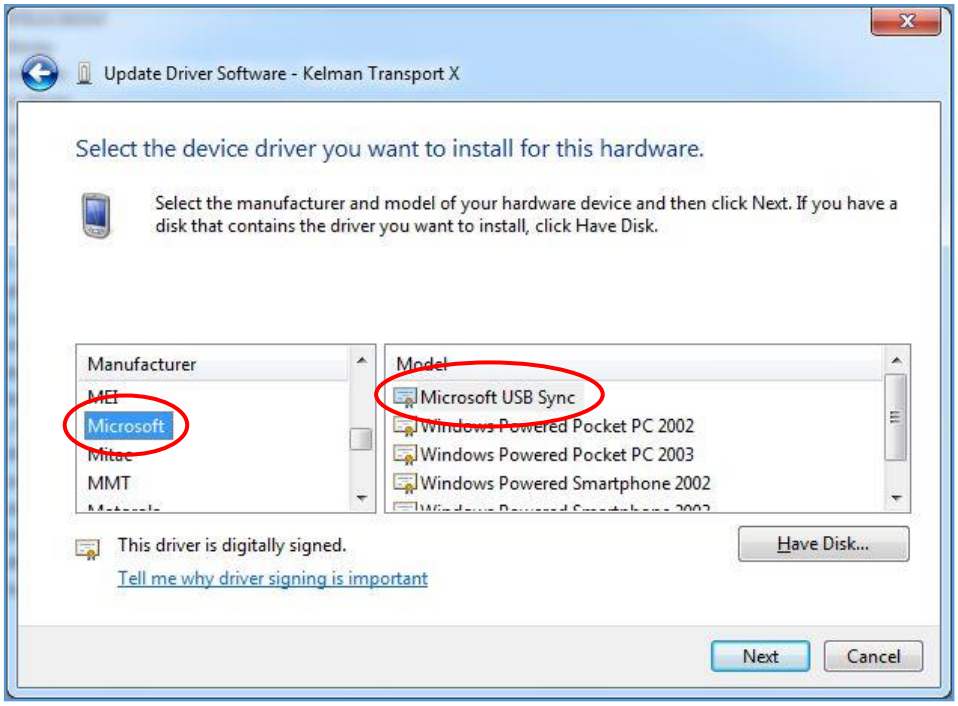


Figure A-14: Select the device driver

- Select **Connect without setting up your device.**
- In the 'Update Driver Warning' dialog, click **Yes** as shown in Figure A-15.

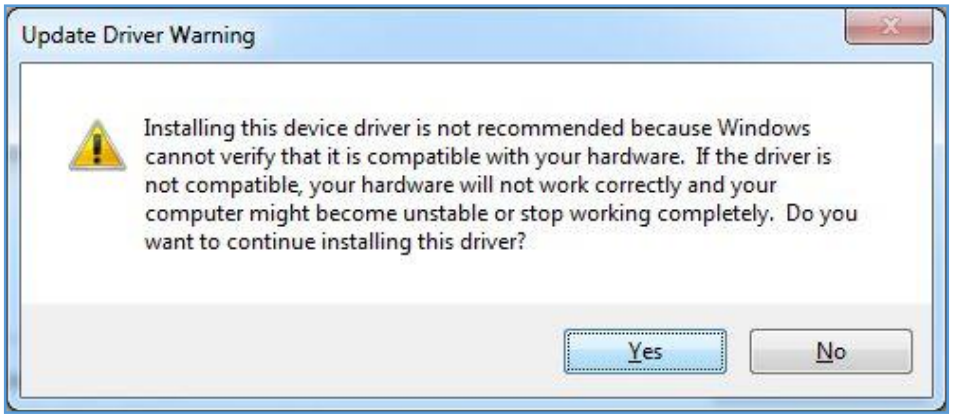


Figure A-15: Update driver warning

- The Installing Driver Software progress bar displays as shown in Figure A-16.

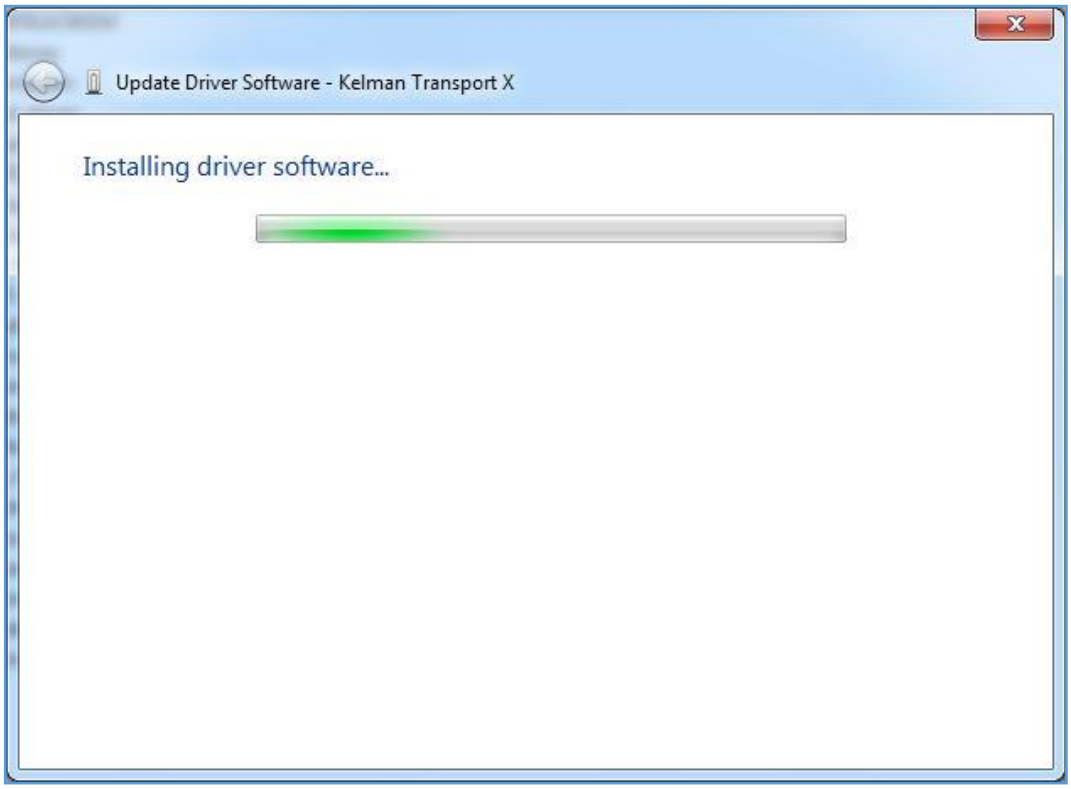


Figure A-16: Installation progress bar

- When the driver has successfully updated, the following screen as shown in Figure A-17 displays.

Figure A-17: Driver update complete

- A successful connection is indicated by a green check mark and the word ‘Connected’ as shown in Figure A-18.

Figure A-18: Successful connection

Appendix BDatabase Mappings for Import and Export

During a Perception export, only the browse names get exported to the CSV file for oil source and peripheral measurements including their group names. For example, multiple oil sources, such as the Main, Selector and Diverter tanks, are represented in the software with the following browse names OilSourceA, OilSourceB and OilSourceC respectively. On export it is only these underlying browse names that get exported to the CSV file (not the user-defined names for multiple oil sources specified in the device setup). The reason for this is that Perception analytics (such as Duval, GasRatio, KeyGas) recognises only the browse name for the oil sources. Common browse names also allow Perception data to be imported into any other localised version of Perception.

Table B-1 lists all the CSV headers, the corresponding field mappings in the Perception database and a brief description below (where required). When creating custom import and export mappings, refer to this table to ensure valid data exchange.

Table B-1: Database Mappings

CSV header	Field mapping
equipnum	equipnum
The name of the asset shown in the Asset Explorer on import. Data must contain an 'equipnum' or 'Serialnum' field.	
assettype	assettype
The type of asset. Required, otherwise a transformer asset will be created on import (used for TOA and TransportX format files). assettype = HydranM2, MO150, Transfix1_6, MINITRANS, DGA 500, MULTITRANS, TAPTRANS, DUALTRANS, BMT300, Transfix1_5, Transformer, TransformerBank, Hydran201ti, SubStation, Area	
Serialnum	SerialNumber
The serial number of the asset. Data must contain an 'equipnum' or 'Serialnum' field.	
sampledate	sampledate
The data records. Required field if importing 'measurement data'. If importing 'properties' only, this field can be omitted.	
Tank	Tank
The tanks listed under the transformer. Required for the import of TOA format files only.	
apprtype	apprtype
The type of asset. E.g. Transfix 1.6 (used for Perception and TransConnect format files). apprtype = HydranM2, MO150, Transfix1_6, MINITRANS, DGA 500, MULTITRANS, TAPTRANS, DUALTRANS, BMT300, Transfix1_5, Transformer, TransformerBank, Hydran201ti, SubStation, Area	
pgaerrorcodes	pgaerrorcodes
OilSourceA|H2	OilSourceA|H2
The first value denotes the measurement group or oil source that gets created on import, the second value denotes a measurement point under that group or oil source. Required for all CSV headers, except the following: headers that represent property fields headers appended with the text 'Diagnostic'.	
OilSourceA|H2|Diagnostic	OilSourceA|H2|Diagnostic
Any header format appended with the text 'Diagnostic', imports the diagnostic information for the measurement where the data is of bad or uncertain quality (!B or !U).	
OilSourceA|CH4	OilSourceA|CH4

OilSourceA|CH4|Diagnostic	OilSourceA|CH4|Diagnostic
OilSourceA|C2H2	OilSourceA|C2H2
OilSourceA|C2H2|Diagnostic	OilSourceA|C2H2|Diagnostic
OilSourceA|C2H4	OilSourceA|C2H4
OilSourceA|C2H4|Diagnostic	OilSourceA|C2H4|Diagnostic
OilSourceA|C2H6	OilSourceA|C2H6
OilSourceA|C2H6|Diagnostic	OilSourceA|C2H6|Diagnostic
OilSourceA|CO	OilSourceA|CO
OilSourceA|CO|Diagnostic	OilSourceA|CO|Diagnostic
OilSourceA|CO2	OilSourceA|CO2
OilSourceA|CO2|Diagnostic	OilSourceA|CO2|Diagnostic
OilSourceA|O2	OilSourceA|O2
OilSourceA|O2|Diagnostic	OilSourceA|O2|Diagnostic
OilSourceA|TDCG	OilSourceA|TDCG
OilSourceA|TDCG|Diagnostic	OilSourceA|TDCG|Diagnostic
OilSourceA|H2O	OilSourceA|H2O
OilSourceA|H2O|Diagnostic	OilSourceA|H2O|Diagnostic
OilSourceA|AmbientTemp	OilSourceA|AmbientTemp
OilSourceA|AmbientTemp|Diagnostic	OilSourceA|AmbientTemp|Diagnostic
OilSourceA|NormalizationTemp	OilSourceA|NormalizationTemp
OilSourceA|NormalizationTemp|Diagnostic	OilSourceA|NormalizationTemp|Diagnostic
OilSourceA|OilPressure	OilSourceA|OilPressure
OilSourceA|OilPressure|Diagnostic	OilSourceA|OilPressure|Diagnostic
OilSourceA|OilTemp	OilSourceA|OilTemp
OilSourceA|OilTemp|Diagnostic	OilSourceA|OilTemp|Diagnostic

OilSourceA|N2	OilSourceA|N2
OilSourceA|N2|Diagnostic	OilSourceA|N2|Diagnostic
OilSourceA|TDG	OilSourceA|TDG
OilSourceA|TDG|Diagnostic	OilSourceA|TDG|Diagnostic
Peripherals|Analog|Analog Input-2	Peripherals|Analog|Analog Input-2
On import of this header format, for example, a 'Peripherals' group is created with an 'Analog' subgroup. Input-2 is the measurement created under the Analog subgroup. This interpretation is similar for all peripheral inputs. Note: If the CSV header contains more than one attribute separated by a pipe character (|), it is the value after the last pipe character that is considered the measurement point. All preceding values are treated as subgroups. The only exceptions to this behavior are headers with the appendage 'Diagnostic'.	
Peripherals|Analog|Analog Input-1	Peripherals|Analog|Analog Input-1
Peripherals|Analog|Analog Input-6	Peripherals|Analog|Analog Input-6
Peripherals|Analog|Analog Input-5	Peripherals|Analog|Analog Input-5
Peripherals|Analog|Analog Input-4	Peripherals|Analog|Analog Input-4
Peripherals|Analog|Analog Input-3	Peripherals|Analog|Analog Input-3
Peripherals|TransOpto|Channel1	Peripherals|TransOpto|Channel1
OilSourceB|H2	OilSourceB|H2
OilSourceB|CH4	OilSourceB|CH4
OilSourceB|C2H2	OilSourceB|C2H2
OilSourceB|C2H4	OilSourceB|C2H4
OilSourceB|C2H6	OilSourceB|C2H6
OilSourceB|CO	OilSourceB|CO
OilSourceB|CO2	OilSourceB|CO2
OilSourceB|O2	OilSourceB|O2
OilSourceB|TDCG	OilSourceB|TDCG
OilSourceB|H2O	OilSourceB|H2O
OilSourceB|AmbientTemp	OilSourceB|AmbientTemp
OilSourceB|NormalizationTemp	OilSourceB|NormalizationTemp

OilSourceB|OilPressure	OilSourceB|OilPressure
OilSourceB|OilTemp	OilSourceB|OilTemp
OilSourceB|N2	OilSourceB|N2
OilSourceC|H2	OilSourceC|H2
OilSourceC|CH4	OilSourceC|CH4
OilSourceC|C2H2	OilSourceC|C2H2
OilSourceC|C2H4	OilSourceC|C2H4
OilSourceC|C2H6	OilSourceC|C2H6
OilSourceC|CO	OilSourceC|CO
OilSourceC|CO2	OilSourceC|CO2
OilSourceC|O2	OilSourceC|O2
OilSourceC|TDCG	OilSourceC|TDCG
OilSourceC|H2O	OilSourceC|H2O
OilSourceC|AmbientTemp	OilSourceC|AmbientTemp
OilSourceC|NormalizationTemp	OilSourceC|NormalizationTemp
OilSourceC|OilPressure	OilSourceC|OilPressure
OilSourceC|OilTemp	OilSourceC|OilTemp
GasRatioFormulaContainer|OilSourceA|FormulaInfo1|Formula	
GasRatioFormulaContainer|OilSourceA|FormulaInfo2|Formula	
GasRatioFormulaContainer|OilSourceA|FormulaInfo3|Formula	
GasRatioFormulaContainer|OilSourceA|FormulaInfo4|Formula	
GasRatioFormulaContainer|OilSourceA|FormulaInfo5|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo1|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo2|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo3|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo4|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo5|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo1|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo2|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo3|Formula	
GasRatioFormulaContainer|OilSourceB|FormulaInfo4|Formula	

GasRatioFormulaContainer|OilSourceB|FormulaInfo5|Formula	
GasRatioFormulaContainer|OilSourceC|FormulaInfo1|Formula	
GasRatioFormulaContainer|OilSourceC|FormulaInfo2|Formula	
GasRatioFormulaContainer|OilSourceC|FormulaInfo3|Formula	
GasRatioFormulaContainer|OilSourceC|FormulaInfo4|Formula	
GasRatioFormulaContainer|OilSourceC|FormulaInfo5|Formula	
GasRatioFormulaContainer|OilSourceA|FormulaInfo1|FormulaName	
GasRatioFormulaContainer|OilSourceA|FormulaInfo2|FormulaName	
GasRatioFormulaContainer|OilSourceA|FormulaInfo3|FormulaName	
GasRatioFormulaContainer|OilSourceA|FormulaInfo4|FormulaName	
GasRatioFormulaContainer|OilSourceA|FormulaInfo5|FormulaName	
GasRatioFormulaContainer|OilSourceB|FormulaInfo1|FormulaName	
GasRatioFormulaContainer|OilSourceB|FormulaInfo2|FormulaName	
GasRatioFormulaContainer|OilSourceB|FormulaInfo3|FormulaName	
GasRatioFormulaContainer|OilSourceB|FormulaInfo4|FormulaName	
GasRatioFormulaContainer|OilSourceB|FormulaInfo5|FormulaName	
GasRatioFormulaContainer|OilSourceC|FormulaInfo1|FormulaName	
GasRatioFormulaContainer|OilSourceC|FormulaInfo2|FormulaName	
GasRatioFormulaContainer|OilSourceC|FormulaInfo3|FormulaName	
GasRatioFormulaContainer|OilSourceC|FormulaInfo4|FormulaName	
GasRatioFormulaContainer|OilSourceC|FormulaInfo5|FormulaName	
Peripherals|Digital|Digital Input-1	Peripherals|Digital|Digital Input-1
Peripherals|Digital|Digital Input-2	Peripherals|Digital|Digital Input-2
Peripherals|Digital|Digital Input-3	Peripherals|Digital|Digital Input-3
Hydran|Hydran Hourly Trend Period	Hydran|Hydran Hourly Trend Period
The first value denotes the measurement group that gets created on import e.g. Hydran, the second value denotes a measurement point under that group e.g. Hydran Hourly Trend Period. This interpretation is similar for all CSV headers of this format.	
Hydran|Hydran Daily Trend Period	Hydran|Hydran Daily Trend Period
System|Battery	System|Battery
System|Transformer Type	System|Transformer Type
Moisture|%RH Hourly Average Period	Moisture|%RH Hourly Average Period
Moisture|Standard Temperature for RH	Moisture|Standard Temperature for RH
Temperature|Ambient Temperature	Temperature|Ambient Temperature
Temperature|Top Oil Temperature	Temperature|Top Oil Temperature
Temperature|Calculated Top Oil Temperature	Temperature|Calculated Top Oil Temperature

Temperature|Calculated Top Oil Difference	Temperature|Calculated Top Oil Difference
Temperature|Calculated Bottom Oil Temperature	Temperature|Calculated Bottom Oil Temperature
Power|Apparent Power from H Winding	Power|Apparent Power from H Winding
Power|Apparent Power from X Winding	Power|Apparent Power from X Winding
Power|Apparent Power from Y Winding	Power|Apparent Power from Y Winding
Current|Current Winding H	Current|Current Winding H
Current|Current Winding X	Current|Current Winding X
Current|Current Winding Y	Current|Current Winding Y
Winding Hot Spot|Per Unit load on the most loaded winding	Winding Hot Spot|Per Unit load on the most loaded winding
Winding Hot Spot|Winding Hot-Spot Temperature in Winding H	Winding Hot Spot|Winding Hot-Spot Temperature in Winding H
Winding Hot Spot|Winding Hot-Spot Temperature in Winding X	Winding Hot Spot|Winding Hot-Spot Temperature in Winding X
Winding Hot Spot|Winding Hot-Spot Temperature in Winding Y	Winding Hot Spot|Winding Hot-Spot Temperature in Winding Y
Winding Hot Spot|Highest Winding Hot-Spot Temperature	Winding Hot Spot|Highest Winding Hot-Spot Temperature
Winding Hot Spot|Per Unit load on the most loaded winding corrected for Ambient and Altitude	Winding Hot Spot|Per Unit load on the most loaded winding corrected for Ambient and Altitude
Winding Hot Spot|Highest Winding Hot-Spot Temperature Source Winding	Winding Hot Spot|Highest Winding Hot-Spot Temperature Source Winding
Winding Hot Spot|Per Unit load on the most loaded winding source	Winding Hot Spot|Per Unit load on the most loaded winding source
OLTC|OLTC Tank Temperature	OLTC|OLTC Tank Temperature
OLTC|OLTC Differential Temperature	OLTC|OLTC Differential Temperature
OLTC|Short Term Average of Tap Changer Temperature Differential	OLTC|Short Term Average of Tap Changer Temperature Differential
OLTC|Short Term Filtering Value	OLTC|Short Term Filtering Value
OLTC|Long Term Average of Tap Changer Temperature Differential	OLTC|Long Term Average of Tap Changer Temperature Differential

OLTC|Long Term Filtering Value	OLTC|Long Term Filtering Value
Cooling|Cooling Efficiency Index	Cooling|Cooling Efficiency Index
Cooling|Cooling Stage 0 Total Activity Time	Cooling|Cooling Stage 0 Total Activity Time
Cooling|Cooling Bank1 Total Activity Time	Cooling|Cooling Bank1 Total Activity Time
Cooling|Cooling Bank2 Total Activity Time	Cooling|Cooling Bank2 Total Activity Time
Cooling|Cooling Bank 1 Current	Cooling|Cooling Bank 1 Current
Cooling|Cooling Bank 2 Current	Cooling|Cooling Bank 2 Current
Cooling|Cooling Bank1 Activated	Cooling|Cooling Bank1 Activated
Cooling|Cooling Bank2 Activated	Cooling|Cooling Bank2 Activated
Cooling|Cooling Stage	Cooling|Cooling Stage
Insulation Aging|Thermal Aging Acceleration Factor	Insulation Aging|Thermal Aging Acceleration Factor
Insulation Aging|Moisture Aging Acceleration Factor	Insulation Aging|Moisture Aging Acceleration Factor
Insulation Aging|Global Aging Acceleration Factor	Insulation Aging|Global Aging Acceleration Factor
Insulation Aging|Cumulative Aging	Insulation Aging|Cumulative Aging
Insulation Aging|Service Time	Insulation Aging|Service Time
Tap Position|Permanent Tap Position Transition Count	Tap Position|Permanent Tap Position Transition Count
Tap Position|Permanent Transition Count for Position 1	Tap Position|Permanent Transition Count for Position 1
Tap Position|Permanent Transition Count for Position 2	Tap Position|Permanent Transition Count for Position 2
Tap Position|Permanent Transition Count for Position 3	Tap Position|Permanent Transition Count for Position 3
Tap Position|Permanent Transition Count for Position 4	Tap Position|Permanent Transition Count for Position 4
Tap Position|Permanent Transition Count for Position 5	Tap Position|Permanent Transition Count for Position 5
Tap Position|Permanent Transition Count for Position 6	Tap Position|Permanent Transition Count for Position 6
Tap Position|Permanent Transition Count for Position 7	Tap Position|Permanent Transition Count for Position 7
Tap Position|Permanent Transition Count for Position 8	Tap Position|Permanent Transition Count for Position 8
Tap Position|Permanent Transition Count for Position 9	Tap Position|Permanent Transition Count for Position 9

Tap Position|Permanent Transition Count for Position 10	Tap Position|Permanent Transition Count for Position 10
Tap Position|Permanent Transition Count for Position 11	Tap Position|Permanent Transition Count for Position 11
Tap Position|Permanent Transition Count for Position 12	Tap Position|Permanent Transition Count for Position 12
Tap Position|Permanent Transition Count for Position 13	Tap Position|Permanent Transition Count for Position 13
Tap Position|Permanent Transition Count for Position 14	Tap Position|Permanent Transition Count for Position 14
Tap Position|Permanent Transition Count for Position 15	Tap Position|Permanent Transition Count for Position 15
Tap Position|Permanent Transition Count for Position 16	Tap Position|Permanent Transition Count for Position 16
Tap Position|Permanent Transition Count for Position 17	Tap Position|Permanent Transition Count for Position 17
Tap Position|Permanent Transition Count for Position 18	Tap Position|Permanent Transition Count for Position 18
Tap Position|Permanent Transition Count for Position 19	Tap Position|Permanent Transition Count for Position 19
Tap Position|Permanent Transition Count for Position 20	Tap Position|Permanent Transition Count for Position 20
Tap Position|Permanent Transition Count for Position 21	Tap Position|Permanent Transition Count for Position 21
Tap Position|Permanent Transition Count for Position 22	Tap Position|Permanent Transition Count for Position 22
Tap Position|Permanent Transition Count for Position 23	Tap Position|Permanent Transition Count for Position 23
Tap Position|Permanent Transition Count for Position 24	Tap Position|Permanent Transition Count for Position 24
Tap Position|Permanent Transition Count for Position 25	Tap Position|Permanent Transition Count for Position 25
Tap Position|Permanent Transition Count for Position 26	Tap Position|Permanent Transition Count for Position 26
Tap Position|Permanent Transition Count for Position 27	Tap Position|Permanent Transition Count for Position 27

Tap Position|Permanent Transition Count for Position 28	Tap Position|Permanent Transition Count for Position 28
Tap Position|Permanent Transition Count for Position 29	Tap Position|Permanent Transition Count for Position 29
Tap Position|Permanent Transition Count for Position 30	Tap Position|Permanent Transition Count for Position 30
Tap Position|Permanent Transition Count for Position 31	Tap Position|Permanent Transition Count for Position 31
Tap Position|Permanent Transition Count for Position 32	Tap Position|Permanent Transition Count for Position 32
Tap Position|Permanent Transition Count for Position 33	Tap Position|Permanent Transition Count for Position 33
Tap Position|Permanent Transition Count for Position 34	Tap Position|Permanent Transition Count for Position 34
Tap Position|Permanent Transition Count for Position 35	Tap Position|Permanent Transition Count for Position 35
Tap Position|Operator Tap Position Transition Count	Tap Position|Operator Tap Position Transition Count
Tap Position|Resettable Count for Position 1	Tap Position|Resettable Count for Position 1
Tap Position|Resettable Count for Position 2	Tap Position|Resettable Count for Position 2
Tap Position|Resettable Count for Position 3	Tap Position|Resettable Count for Position 3
Tap Position|Resettable Count for Position 4	Tap Position|Resettable Count for Position 4
Tap Position|Resettable Count for Position 5	Tap Position|Resettable Count for Position 5
Tap Position|Resettable Count for Position 6	Tap Position|Resettable Count for Position 6
Tap Position|Resettable Count for Position 7	Tap Position|Resettable Count for Position 7
Tap Position|Resettable Count for Position 8	Tap Position|Resettable Count for Position 8
Tap Position|Resettable Count for Position 9	Tap Position|Resettable Count for Position 9
Tap Position|Resettable Count for Position 10	Tap Position|Resettable Count for Position 10
Tap Position|Resettable Count for Position 11	Tap Position|Resettable Count for Position 11
Tap Position|Resettable Count for Position 12	Tap Position|Resettable Count for Position 12
Tap Position|Resettable Count for Position 13	Tap Position|Resettable Count for Position 13

Tap Position|Resettable Count for Position 14	Tap Position|Resettable Count for Position 14
Tap Position|Resettable Count for Position 15	Tap Position|Resettable Count for Position 15
Tap Position|Resettable Count for Position 16	Tap Position|Resettable Count for Position 16
Tap Position|Resettable Count for Position 17	Tap Position|Resettable Count for Position 17
Tap Position|Resettable Count for Position 18	Tap Position|Resettable Count for Position 18
Tap Position|Resettable Count for Position 19	Tap Position|Resettable Count for Position 19
Tap Position|Resettable Count for Position 20	Tap Position|Resettable Count for Position 20
Tap Position|Resettable Count for Position 21	Tap Position|Resettable Count for Position 21
Tap Position|Resettable Count for Position 22	Tap Position|Resettable Count for Position 22
Tap Position|Resettable Count for Position 23	Tap Position|Resettable Count for Position 23
Tap Position|Resettable Count for Position 24	Tap Position|Resettable Count for Position 24
Tap Position|Resettable Count for Position 25	Tap Position|Resettable Count for Position 25
Tap Position|Resettable Count for Position 26	Tap Position|Resettable Count for Position 26
Tap Position|Resettable Count for Position 27	Tap Position|Resettable Count for Position 27
Tap Position|Resettable Count for Position 28	Tap Position|Resettable Count for Position 28
Tap Position|Resettable Count for Position 29	Tap Position|Resettable Count for Position 29
Tap Position|Resettable Count for Position 30	Tap Position|Resettable Count for Position 30
Tap Position|Resettable Count for Position 31	Tap Position|Resettable Count for Position 31
Tap Position|Resettable Count for Position 32	Tap Position|Resettable Count for Position 32
Tap Position|Resettable Count for Position 33	Tap Position|Resettable Count for Position 33
Tap Position|Resettable Count for Position 34	Tap Position|Resettable Count for Position 34
Tap Position|Resettable Count for Position 35	Tap Position|Resettable Count for Position 35
Tap Position|Actual Tap Position	Tap Position|Actual Tap Position
DLG|Rated Voltage on LV side	DLG|Rated Voltage on LV side
DLG|Rated Voltage on HV side	DLG|Rated Voltage on HV side

DLG|Rated Power at Cooling Stage 0	DLG|Rated Power at Cooling Stage 0
DLG|Rated Power at Cooling Stage 1	DLG|Rated Power at Cooling Stage 1
DLG|Rated Power at Cooling Stage 2	DLG|Rated Power at Cooling Stage 2
DLG|User estimated Water content in Winding insulation Paper	DLG|User estimated Water content in Winding insulation Paper
DLG|Number of Cooling Banks	DLG|Number of Cooling Banks
DLG|OverLoad Duration #1	DLG|OverLoad Duration #1
DLG|Load Limiting Factor #1	DLG|Load Limiting Factor #1
DLG|OverLoad Duration #2	DLG|OverLoad Duration #2
DLG|Load Limiting Factor #2	DLG|Load Limiting Factor #2
DLG|OverLoad Duration #3	DLG|OverLoad Duration #3
DLG|Load Limiting Factor #3	DLG|Load Limiting Factor #3
DLG|OverLoad Duration #4	DLG|OverLoad Duration #4
DLG|Load Limiting Factor #4	DLG|Load Limiting Factor #4
DLG|OverLoad Duration #5	DLG|OverLoad Duration #5
DLG|Load Limiting Factor #5	DLG|Load Limiting Factor #5
DLG|OverLoad Duration #6	DLG|OverLoad Duration #6
DLG|Load Limiting Factor #6	DLG|Load Limiting Factor #6
DLG|OverLoad Duration #7	DLG|OverLoad Duration #7
DLG|Load Limiting Factor #7	DLG|Load Limiting Factor #7
DLG|OverLoad Duration #8	DLG|OverLoad Duration #8
DLG|Load Limiting Factor #8	DLG|Load Limiting Factor #8
DLG|OverLoad Duration #9	DLG|OverLoad Duration #9
DLG|Load Limiting Factor #9	DLG|Load Limiting Factor #9
DLG|OverLoad Duration #10	DLG|OverLoad Duration #10

DLG|Load Limiting Factor #10	DLG|Load Limiting Factor #10
DLG|Max. Top Oil Temp.	DLG|Max. Top Oil Temp.
DLG|Max. Hot Spot Temp.	DLG|Max. Hot Spot Temp.
DLG|Min. Bubbling Margin Temp.	DLG|Min. Bubbling Margin Temp.
DLG|Max. Load Factor on HV Bushing	DLG|Max. Load Factor on HV Bushing
DLG|Max. Load Factor on LV Bushing	DLG|Max. Load Factor on LV Bushing
DLG|Max. Load Factor on Tap Changer	DLG|Max. Load Factor on Tap Changer
Communications|ConnectionString Communications|CronString Communications|IsScheduleEnabled Communications|NextScheduledDownload Communications|ServiceAlarmDescription Communications|NotificationEmail Communications|ExpertEmail Communications|IsAutoExportEnabled Communications|ExportCronString Communications|DownloadError Communications|ServiceAlarmDescription	Communications|ConnectionString Communications|CronString Communications|IsScheduleEnabled Communications|NextScheduledDownload Communications|ServiceAlarmDescription Communications|NotificationEmail Communications|ExpertEmail Communications|IsAutoExportEnabled Communications|ExportCronString Communications|DownloadError Communications|ServiceAlarmDescription
These are all property fields. No mapping is required.	
Environmental|Ambient Humidity	Environmental|Ambient Humidity
Environmental|Ambient Temperature	Environmental|Ambient Temperature
Environmental|Bottom Oil Temperature	Environmental|Bottom Oil Temperature
Environmental|Top Oil Temperature	Environmental|Top Oil Temperature
PrimaryBushing|C1% A	PrimaryBushing|C1% A
PrimaryBushing|C1% B	PrimaryBushing|C1% B
PrimaryBushing|C1% C	PrimaryBushing|C1% C
PrimaryBushing|C1% Polar Plot Level	PrimaryBushing|C1% Polar Plot Level
PrimaryBushing|C1% Polar Plot Angle	PrimaryBushing|C1% Polar Plot Angle
PrimaryBushing|PF% A	PrimaryBushing|PF% A
PrimaryBushing|PF% B	PrimaryBushing|PF% B
PrimaryBushing|PF% C	PrimaryBushing|PF% C
PrimaryBushing|PF% Polar Plot Level	PrimaryBushing|PF% Polar Plot Level

PrimaryBushing|PF% Polar Plot Angle	PrimaryBushing|PF% Polar Plot Angle
PrimaryBushing|AngleACReferenceDiff	PrimaryBushing|AngleACReferenceDiff
PrimaryBushing|AngleABReferenceDiff	PrimaryBushing|AngleABReferenceDiff
PrimaryBushing|Current A	PrimaryBushing|Current A
PrimaryBushing|Current B	PrimaryBushing|Current B
PrimaryBushing|Current C	PrimaryBushing|Current C
PrimaryBushing|System Frequency	PrimaryBushing|System Frequency
SecondaryBushing|C1% A	SecondaryBushing|C1% A
SecondaryBushing|C1% B	SecondaryBushing|C1% B
SecondaryBushing|C1% C	SecondaryBushing|C1% C
SecondaryBushing|C1% Polar Plot Level	SecondaryBushing|C1% Polar Plot Level
SecondaryBushing|PF% A	SecondaryBushing|PF% A
SecondaryBushing|PF% B	SecondaryBushing|PF% B
SecondaryBushing|PF% C	SecondaryBushing|PF% C
SecondaryBushing|PF% Polar Plot Level	SecondaryBushing|PF% Polar Plot Level
SecondaryBushing|PF% Polar Plot Angle	SecondaryBushing|PF% Polar Plot Angle
SecondaryBushing|AngleABReferenceDiff	SecondaryBushing|AngleABReferenceDiff
SecondaryBushing|AngleACReferenceDiff	SecondaryBushing|AngleACReferenceDiff
SecondaryBushing|Current A	SecondaryBushing|Current A
SecondaryBushing|Current B	SecondaryBushing|Current B
SecondaryBushing|Current C	SecondaryBushing|Current C
TertiaryBushing|C1% A	TertiaryBushing|C1% A
TertiaryBushing|C1% B	TertiaryBushing|C1% B
TertiaryBushing|C1% C	TertiaryBushing|C1% C

TertiaryBushing|C1% Polar Plot Level	TertiaryBushing|C1% Polar Plot Level
TertiaryBushing|PF% A	TertiaryBushing|PF% A
TertiaryBushing|PF% B	TertiaryBushing|PF% B
TertiaryBushing|PF% C	TertiaryBushing|PF% C
TertiaryBushing|PF% Polar Plot Level	TertiaryBushing|PF% Polar Plot Level
TertiaryBushing|PF% Polar Plot Angle	TertiaryBushing|PF% Polar Plot Angle
TertiaryBushing|AngleABReferenceDiff	TertiaryBushing|AngleABReferenceDiff
TertiaryBushing|AngleACReferenceDiff	TertiaryBushing|AngleACReferenceDiff
TertiaryBushing|Current A	TertiaryBushing|Current A
TertiaryBushing|Current B	TertiaryBushing|Current B
TertiaryBushing|Current C	TertiaryBushing|Current C
PD|PD Count Polar Plot Angle	PD|PD Count Polar Plot Angle
PD|PD Count Polar Plot Level	PD|PD Count Polar Plot Level
PD|PD Average Polar Plot Angle	PD|PD Average Polar Plot Angle
PD|PD Average Polar Plot Level	PD|PD Average Polar Plot Level
PD|PDI Polar Plot Angle	PD|PDI Polar Plot Angle
PD|PDI Polar Plot Level	PD|PDI Polar Plot Level
PD|PhaseA|Correlation PDi-RH	PD|PhaseA|Correlation PDi-RH
PD|PhaseA|PD Count	PD|PhaseA|PD Count
PD|PhaseA|PD Average Apparent Charge	PD|PhaseA|PD Average Apparent Charge
PD|PhaseA|PDI	PD|PhaseA|PDI
PD|PhaseB|Correlation PDi-RH	PD|PhaseB|Correlation PDi-RH
PD|PhaseB|PD Count	PD|PhaseB|PD Count
PD|PhaseB|PD Average Apparent Charge	PD|PhaseB|PD Average Apparent Charge

PD|PhaseB|PDI	PD|PhaseB|PDI
PD|PhaseC|Correlation PDi-RH	PD|PhaseC|Correlation PDi-RH
PD|PhaseC|PD Count	PD|PhaseC|PD Count
PD|PhaseC|PD Average Apparent Charge	PD|PhaseC|PD Average Apparent Charge
PD|PhaseC|PDI	PD|PhaseC|PDI
Parent	Parent

This is used to maintain the parent-child hierarchy so that the asset can be created at the appropriate level. No mapping is required.

An example hierarchy is as follows:

Area
  Substation
    Transformer1
      Transfix 1.6
      HydranM2
Transformer2
      TAPTRANS
      BMT300

Perception data exported to CSV format adheres to the following rules:

- The Parent header column against Transfix 1.6 and HydranM2 data rows will have the value 'Transformer1'.
- The Parent header column against TAPTRANS and BMT 300 data rows will have the value 'Transformer2'.
- The Transformer1 and Transformer2 data rows will have the value 'Substation' against their Parent header column.
- The Substation data row will have the value 'Area' against its Parent header column.

Data imported from a CSV file follows a three-step process for each asset to ensure that the same asset structure is maintained in the Asset Explorer. This is best explained as follows:

1. Perception first checks the Parent value of the asset. If the Parent node doesn't already exist in the database, Perception creates the Parent node and any associated child nodes in the hierarchy. If the Parent value in the CSV file is empty, then any child nodes are created at the top level of the hierarchy i.e. directly under the database node.
2. If the Parent node already exists in the database, then it checks the 'equipnum' and 'serialnum' fields. If both the values match, then any child assets will be created under that parent. If any one of them doesn't match, then a new Parent node will be created with the corresponding child assets.
3. The same logic of step 2 also applies to any child assets. If any asset already exists i.e. there is a match of the values 'parent', 'equipnum' and 'serialnum', then the data will be replaced for that asset on import. Otherwise if any one of them doesn't match, a new asset will be created.

Alarm Mappings

During import and export, alarms are treated as attributes of measurement points. Measurement points have various attributes. The alarm-specific attributes are as follows:

[OilSource] | [MeasurementType] | HighLimit *(numeric)*
[OilSource] | [MeasurementType] | HighEnabled *(boolean)*
[OilSource] | [MeasurementType] | HighHighLimit (*numeric)*
[OilSource] | [MeasurementType] | HighHighEnabled *(boolean)*

[OilSource] | [MeasurementType] | LowLimit *(numeric)*
[OilSource] | [MeasurementType] | LowEnabled *(boolean)*
[OilSource] | [MeasurementType] | LowLowLimit *(numeric)*
[OilSource] | [MeasurementType] | LowLowEnabled *(boolean)*

[OilSource] | [MeasurementType] | Formula *(text)*
[OilSource] | [MeasurementType] | FormulaName *(text)*
[OilSource] | [MeasurementType] | UpperAlarmValue *(numeric)*
OilSource] | [MeasurementType] | LowerAlarmValue *(numeric)*
OilSource] | [MeasurementType] | UpperRatioAlarmEnabled *(Boolean)*
OilSource] | [MeasurementType] | LowerRatioAlarmEnabled *(Boolean)*

The attributes required vary according to the measurement point. For example, the alarm for the O2 measurement point is defined as follows:
OilSourceA | 02
(the measurement point)
OilSourceA | 02 | EngineeringUnits
(ppm for gases)
OilSourceA | 02 | HighLimit
(numeric value)
OilSourceA | O2 | HighEnabled
(boolean flag to mark the High limit enabled or disabled by setting as TRUE or FALSE)
GasRatioFormulaContainer | OilSourceA | FormulaInfo1 | Formula
(numeric formula)
GasRatioFormulaContainer | OilSourceA | FormulaInfo1 | FormulaName
(text value)
GasRatioFormulaContainer | OilSourceA | FormulaInfo1 | UpperAlarmValue
(numeric value)
GasRatioFormulaContainer | OilSourceA | FormulaInfo1 | UpperRatioAlarmEnabled
(boolean flag to mark the Upper limit enabled or disabled by setting as TRUE or FALSE)

OilSourceA|O2	OilSourceA|O2|EngineeringUnits	OilSourceA|O2|HighLimit	OilSourceA|O2|HighEnabled
15838	ppm	100	TRUE

GasRatioFormulaContainer|OilSourceA|FormulaInfo1|Formula
(H2+C2H4+C2H6+CH4)/(C2H4)

GasRatioFormulaContainer|OilSourceA|FormulaInfo1|FormulaName
Ratio 1

GasRatioFormulaContainer|OilSourceA|FormulaInfo1|UpperAlarmValue
15

GasRatioFormulaContainer|OilSourceA|FormulaInfo1|UpperRatioAlarmEnabled
TRUE

Appendix C Troubleshooting

Table C-1 lists several problems and resolutions.

Table C-1: Problems & Resolutions

Problem	Resolution
Alarms not triggering for data imported from a CSV file? This happens because the AlarmStatus column in the CSV file incorrectly defaults to zero.	Before importing, ensure that the AlarmStatus column in the CSV file is manually populated with the correct values. If you are uncertain about the values, then delete the entire AlarmStatus column from the CSV file. During the import, when the AlarmStatus column is found to be missing, Perception regenerates that column with the correct values.
Anti-Virus software or firewall blocks Perception-related executables.	Perception-related executables may need to be added to the host PC or corporate anti-virus and firewall software. The following executables are launched from Perception: C:\Program Files (x86)\KelmanDownload\ KelmanDownload.exe C:\Program Files (x86)\GE Digital Energy\Perception 2.4.5\ TransconnectBootLoader.Exe CefSharp.BrowserSubprocess.exe MPDump.exe Perception.Database.Upgrade.Tool.exe Perception.Desktop.exe Perception.Devices.Provider.Host.exe Perception.Server.Configuration.Tool.exe Perception.Server.exe Transconnect.exe Perception.Workflow.Designer.exe C:\Program Files (x86)\GE Energy\BMT 330\BMT_330.exe
Failure to Connect to the Server	Server certificate not trusted. See Section 2.4.1.1
Perception Service does not appear in Desktop Discovery wizard.	This can be caused by several incorrect configurations. • Ensure IP Address or Hostname of Perception Server is correct. • If Perception Server is installed on a PC with another OPC service, ensure that the UA Discovery Server service is running. Verify in services.msc. • Ensure the Perception Server Service is running, check in services.msc. • Ensure the SQL Service is running, check in services.msc. • Ensure the Kelman database is configured in the Perception Server Config Tool. • Ensure the Microsoft Distributed Transaction Coordinator service (MS-DTC) has started on the PC running the Perception Server. If it was not running you may need to restart the Perception Server and UA Local Discovery Server services after starting.

	• Ensure MS-DTC is configured correctly: Windows Server 2008. See http://support.microsoft.com/kb/817064 • Ensure the Perception Server and Discovery Server certificates exist in the trusted certificate folder and that they are configured correctly within the services configuration files. To correct configuration, run the Perception Server installer and select the repair option.
Security parameters not appearing at the end of the Perception Server discovery connection wizard.	Ensure the ports required by the Perception applications are not blocked by a firewall (ports 4840 & 62541).
The Gas Ratios 3D graph does not appear on the Gas Ratios workbook.	Ensure you have the latest drivers for your graphics card.
When you launch Perception Desktop the application or activation window is blank.	Ensure you have the latest drivers for your graphics card.
Users are no longer able to log in even though usernames and passwords are correct.	This can occur if a new server certificate has been created on the Perception Server host. To correct the issue you need to delete and re-add the users.
HydranM2: Exception raised when configuring HM2 via Perception Setup	Intermittent issue. The workaround is to instead use the Multihost software to configure the device.
While importing CSV files into a local KPD file, the browsing performance of Asset Explorer is slow.	This may be hardware performance related. Wait until the KPD import completes. This is not an issue using SQL Server.
Perception Desktop Freezes when you open a KPD database or try to connect to Perception Server.	Delete the Perception folder located in: %APPDATA%\GE_Energy Note: '%APPDATA%' points to the 'Roaming' application data folder
Connecting to Perception Server Error - 'The requested key container was not found'.	Intermittent issue. Close the 'The requested key container was not found' error by clicking OK. Close the Perception Desktop application and reopen it. Attempt connection to Perception Server again.
Perception installer failure – 'An internal error occurred'.	Perception installers will fail if the following Microsoft Windows update is installed on the machine KB2918614. This is a known Microsoft Windows update issue; the update must be removed in order to install Perception successfully.
Trouble importing CSV data in Non-English windows environment.	If the decimal and list separator symbols used in the CSV file to be imported into Perception Desktop do not match the environment variables set in Microsoft Windows, the import of the data into Perception will fail. Either the CSV file must be updated with the correct symbols or the environment variables should be changed to match the CSV file.
Perception Desktop certificates error – 'Perception Desktop certificate missing, reinstall/repair setup to connect' reinstall/repair does not correct error.	Intermittent issue. Perception Desktop installer fails to create certificates or certificate assignments can be missing after a Perception Desktop upgrade is performed. To resolve this issue (Windows 7): 1. Browse to C:\ProgramData\ 2. Delete the 'OPC Foundation' folder 3. Browse to C:\Program Files (x86)\Common Files (on x64 OS) 4. Delete the 'OPC Foundation' folder 5. Browse to C:\Program Files\Common Files (on x86 OS) 6. Delete the 'OPC Foundation' folder 7. Uninstall Perception Desktop 8. Re-install Perception Desktop

Unexpected or empty wallboards	Clear wallboards cache – folder located in: C:\Documents and Settings\<User>\Local Settings\Temp\Wallboard, where <User> stands for a user logged in to the Windows system
When attempting to download from an MS 3000 device, the following message appears in the Response field: ”The remote certificate is invalid according to the validation procedure”.	The MS 3000 is configured for HTTPS communication, but downloading data from the device requires a valid certificate to be added. See Appendix G: MS 3000: HTTPS & Self-signed Certificates.
When trying to download from a Hydran unit or launching setup for a Hydran unit, an error appears stating TMW.SCL.dll or related component cannot be loaded.	The Windows environment does not have the required C++ library (x86). Please install the Microsoft Visual C++ 2010 Service Pack 1 Redistributable Package, https://www.microsoft.com/en-gb/download/details.aspx?id=26999

Appendix D PGA Diagnostic Error codes and Status Flags

The Data Table tooltip, an example of which is shown below, includes a Diagnostic row that lists PGA diagnostic information. E.g. PGA;0,0,6. The syntax for the PGA entry is:

```
PGA;[errorState],[errorCodes],[flagNumber]
```

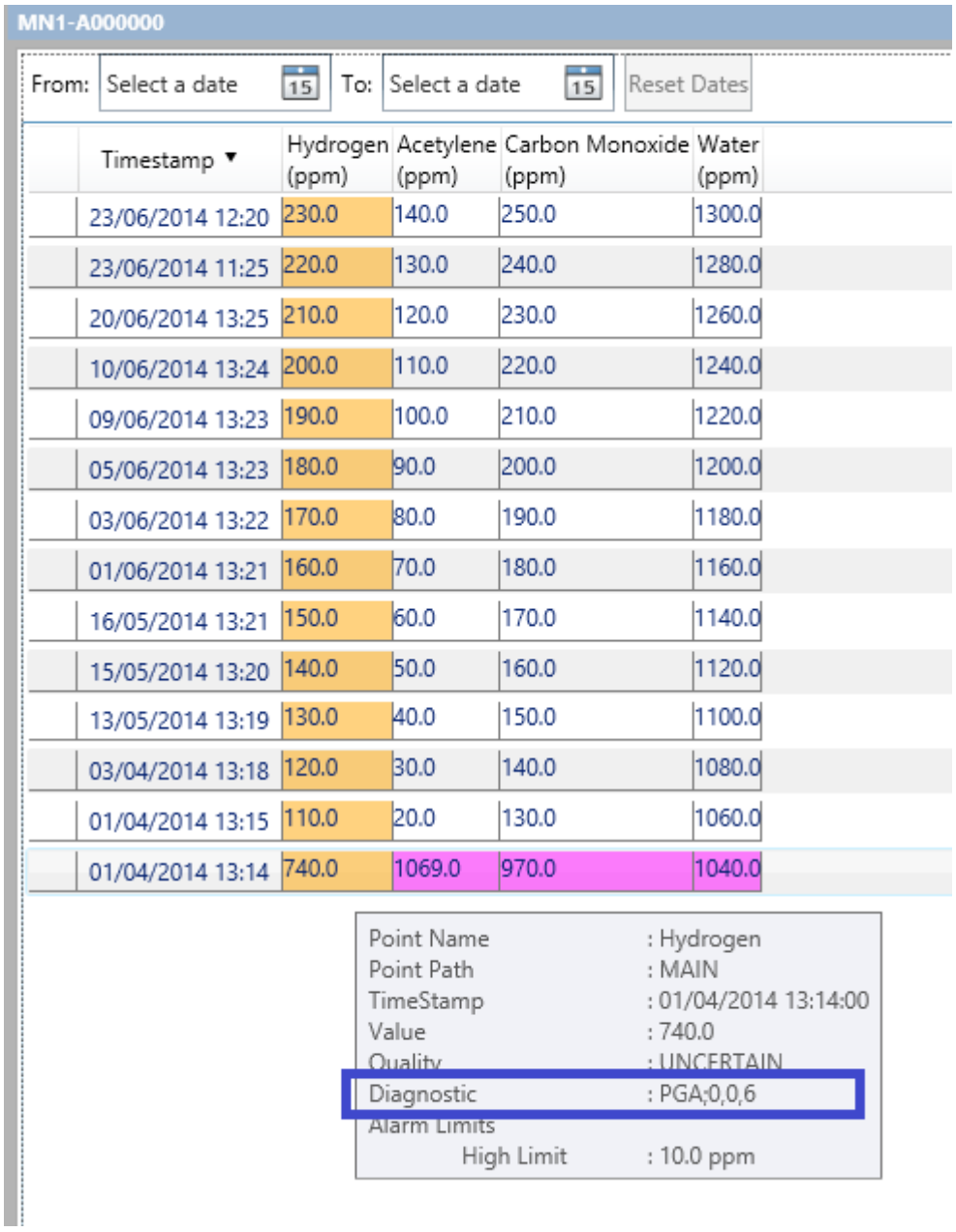


Figure D-1: PGA diagnostic information

Note: Perception displays the flag number in decimal, but this must be converted to binary in order to draw comparison with the bitmap outlined in Table D-3. E.g. a decimal status flag of 6 in the above example equates to binary 0000000000000110. Using Table D-3, this would indicate that the PPM values are valid and that it is the first measurement after a reset.

Table D-1 lists all Transfix-family PGA Diagnostic Error Codes.

Table D-1: Transfix-family PGA Error codes

Error Codes (32-bit field)	Description
bit 0	1 = Missing mains input (obsoleted)
bit 1	1 = PGA power supply voltage too low
bit 2	1 = PGA chopper frequency outside range
bit 3	1 = PGA IR-source outside range
bit 4	1 = Gas flow lower than limit
bit 5	1 = Background noise/vibration too high
bit 6	1 = Microphone test failed
bit 7	1 = Not Levelsensor1 pulses (level)
bit 8	1 = Not Levelsensor3 (drain)
bit 9	1 = Fill level shows oil
bit 10	1 = Over Fill level shows Oil
bit 11	1 = PGA Air temperature outside limits
bit 12	1 = Bad communication with control PCB
bit 13	1 = Gas leak test: Pump pressure too low
bit 14	1 = Gas leak test: Pressure decay too high
bit 15	1 = Unusual ambient gas measurements
bit 16	1 = Oil temperature too low
bit 17	1 = Oil temperature too high
bit 18	1 = Oil pressure too low
bit 19	1 = Oil pressure too high
bit 20	1 = Oil pump tacho count too high
bit 21	1 = Oil pump pressure too low
bit 22	1 = Oil pump speed out of range
bit 23	1 = Manual oil sampling switch
bit 24	1 = Oil pump tacho count too low
bit 25	1 = Oil pump not turning
bit 26	{not used/defined}
bit 27	1 = Temperature Sensor(s) 1 disconnected
bit 28	1 = Temperature Sensor(s) 2 disconnected
bit 29	1 = Drain level shows oil
bit 30	1 = Conditioned oil temp. outside limits
bit 31	{not used/defined}

Table D-2 lists all MINITRANS PGA Diagnostic Error Codes.

Table D-2: MINITRANS PGA Error codes

Error Codes (32-bit field)	Description
bit 0	1 = Missing mains input (obsoleted)
bit 1	1 = PGA power supply voltage too low
bit 2	1 = PGA chopper frequency outside range
bit 3	1 = PGA IR-source outside range
bit 4	1 = Gas flow lower than limit
bit 5	1 = Background noise/vibration too high
bit 6	1 = Microphone test failed
bit 7	1 = Not Levelsensor1 pulses (level)
bit 8	1 = Not Levelsensor3 (drain)
bit 9	1 = Levelsensor1 (level)

bit 10	1 = Levelsensor2 (level alert)
bit 11	1 = PGA Air temperature outside limits
bit 12	1 = Bad communication with control PCB
bit 13	1 = Gas leak test: Pump pressure too low
bit 14	1 = Gas leak test: Pressure decay too high
bit 15	1 = Unusual ambient gas measurements
bit 16	1 = Oil temperature too low
bit 17	1 = Oil temperature too high
bit 18	1 = Oil pressure too low
bit 19	1 = Oil pressure too high
bit 20	1 = Oil pump tacho count too high
bit 21	1 = Oil pump pressure too low
bit 22	1 = Oil pump speed out of range
bit 23	1 = Manual oil sampling switch
bit 24	1 = Oil pump tacho count too low
bit 25	{not used/defined}
bit 26	1 = 5 V supply below 4.5 V
bit 27	1 = Temperature Sensor(s) 1 disconnected
bit 28	1 = Temperature Sensor(s) 2 disconnected
bit 29	1 = Drain level shows oil
bit 30	{not used/defined}
bit 31	{not used/defined}

Table D-3 lists all PGA Status Flags.

Table D-3: PGA Status flags

Status Flag (bit field)	Description
bit 0	1 = ESHL Valid
bit 1	1 = PPM values valid
bit 2	1 = First measurement after reset
bit 3	1 = Sampling Skipped
bit 4	1 = Error checking disabled
bit 5	1 = Nitrogen Valid
bit 6	1 = TDG Valid
bit 7	1 = Oil Switch failed
bit 8	1 = Spurious alarm suspected
bit 9	1 = Manual Sample
bit 10	1 = Measurement Manually Stopped
bit 11	1 = Weak NHC Indication
bit 12	1 = Strong NHC Indication
bit 13	1 = Measured with PreSens sensor
bit 14	1 = External Alarm ON
bit 15	1 = TDH Valid

Appendix E Model Descriptions

E.1 Japanese ETRA Models

Reference source: “Latest Diagnostic Methods of Gas-in-oil Analysis for Oil-filled Transformer in Japan; Proceedings of 13th International Conference on Dielectric Liquids (ICDL ’99), Nara Japan 20-25th July 1999.”

An extract of the summary and introduction are reproduced below:

DGA is one of the most widely used diagnostic techniques for detecting and evaluating types of faults in a transformer. The first edition of "Supervision and Maintenance by DGA” standardized by the ETRA in 1980, has been widely used for oil filled transformers in Japan. The standard, however, lacked diagnoses for some cases and had no detection limits nor precision requirements for DGA. Therefore, the ETRA started to investigate the actual status of conventional diagnosis by DGA in Japan and overseas. Also, DGA data have been investigated on about 1300 operating transformers which are now in service including some which have experienced inner faults. As a result, a new "Supervision and Maintenance by DGA" which is the second edition was released in February 1999. This paper summarizes that standard.

Regarding gas analysis methods in oil which are used presently in Japan, torricelli, toepler pump, vacuum piston and stripping methods are used for the extraction of dissolved gases in oil and gas chromatography is used for analysis of the extracted gases. Review of the analysis sensitivity of each gas in 12 laboratories showed the detection and determination limits had some scattering among the laboratories. By considering the detection limits that were standardized in IEC 567 (1992) and the determination limits which are necessary to improve the precision of present diagnoses by DGA, the detection limit was defined as 3 times the noise level and the determination limit was defined as 5 times the detection limits. The repeatability and reproducibility were evaluated by the Round Robin Test with the three gas-in-oil-standard samples and the sample oils taken from transformers in service. By using the evaluation formula of repeatability which was prescribed by IEC 567 (1992) and the detection limit, it was found that the repeatability for each gas at each laboratory satisfied the evaluation formula at a 93.9% probability. It was found that the repeatability and reproducibility of the stripping method were better than those of the other extraction methods.

The paper then defines some new gas correlations that have prognostic utility.

E.2 Multi-Host Models

Reference source: GE Multi-Host Manual, part# 18415

E.2.1 Dynamic Loading Model

The purpose of this model is to provide the transformer owner and operator with a continuous estimation of the capacity of the transformer (and its associated components) to continue safe operation under overloading conditions. Starting with current conditions of oil temperature and ambient temperature and using a steady load of a given magnitude, the model computes how long this load can be carried until a limit condition is reached. The implementation of this model in the Hydran M2 with Models and Intellix MO150 Devices is also known as 'Time vs Steady Load.'

The model's Device Provider setup offers two choices for the Ambient Air Temperature and Top Oil Temperature — either to use manual input values or sensor-measured values. Manual input values are useful for simulation purposes and are used only in the calculations of the model. The device will still always gather sensor-measured values and render these in all other areas of the software where these values are used e.g. data view charts and dashboards. This feature is available only for the MO150 device with firmware version 3.06 or higher.

This model is intended for short-duration overloads, as when a parallel transformer is removed from service for maintenance for a few hours or less. Model computations are made with the assumption that the transformer is operating on the top-cooling mode. Computations of the top oil and winding temperatures are carried out according to Section 7.2 of IEEE C57.91-1995, Guide for Loading Mineral-Oil-Immersed Transformers. A similar calculation method is described in Section 8.2.2 of IEC 60076-7, Loading Guide for Oil-Immersed Power Transformers.

Calculation starts with a load of 1.1 p.u. and actual values for Ambient Temperature and Top Oil Temperature (from sensors). The ambient temperature is assumed to remain constant for the period of overload being considered. The actual top oil temperature will be used as a starting point for oil temperature calculation at each load level. Calculations are done with this load level (1.1 p.u.) and with a time increment of 0.1 hour (6 minutes) until one of the Limiting Factors (or Overload Limit) is exceeded or when the acceptable duration exceeds 12 hours (720 minutes). The calculation is then repeated with a load of 1.2 p.u. and the acceptable duration is determined (less or equal to 720 minutes) again along with the Limiting Factor that was first reached. This calculation is repeated until a load of 2.0 p.u. is reached.

For each Load level, the time duration to reach the limit is recorded along with the Limiting Factor that was first reached. If the 12 hours (720 minutes) were reached but no Limiting Factor was exceeded, the Limiting Factor is shown as "Duration." If the Hydran M2 with Models and Intellix MO150 Devices are working in the on-line mode of operation, then the computation is repeated every 10 minutes using the actual sensor values. If the Hydran M2 with Models and Intellix MO150 Devices are working in the off-line mode of operation, then

the output screen reflects the values computed during the last on-line operation.

E.2.2 Insulation Ageing Model

Winding insulation is made of oil-impregnated cellulose material. In order to properly fulfil its function, this material must have a certain mechanical strength and flexibility. These properties depend on the length of the cellulose chain constituent of the paper and pressboard. With time and temperature, these long polymer chains break down into shorter segments, a process called depolymerisation. The practical effect is that the paper loses its flexibility and tensile strength to become a brittle material. The winding is continuously submitted to clamping forces and vibrations. Moreover, during short-circuit on the system, these forces are increased tremendously and if the insulating paper is too brittle, it may rupture under the pressure and create a weak point in the insulation that will later allow flashover between adjacent turns when a voltage surge occurs on the transformer.

This insulation aging process is irreversible. It is also the main factor determining the transformer's end of life. The rate of aging of cellulose insulation material is a function of the following factors:

- *Insulation temperature at the hot spot*: The effect of temperature is the most important, as described in the IEEE and IEC Loading Guides. The effect of temperature on aging is a function of the type of paper. It is therefore important to state in the configuration page the type of paper used for winding insulation.
- *Water content in the winding insulation paper*: It is assumed that the aging acceleration factor is directly proportional to the water content with 0.5 % as reference value for dry paper. The water content in winding insulation is computed in the Moisture Content in Insulating Barrier model. The effect is more severe on normal Kraft paper than on thermally-upgraded paper and it can be practically neglected on Aramid paper.
- *Oxygen content of the insulating oil*: This oxygen content can be inferred from the type of oil preservation system. The IEEE Loading Guide recommends using an aging acceleration factor of 2.5 for free-breathing conservators while the sealed-type transformers and those with a membrane in the conservator are practically oxygen-free.

The following Model Output Text Parameters are displayed in the Insulation Ageing Model:

- *Thermal Aging Acceleration Factor*: It considers only the hot-spot current temperature.
- *Moisture Aging Acceleration Factor*: It considers only the effect of moisture in paper.
- *Global Aging Acceleration Factor*: This is the actual aging rate or aging acceleration factor, considering the cumulated effect of temperature, moisture and oxygen in oil.

- *Cumulative Aging*: This field indicates the aging cumulated since the commissioning of the system, adding the “Previous Aging” if this value was configured on the Insulation Aging Model configuration page. The value is expressed in days of operation at rated temperature; for instance, a transformer with thermally upgraded paper operating 24 hours at 117 °C will undergo 2 days of “normal aging at rated temperature.”
- *Service Time*: This field indicates the number of days the transformer has been in service since the commissioning of the system, adding the “Previous Service Time” if this value has been configured.

E.2.3 Moisture and Bubbling Model

The moisture content of the oil and the solid insulation is a serious concern for power transformers, especially for aging units. Extensive drying procedures are applied at the manufacturing stage and sustained efforts are deployed in service to maintain a high level of dryness. However, with time, water can penetrate through various paths such as the air breather and leaky gaskets. Aging of cellulose also releases some water. Moisture tends to accumulate in the solid insulation and leads to several detrimental consequences, namely:

- Acceleration of insulation aging.
- Risk of water vapour bubbles being released from the winding insulation.
- Reductions of dielectric strength of insulating barriers.
- Risk of water condensation in transformer oil at low temperatures.

Moisture content assessment is too often derived from a single oil sample submitted to a Karl Fischer test in laboratory. This is a valid approach for oil evaluation but it does not allow evaluation of the moisture content in the solid insulation as the rate of water exchange between the oil and the paper has to be considered. On-line monitoring of moisture in oil allows the integration of temperature variations and the computation of a dependable value for moisture content in the various components of the solid insulation system, even if they are at different temperatures and characterized by different diffusion rates.

The most critical part of the winding insulation is the top of the winding that operates at the hot-spot temperature. This is the area where the aging is most severe, and the effect of the water content can be computed. The determination of the critical temperature for bubble evolution takes into account the atmospheric pressure, the oil pressure above the hot-spot area, and the amount of gas dissolved in the oil.

The moisture sensor continuously monitors the oil’s temperature and relative moisture saturation at the sensor location. A filtering is applied to remove the effect of cyclic heating created by the sensor to ensure oil circulation. This filtered value is used to calculate the absolute value of the water content in the oil, the temperature of water condensation, and the relative saturation at the reference temperature.

Since the oil and winding temperature varies continuously, this moving target is used with an integrating algorithm taking into account the diffusion time constant and the temperature. The calculated value of the water content in the winding insulation allows prediction of the bubbling temperature. It is also used in the Insulation Aging model (described above).

E.2.4 Apparent Power Model (MVA)

The primary function of this model is to continuously monitor the load carried by the transformer in MVA (Mega Volt-Amperes). The Apparent Power can be computed on the primary, secondary, and tertiary windings, depending on the input configuration. The historic maximum MVA value is retained with a time stamp and can be reset.

The current signal is a mandatory input, whereas the voltage signal is configured as a fixed value. Since voltage variations occurring in service and tap changer operations are not taken into consideration, the MVA is an approximate reading, and used only for display purposes.

The model's Device Provider setup offers two choices for the Apparent Power model computations — either to use manual input values or sensor-measured values. The former requires the user to assign three new types to the output models of an Analog input:

- Rated Voltage on HV side
- Rated Voltage on LV side
- Rated Voltage on tertiary side

When a new measurement sensor for voltage output is assigned to an Analog input, the Apparent power model is calculated based on this measured voltage instead of the one manually configured on the device, and displayed in the appropriate worksheets in Perception.

Manual input values are useful for simulation purposes and are used only in the calculations of the model. The device will still always gather sensor-measured values and render these in all other areas of the software where these values are used e.g. data view charts and dashboards. This feature is available only for the MO150 device with firmware version 3.06.

E.2.5 Winding Hot-Spot Temperature Model (WHST)

The rating of a transformer is closely linked to the winding temperature as it governs the insulation aging rate and bubbling release threshold (both estimated by other models described above). This winding temperature can also raise an alarm if excessively high values occur. In the industry standards, the winding temperature limit is defined as a temperature rise above the ambient air temperature. The cooling system is designed to ensure that at full load, the average winding temperature rise does not exceed the industry-accepted value (usually 65 °C).

However, it is not the average winding temperature that is of most interest but rather the temperature in the hottest area (the 'hot-spot temperature'). This temperature cannot be measured directly as it is not possible to insert thermocouples in a winding that is to be put in service. It is possible to use fibre optic temperature sensors that do not interfere with dielectric strength, but this procedure is costly and is usually limited to the validation of the manufacturer calculation methods. Therefore the traditional method was to use a Winding Temperature Indicator to fulfil that function.

A more accurate and reliable evaluation of the hot-spot temperature can be provided, using the equations provided in the IEEE and IEC Loading Guides:

- IEEE C57.91 - 1995, IEEE Guide for Loading Mineral-Oil-Immersed Transformers
- IEC 60076-7 - 2005, Power Transformers - Part 7: Loading Guide for Oil-Immersed Power Transformers

In the computation methods described in these Loading Guides, a key value is the temperature difference between the winding hot-spot and the top oil at rated conditions. This value is normally provided by the transformer manufacturer after suitable validation of their computation method. In the Winding Hot-Spot Temperature model, this rated value is corrected to account for actual load current and winding thermal time constant. The computed hot-spot temperature rise is then added to the measured top oil temperature to provide the actual winding hottest-spot temperature.

The winding hot-spot temperature is computed separately for each winding. The highest value of winding hot-spot temperature is identified and used to raise an alarm signal on the transformer. The hottest winding might not always be the same, depending on the load on the tertiary winding and on the position of the tap changer.

For autotransformers, the winding hot-spot temperature is calculated for the series winding (H), the common winding (C) and the tertiary winding (Y). The current in the common winding is calculated by subtracting the secondary load current minus the primary load current.

E.2.6 Cooling Status

This model allows identification of the cooling stage currently in service. The cooling bank refers to the cooling device. A transformer can have several sets of fans and each one will be supplied by a feeder where the current can be measured. Information concerning the status of each cooling device (oil pumps, water pumps, fans) can be provided from several sources. The most common is a set of digital inputs giving the status (ON / OFF) of the relay supplying the cooling device. This information is adequate to allow determination of the cooling stage and the cumulative operating time for each device. A measurement of the current consumption by each cooling device can also be provided by AC RMS sensors or DC analog sensors. If this is the

case, additional information can be developed such as detection of inoperative fans or bearing gripping. The digital indication of cooling bank status is to be used as the prime source of information. For determination of cooling bank status, cooling bank feeder current is to be used only if no digital information is available. The digital indication of cooling bank status is to be used as prime source of information. For determination of cooling bank status, cooling bank feeder current is to be used only if no digital information is available.

E.2.7 Cooling Efficiency

This model computes the top oil temperature that should be expected considering the load current, the ambient temperature, the cooling mode, the oil time constant and the altitude.

The calculated value is then compared with the measured value and an alarm is raised if the transformer is found to be overheating. This calculation is used to detect obstructions, such as dirt on the coolers, which could be a limiting factor when the transformer is required to operate at full load or under overload conditions.

During the initial model computation, the measured values of top oil temperature and ambient temperature are used to provide a starting point for the calculated value of top oil temperature rise. From then on, the calculated temperature at the end of the time interval is used as the initial temperature for the next time interval. This calculation is run with load current in the H winding only. The rated current for each cooling stage is calculated from the rated power on each stage and the rated current on the top cooling stage. The ultimate temperature rise and the current temperature rise are calculated considering the actual cooling stage and the actual oil time constant. This value is added to the ambient temperature to provide a calculated top oil temperature. This value is subtracted from the measured top oil temperature and the difference is averaged over a configurable period. An alarm is raised when the difference exceeds a configured value for a period of time that is also configurable. The model can accommodate a transformer with one, two or three cooling stages.

E.2.8 OLTC Tap Position

Tap changer driving mechanisms are always provided with a visual tap position indicator and a counter indicating the total number of operations. This model provides additional information that is useful to monitor the proper operation of this critical unit, such as:

- The cumulative number of operations at each tap since commissioning
- Resettable variables for operation and maintenance counts
- Warnings for excessive number of operations over a certain period

- The time spent since the last operation of the reversing switch
- A warning to avoid contact cooking because of insufficient operation

A position transducer, driven by the visual indicator shaft (also called Geneva shaft), provides a 4–20 mA signal that is proportional to the tap changer mechanical position. The multi position switch can be equipped with jumpers (instead of resistors) in the “through positions” where the tap position indicator stays only momentarily during operation of the reversing switch. In this case, the potentiometer provides an indication of the electric position of the tap changer. When the tap changer operates, the signal should remain steady, until it changes to a new value without falling to zero.

It is assumed that the Geneva shaft rotates by a fixed value for each step on the transducer. The signal from the Geneva shaft position transducer is read at regular intervals and is analyzed to determine the actual position of the visual position indicator.

The position generated may refer to the mechanical position of the Geneva gear or the electrical position. In the first case, the mechanical position is converted into the electrical position considering the number of through positions specific to this tap changer when it moves to the neutral position.

The number of operations on each tap position is presented by histograms using the tap position denomination configured. The system provides three separate registers to record the number of operations carried out by the tap changer:

- The *Permanent Tap Position Transition Count* is intended to sum all operations since the commissioning of the system. However, if the monitoring system is moved to a different transformer, the System Administrator can reset this value to zero. This counter provides the number of operations on each tap position, the total number of operations, and the date when the system was put in service. The total number of operations performed prior to the commissioning of the system can also be taken into account.
- The *Operator Tap Position Transition Count* can be reset by the Operator when there is a need to check the number of operations in one day, or several days, in order to demonstrate that the tap changer control unit is operating properly. This counter provides the number of operations on each tap position, the maximum and minimum positions visited by the tap changer since the last reset, and the date of the last reset.
- The *Maintenance Tap Position Transition Count* is used by maintenance personnel to assess the need for maintenance and to plan maintenance schedules. It is typically reset every three or four years when an inspection activity is performed on the unit. This counter provides the number of operations on each tap position, the maximum and minimum positions visited by the tap changer since the last reset, and the date of the last reset.

E.2.9 OLTC Differential Temperature

The On-Load Tap Changer (OLTC) Temperature Differential model continuously compares the top oil temperature in the main tank with the tap changer compartment temperature. Monitoring of the tap changer temperature is a recognized method of detecting abnormal operating conditions in the tap changer. This monitoring method is intended for tap changers mounted on a separate compartment on the transformer tank. The tap changer temperature is normally lower than the main tank temperature because no heat source is expected in the tap changer. If the tap changer temperature rises above the main tank temperature, it is indicative of an overheating contact.

The temperature difference is calculated by subtracting the tap changer temperature minus the main tank temperature, thus yielding a negative value. This method allows to set the alarm on a positive threshold value rather than a negative value. This temperature difference is averaged with a low-pass filter to eliminate normal variations arising from sunshine and wind.

A short-term averaged value is generated with a configurable filtering factor typically set at 60 minutes. This short-term average is intended to detect severe heat sources such as resistor overheating when the mechanical links break while the switches are between two contacts.

A long-term averaged value is generated with a configurable filtering factor typically set at 7 days. This long-term average is intended to detect slow-evolving thermal problems such as contact overheating. The measured temperature difference is averaged over a round number of days to filter out the daily temperature variations.

E.2.10 Temperature Model

The Temperature Model is specific to the Hydran M2. It displays a trend for the temperature readings taken for the thermal sensors supported on the Hydran M2.

The following values are displayed:

- Tank #1 %RH Sensor Temperature °C (Relative Humidity)
- Sensor #1 Heater Power in %
- Top Oil Temperature °C
- Tank #1 %RH Sensor Temperature °C Hourly Average (Relative Humidity)
- Sensor #1 Hydran Sensor Temperature °C
- Sensor #1 Base Plate Temperature °C

E.2.11 Hydran Reading

The Hydran Reading worksheet is specific to the Hydran M2. It displays the Hydran gas level readings taken from the device as well as the Hydran Sensor Temperature.

The gas levels are displayed as actual level in PPM, Hourly Trend in PPM and Daily Trend in PPM.

The Hydran Sensor Temperature is displayed in Degrees Celsius.

E.2.12 Transformer Status Model

The Transformer Status Model is specific to the Intellix MO150. It combines information from other models calculations into one worksheet.

The following information is displayed:

- Top Oil Temperature °C
- Ambient Temperature °C
- Tank #1 %RH Level (Relative Humidity)
- Tank #1 Hydran Level
- Tank #1 H2O PPM Hourly Average
- Highest Winding Hot Spot Temperature °C
- Highest (P.U) (Per unit load on the most loaded winding)
- % Moisture Content In Winding Paper
- % Moisture Content in Insulating Barrier

E.2.13 Cooling Control

The transformer manufacturer usually provides a control system that offers several basic features that are not duplicated by this model and need to be maintained:

- Individual thermal protection on each motor
- Electrical protection as specified by local electrical code
- Manual interruption of power to allow for maintenance activity (removal and replacement of a fan)
- Temporization system to avoid the starting of two cooling banks simultaneously, especially if the Device monitoring system experiences a power failure

However, taking advantage of a monitoring system to improve the performance of the cooling system extends the useful life of the transformer while reducing maintenance costs. Beyond the basic features provided by the transformer manufacturer control system, this model provides the following functions:

- Beside input from top oil and winding temperature, it is now possible to link cooler initiation to the load current, thus providing an earlier start when a sudden overload occurs.
- The transformer rating can be adjusted to the ambient temperature to have a more consistent cooler operation. For example, in winter, cooling stages 1 and 2 start at ahigher current.
- The transformer rating can also be adjusted to the altitude. At higher altitude, the ratedcurrent is reduced to account for reduced air density, therefore the cooling system should be started at lower load current.
- For transformers with two cooling banks, a duty-sharing function can be initiated. Many users prefer to alternate the usage of cooling banks to equalize the wear on bearings and extend the period between fan motor maintenance.
- The cumulative operating time is computed for each cooling bank.
- A temporization function is included to avoid the two cooling banks from starting at the same time.
- The current drawn by the two cooling banks is monitored with two dedicated analog inputs. These values can be used to detect cooling bank status if no digital input is available for this purpose.
- A cooler exercising routine can be used to run the units for a few minutes every week.
- Continuous measurement of cooling bank current is also used to detect malfunction when the current is significantly below or significantly above the rated values.
- A cooling discrepancy function will raise an alarm whenever the cooling status of one cooling bank is not reflecting the cooling control instruction that was issued.

The Cooling Control model is intended for transformers that have two or three ratings related to specific cooling modes. The lowest rating is defined as “cooling stage 0”, and it usually applies to the natural cooling of the transformer tank without any fan or pump. In other words, this mode is not controlled by the cooling control system. Some transformers (such as indoor generating units) have only one cooling mode, so that whenever the transformer is energized, the full cooling is automatically initiated. These units are treated as having only cooling stage 0, and several of the control features described below are not applicable.

Appendix F Offline DGA & Oil Quality Workflow

Perception Fleet deploys the Offline DGA & Oil Quality workflow to evaluate transformer risk. The workflow evaluates DGA data including moisture and additional oil properties from laboratory analysis results to calculate the risk index for a transformer.

F.1 Implement the offline risk workflow

Follow these steps to implement the offline risk workflow in Perception Desktop.

Note: Perception Server and Perception Workflow Designer must be installed.

F.1.1 Prepare a CSV file with offline measurements data

Use an editor to create or modify a CSV file with the necessary offline measurements data. The available parameters are listed in Table F-1.

Specify the list of parameters, populate them with values and save the file.
Note: A sample CSV file called “Offline_Oil_Analysis_Example.csv” is located on the installation CD in the “Example Files” folder.

Table F-1: CSV fields

Mandatory fields	Comment
equipnum	TransformerID
serialnum	
apprtype	Always set to TRN
tank	Name of the compartment e.g. ‘MAIN’ in ‘Offline_Oil_Analysis_Example.csv’ associated with the Offline Oil Quality measurements.
sampledate	Sample timestamp
Oil property fields	**Comment**
visual	Standardized oil appearance remarks
color	Fluid color index
iec156	Dielectric breakdown - IEC 156
fq_water	Moisture concentration
acidnum	Acid number
tan_delta	Fluid dissipation factor
resistivity	Resistivity at 90 C (gigohm-meters)
inhibitor	Oxidation inhibitor concentration
ift	Interfacial tension (IFT)
totalpcb	Total PCB concentration
d1275a, d1275b	Corrosive sulfur test result
passivator	Passivator concentration
d1816_1, d1816_2	Dielectric Breakdown Voltage VDE electrode-1mm and -2mm
pf25	Fluid Power Factor at 25 C

pf100	Fluid Power Factor at 100 C
totalfuran	Total furans
resistivity_20	Resistivity at 20 C (gigohm-meters)
sludge	Sediment and sludge, %
h2	Hydrogen concentration in PPM
ch4	Methane concentration in PPM
c2h6	Ethane concentration in PPM
c2h4	Ethylene concentration in PPM
c2h2	Acetylene concentration in PPM
co	Carbon Monoxide concentration in PPM
co2	Carbon Dioxide concentration in PPM

Standard TOA4 field names are also supported. See Appendix F.2 for more details on supported parameters.

F.1.2 Run the workflow

Use Perception Desktop to run the workflow.

1. Start **Perception Desktop**.
2. Connect to the Perception Server.
3. Select **Actions** > **Import** > **Import File** and choose the CSV file created previously. A transformer instance appears in the asset tree using the CSV field value from "equipnum".
4. Select the transformer instance and then select the **Properties** tab.
5. In the Main Transformer Details section, complete the following as shown in Figure F-1 (see Appendix F.2 for configuration details):
   - Rated Voltage Max (kv)
   - Inhibited (check or uncheck)

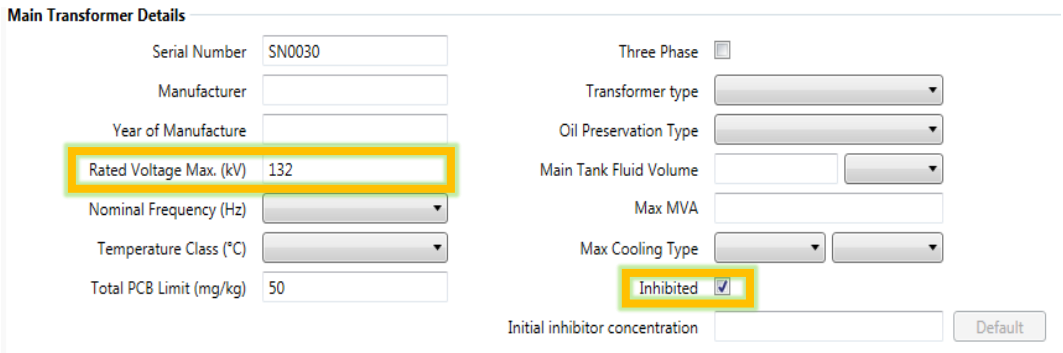


Figure F-1: Main Transformer Details

6. In the Workflow Associations section, complete the following as shown in Figure F-2 (see Appendix F.2 for configuration details):
   - In the Offline Algorithm Standard, select either **IEC** or **IEEE**.
   - In the 'Workflows' dropdown, select **Offline DGA and Oil Quality**.

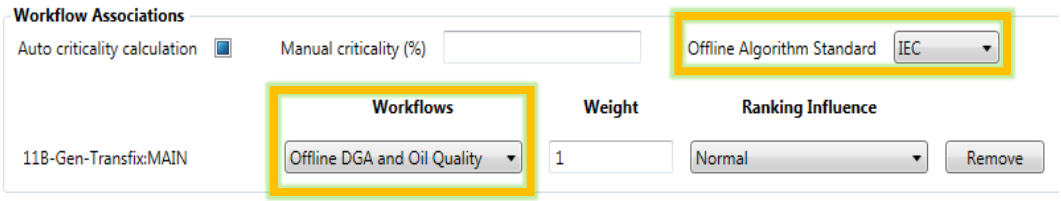


Figure F-2: Workflow Associations

7. Select **Tools** > **Workflow Scheduler**, select **Enabled** and specify the period.
   - ➢ An asterisk (*) in each time field signifies workflow calculation on a minute-by-minute basis.
8. Wait the specified workflow calculation period e.g. 1 minute.
9. Select the transformer instance and then select the **Dashboard** tab.
10. Select the **Ranking Graph**.
    - ➢ The Risk Index and status message display.
11. In the Asset Explorer, select the **Ranking** tab and rest the mouse pointer over a transformer.
    - ➢ A popup displays with the Risk Score.

F.2 Offline risk workflow configuration

The following data is required for offline oil quality:

- Transformer voltage class
- Standard for oil quality tests: IEC or IEEE
- Oil type: inhibited or uninhibited

The voltage class is configured using the 'Rated Voltage Max. (kV)' property.

The IEC standard defines 4 classes as follows:

- O (RV > 400 kV)
- A (170 kV < RV <= 400 kV)
- B (72.5 kV < RV <= 170 kV) and
- C (RV <= 72.5 kV)

The IEEE standard doesn't define literal values and differentiates classes as follows:

- >=230kV
- >69kV - <230kV
- <=69kV

F.2.1 IEC Oil Quality Configuration Parameters

F.2.1.1 Fluid Color Index

ISO 2049 & ASTM D1500 specifies a method for the visual determination of the colour of a variety of petroleum products.

Name	Color
Type	Float
Units	0-8
Standard	ISO 2049

F.2.1.2 Standardized Oil Appearance Remarks

A method of visually inspecting the appearance of the oil and categorising it as either ‘Dark’ or ‘Clear’.

Name	Visual
Type	Text(30)
Units	-
Standard	-

F.2.1.3 Dielectric Breakdown Voltage

IEC 60156 specifies the method for determining the dielectric breakdown voltage of insulating liquids at power frequency.

Name	iec156
Type	float
Units	kV
Standard	IEC60156

F.2.1.4 Moisture Concentration

IEC 60814 describes methods for the determination of water in insulating liquids and in oil-impregnated cellulosic insulation with coulometrically generated Karl Fischer reagent.

Name	fq_water
Type	float
Units	ppm
Standard	IEC60814

F.2.1.5 Acid Number (acidity)

IEC 62021-1 & 2 describes the procedure for the determination of the acidity of unused and used electrical mineral insulating oils.

Name	acidnum
Type	float
Units	mg KOH/g
Standard	IEC 62021-1 Or IEC 62021-2

F.2.1.6 Fluid Dissipation Factor (tan delta)

IEC 60247 describes methods for the determination of the dielectric dissipation factor (tan δ), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature.

Name	tan_delta
Type	float
Units	%
Standard	IEC 60247

F.2.1.7 Resistivity at 20 °C

Describes methods for the determination of the dielectric dissipation factor (tan δ), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature of 20 °C.

Name	resistivity_20
Type	float
Units	Gohm-m
Standard	IEC 60247

F.2.1.8 Resistivity at 90 °C

Describes methods for the determination of the dielectric dissipation factor (tan δ), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature of 90 °C.

Name	resistivity
Type	float
Units	Gohm-m
Standard	IEC 60247

F.2.1.9 Oxidation Inhibitor Concentration

IEC 60666 specifies the concentration of the oxidation inhibitor for the detection and determination of specified additives in unused and used mineral insulating oils.

Name	inhibitor
Type	float
Units	%
Standard	IEC 60666

An Inhibitor value can be added at any time. However, Perception doesn't automatically update the initial concentration value — this must be done manually by the user via the Transformer Properties as shown in Figure F-3.

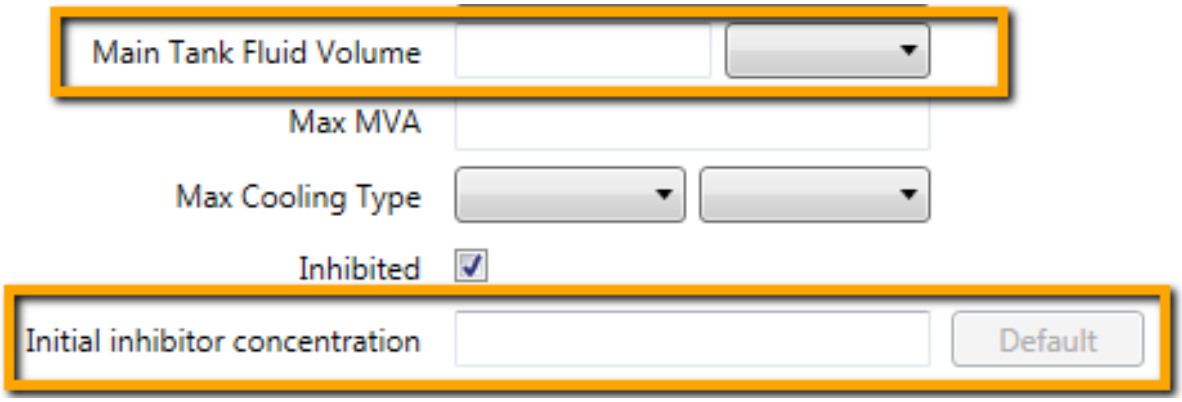


Figure F-3: Inhibitor Concentration

An offline measurement of the inhibitor concentration should reveal a drop from the initial inhibitor concentration. The user should calculate the percentage drop and record this percentage value in the Inhibitor field of the CSV file. Perception calculates the risk for the inhibitor component based on the rate of change from the initial concentration.

If the initial inhibitor concentration is unknown, the user can specify the volume and then click **Default** to generate a reference point value (based on 0.3% of the oil volume).

F.2.1.10 Sediment and Sludge

Annex C of IEC 60422 describes a test method for the determination of sediment and sludge.

Name	sludge
Type	float
Units	%
Standard	Annex C of IEC 60422

F.2.1.11 Interfacial Tension (IFT)

ASTM D971 describes the measurement of the interfacial tension between mineral oil and water, under non-equilibrium conditions.

Name	ift
Type	float
Units	mN/m
Standard	ASTM D971, EN 14210

Note: Risk is calculated in different ways for inhibited and uninhibited oil.

F.2.1.12 Total PCB Concentration

IEC 61619 specifies a method for the determination of polychlorinated biphenyl (PCB) concentration in non-halogenated insulating liquids by high-resolution capillary column gas chromatography using an electron capture detector (ECD).

Name	totalpcb
Type	float
Units	ppm
Standard	IEC 61619

Note: This parameter is specified in ppm (mg/kg) and recorded in the CSV file. The default value is 50 and is compared to the Total PCB Limit transformer property as shown in Figure F-4. Excluding a value (or any value less than 50) means the parameter does not factor in risk calculations.

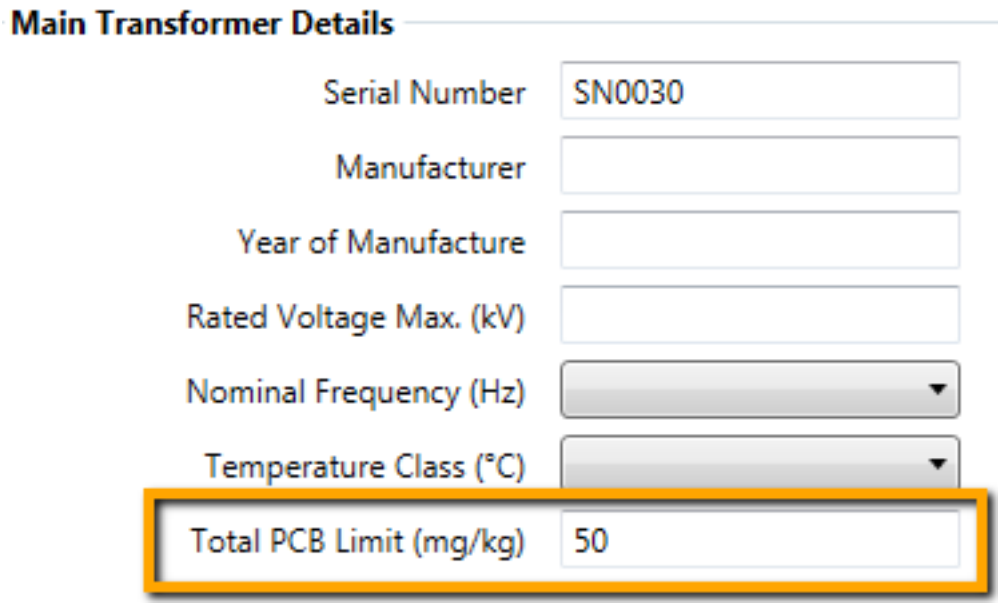


Figure F-4: Total PCB concentration

F.2.1.13 Corrosive Sulfur Test Result

IEC 62535 specifies a test method for the detection of potentially corrosive sulfur in used and unused mineral insulating oil.

Name	d1275a, d1275b
Type	text(30)
Units	-
Standard	IEC 62535

F.2.1.14 Passivator

IEC 60666 specifies the detection and determination of additives in unused and used mineral insulating oils. Annex B specifically defines the analysis method for determination of passivators in mineral oils by high performance liquid chromatography (HPLC)

Name	passivator
Type	float
Units	ppm
Standard	IEC 60666-2010 annex B

If a passivator is added to the oil, the Passivator value should be modified accordingly. However, Perception doesn't automatically update the Passivator value — this must be manually performed by the user via the CSV file.

F.2.1.15 Total Furans

IEC 61198 specifies test methods for the analysis of 2-furfural and related furan compounds resulting from the degradation of cellulosic insulation and found in mineral insulating oil samples taken from electrical equipment.

Name	totalfuran
Type	float
Units	ppb
Standard	IEC 61198

F.2.2 IEEE Oil Quality Configuration Parameters

F.2.2.1 Fluid Color Index

ASTM D1500 & ISO 2049 specifies a method for the visual determination of the colour of a variety of petroleum products.

Name	color
Type	float
Units	-
Standard	ASTM D 1500

F.2.2.2 Dielectric Breakdown Voltage VDE electrode-1 mm and -2 mm

ASTM D1816 specifies the method for determining the dielectric breakdown voltage of insulating liquids at power frequency for a 1 mm gap and 2 mm gap.

Name	d1816_1, d1816_2
Type	float
Units	kV
Standard	ASTM D1816 1 mm gap, ASTM D1816 2 mm gap

F.2.2.3 Moisture Concentration

ASTM D1533 specifies methods for the determination of water in insulating liquids and in oil-impregnated cellulosic insulation with coulometrically generated Karl Fischer reagent.

Name	fq_water
Type	float
Units	ppm
Standard	ASTM D 1533

F.2.2.4 Acid Number (acidity)

Name	acidnum
Type	float
Units	mg KOH/g
Standard	ASTM D 664, ASTM D974

F.2.2.5 Fluid Power Factor at 25 °C

Describes methods for the determination of the dielectric dissipation factor (tan δ), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature of 25 °C.

Name	pf25
Type	float
Units	%
Standard	ASTM D924 25C

F.2.2.6 Fluid Power Factor at 100 °C

Describes methods for the determination of the dielectric dissipation factor (tan δ), relative permittivity and d.c. resistivity of any insulating liquid material at the test temperature of 100 °C.

Name	pf100
Type	float
Units	%
Standard	ASTM D924 100C

F.2.2.7 Oxidation Inhibitor Concentration

ASTM D2668 & ASTM D4768 specify the determination of 2,6-ditertiary-butyl para-cresol and 2,6- ditertiary-butyl phenol in new and used insulating liquids at concentrations up to 0.5 %.

Name	inhibitor
Type	float
Units	%
Standard	ASTM D2668, ASTM D4768

Note: The calculation is based on the value provided in the CSV file according to the risk index table. The 'Initial inhibitor concentration' field is not used in the IEEE standard.

F.2.2.8 Interfacial Tension (IFT)

ASTM D 971 & ASTM D2285 specified a test method covering the measurement of the interfacial tension between mineral oil and water, under non-equilibrium conditions.

Name	ift
Type	float
Units	mN/m
Standard	ASTM D 971, ASTM D2285

F.2.2.9 Total PCB Concentration

ASTM D4059 specifies a method for the determination of polychlorinated biphenyl (PCB) concentration in non-halogenated insulating liquids by high resolution capillary column gas chromatography using an electron capture detector (ECD).

Name	totalpcb
Type	float
Units	ppm
Standard	ASTM D4059

Note: The calculation is performed in the same way as the IEC standard.

F.2.2.10Corrosive Sulfur Test Result

ASTM D1275 method A & DIN 51353 method B describes the detection of corrosive sulfur compounds (both inorganic and organic) in electrical insulating oils of petroleum origin.

Name	d1275a, d1275b
Type	text(30)
Units	-
Standard	ASTM D1275 method A, B DIN 51353

F.2.2.11 Passivator

ASTM D3487 specifies properties for new mineral insulating oil of petroleum origin for use as an insulating and cooling medium in new and existing power and distribution electrical apparatus.

Name	passivator
Type	float
Units	ppm
Standard	ASTM D3487

Note: The calculation is performed in the same way as the IEC standard.

F.2.2.12 Total Furans

ASTM D5837 specifies test methods for the analysis of 2-furfural and related furan compounds resulting from the degradation of cellulosic insulation and found in mineral insulating oil samples taken from electrical equipment.

Name	totalfuran
Type	float
Units	ppb
Standard	ASTM D5837

F.2.3 DGA Configuration Parameters

IEEE C57.104 specifies condition levels for absolute dissolved gas concentration in transformer insulation oil.

Name	h2
Type	float
Units	ppm
Standard	C57.104

Name	ch4
Type	float
Units	ppm
Standard	C57.104

Name	c2h6
Type	float
Units	ppm
Standard	C57.104

Name	c2h4
Type	float
Units	ppm
Standard	C57.104

Name	c2h2
Type	float
Units	ppm
Standard	C57.104

Name	co
Type	float
Units	ppm
Standard	C57.104

Name	co2
Type	float
Units	ppm
Standard	C57.104

Appendix G MS 3000: HTTPS & Self-signed Certificates

To download data from the MS 3000 to Perception (or access the MS 3000 web HMI) over the HTTPS protocol, use a Secure Sockets Layer (SSL) certificate (rather than the default self-signed certificate) to prevent certificate security warnings. For example, with Windows 7 follows these steps in Internet Explorer to access the MS 3000 over HTTPS.

Open Internet Explorer and in the address bar specify the IP address of the MS 3000 device. For example, type `https://192.168.10.1` and press `<Enter>`.

A Certificate Error message displays as shown in Figure G-1. This confirms there is a problem with the website's security certificate. On this occasion only, click **Continue to this website**... to continue.

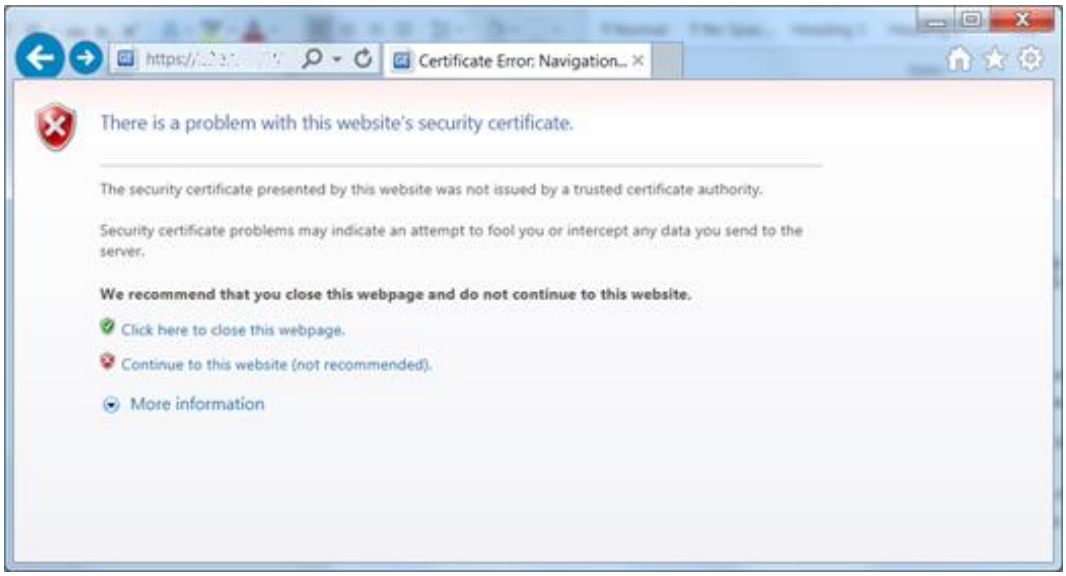


Figure G-1: Certificate Error

The MS 3000 login page displays. Click on the 'Certificate error' icon in the address bar to display the 'Untrusted Certificate' notice shown in Figure G-2. To view the available certificates, click the **View certificates**... link at the bottom of the message.

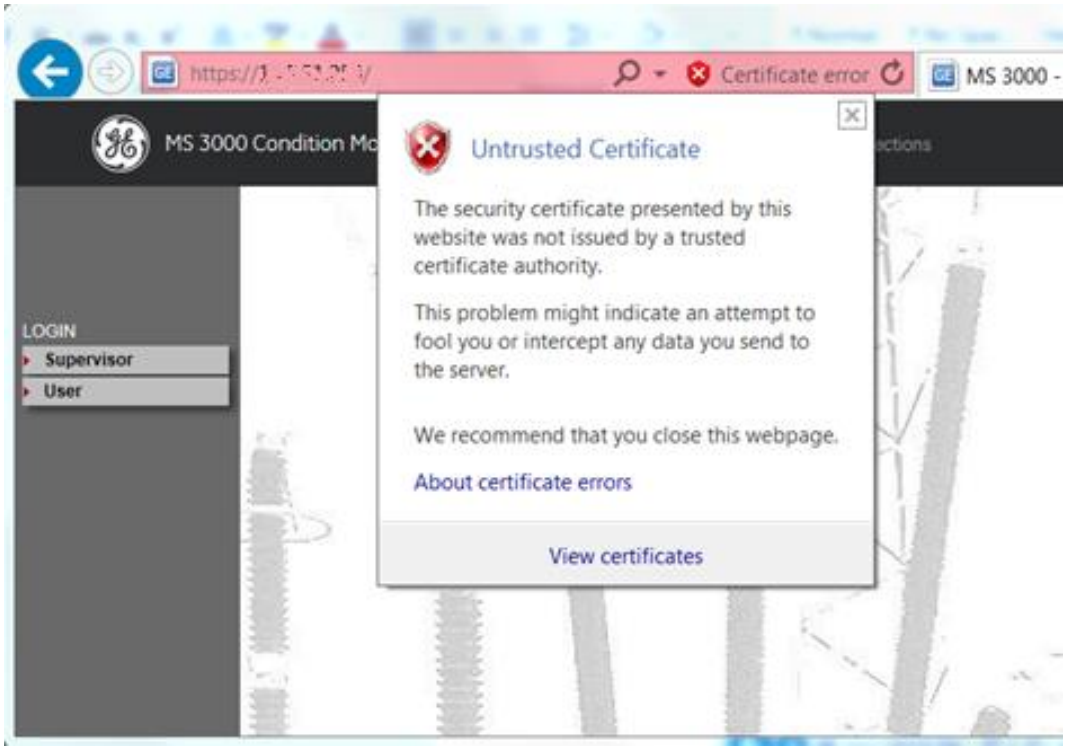


Figure G-2: MS 3000 Untrusted Certificate

The Windows Certificate Information displays as shown in Figure G-3. Click **Install Certificate...** to install the certificate and enable trust.

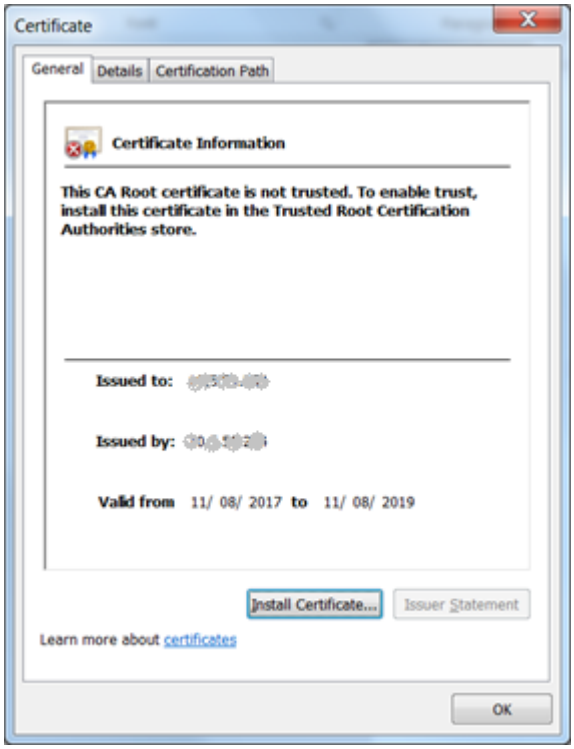


Figure G-3: Certificate Information

The 'Certificate Import Wizard' displays as shown in Figure G-4. Select **Place all certificates in the following store** and click **Browse** to choose the certificate. In the 'Select Certificate Store' dialog, select **Trusted Root Certificate Authorities**.

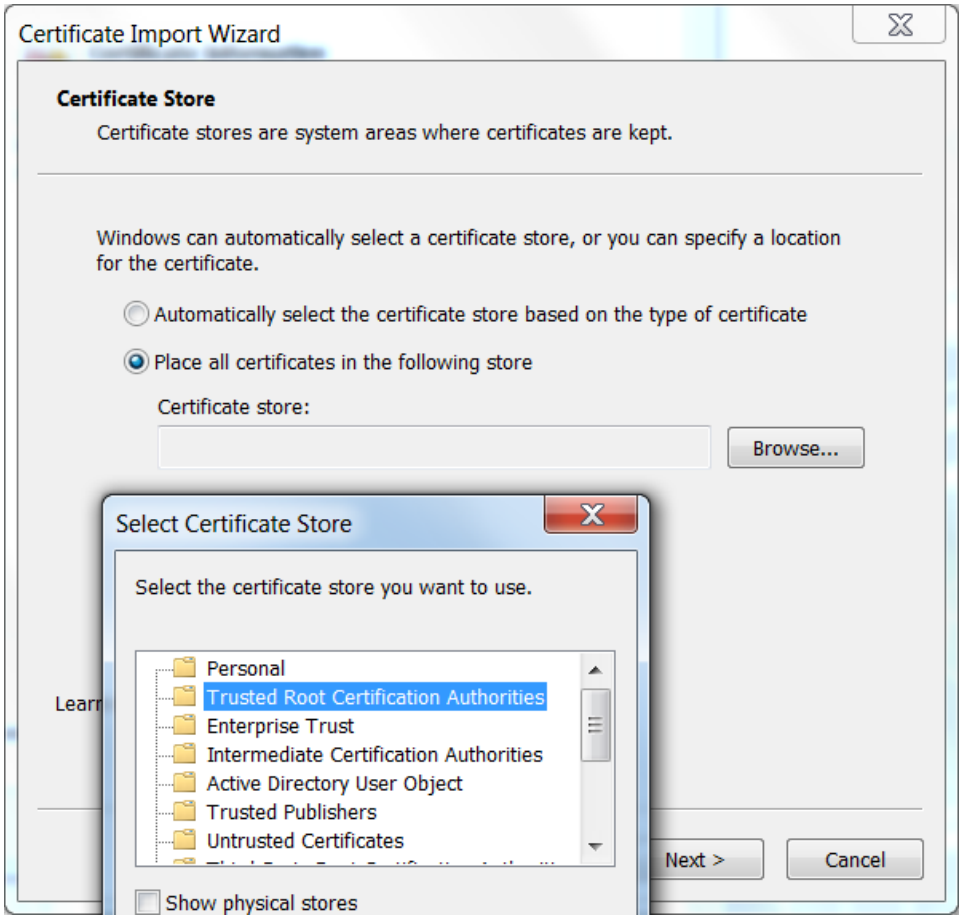


Figure G-4: Certificate Import Wizard – Certificate Store

A confirmation message displays as shown in Figure G-5. Click **OK** to continue.

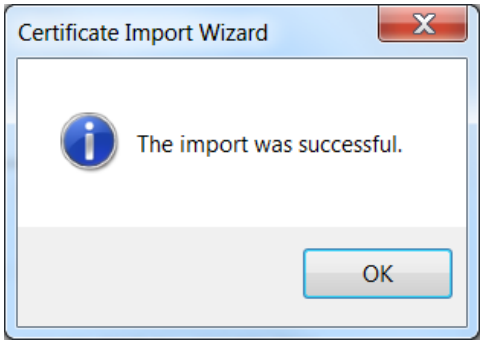


Figure G-5: Certificate Import Wizard – confirmation

Restart Internet Explorer and select **Tools** > **Internet Options** > **Content** as shown in Figure G-6. Then click **Certificates**.

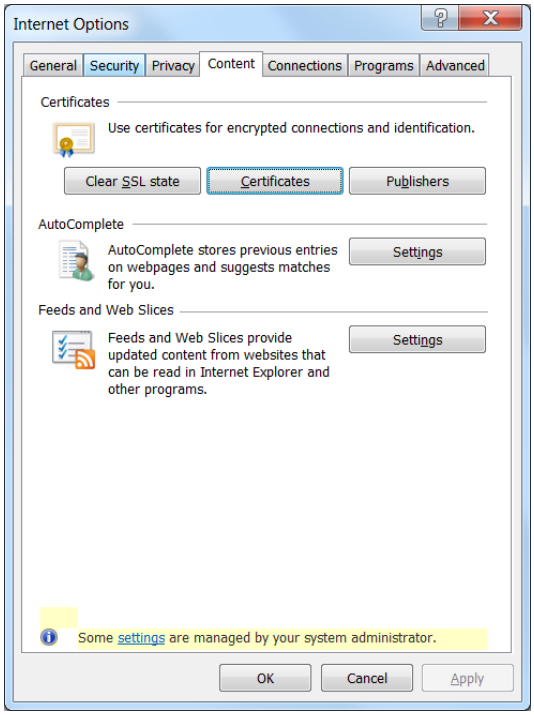


Figure G-6: Internet Options

In the 'Certificates' dialog box, select the **Trusted Root Certification Authorities** tab and select the certificate previously installed and click **Export** as shown in Figure G-7.

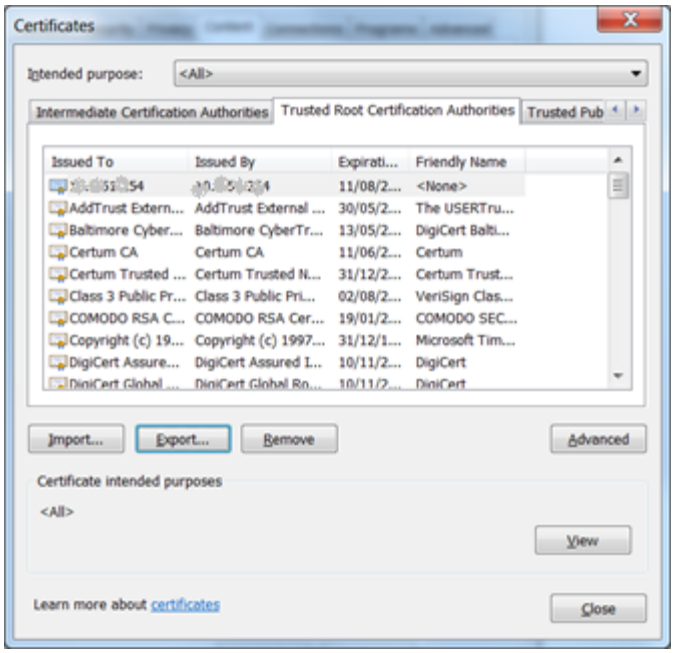


Figure G-7: Certificates: Trusted Root Certification Authorities

The 'Certificate Export Wizard' dialog box opens. Use the default settings and specify a valid path and filename to save the certificate and click **Next** as shown in Figure G-8.

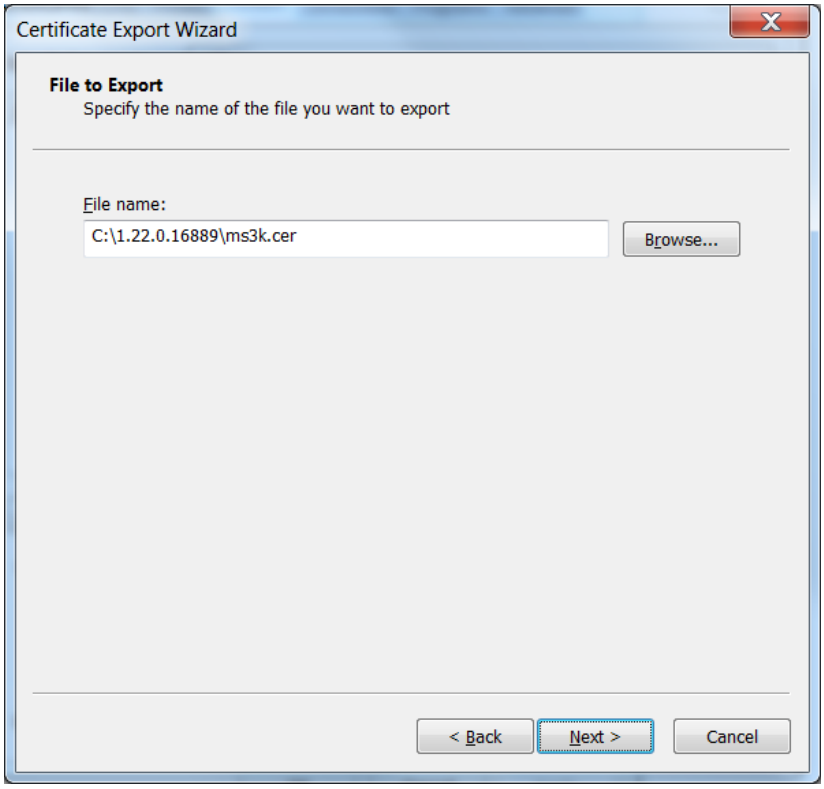


Figure G-8: Certificate Export Wizard – Certificate file name

The 'Certificate Export Wizard' completes with a confirmation message as shown in Figure G-9.

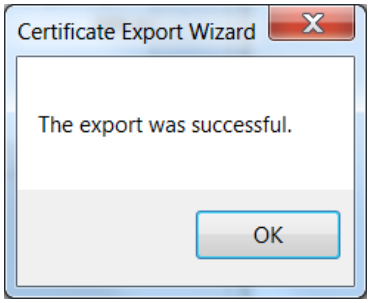


Figure G-9: Certificate Export Wizard – confirmation

From the Windows Taskbar, click **Start > Run** and type `mmc.exe` to launch the Microsoft Management Console as shown in Figure G-10.

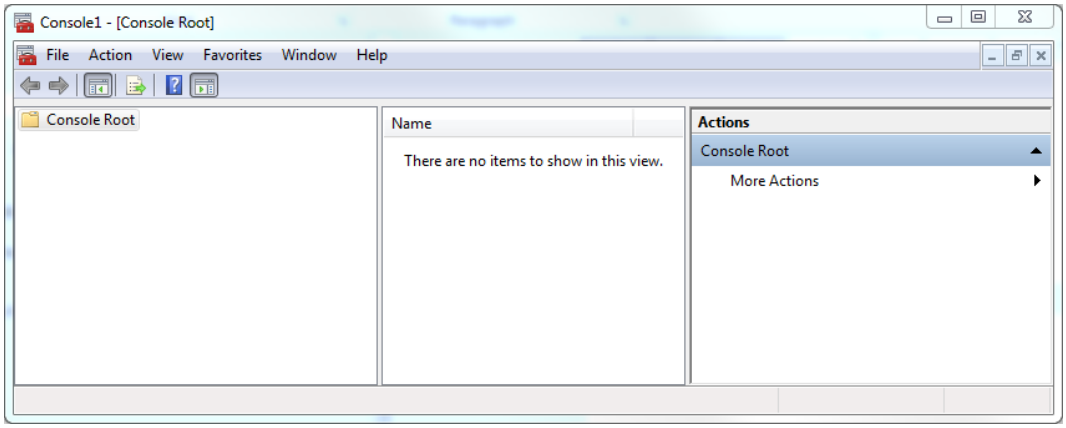


Figure G-10: MMC main screen

In the MMC, select **File > Add/Remove Snap-in**. From the Available snap-ins, select **Certificates** and click **Add** as shown in Figure G-11.

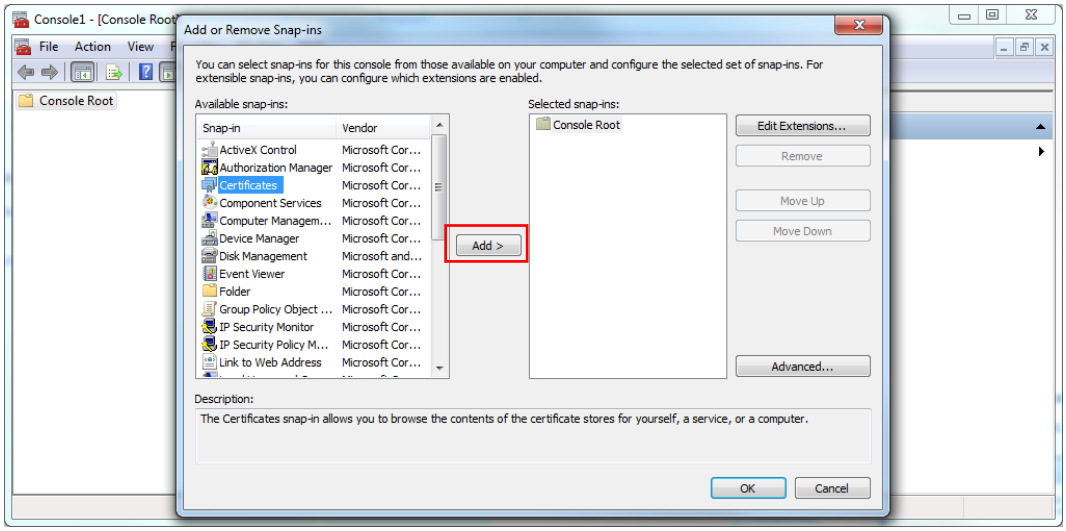


Figure G-11: MMC Add Certificates

In the 'Certificates snap-in' dialog box, select the **Computer account** option and click **Next** as shown in Figure G-12.

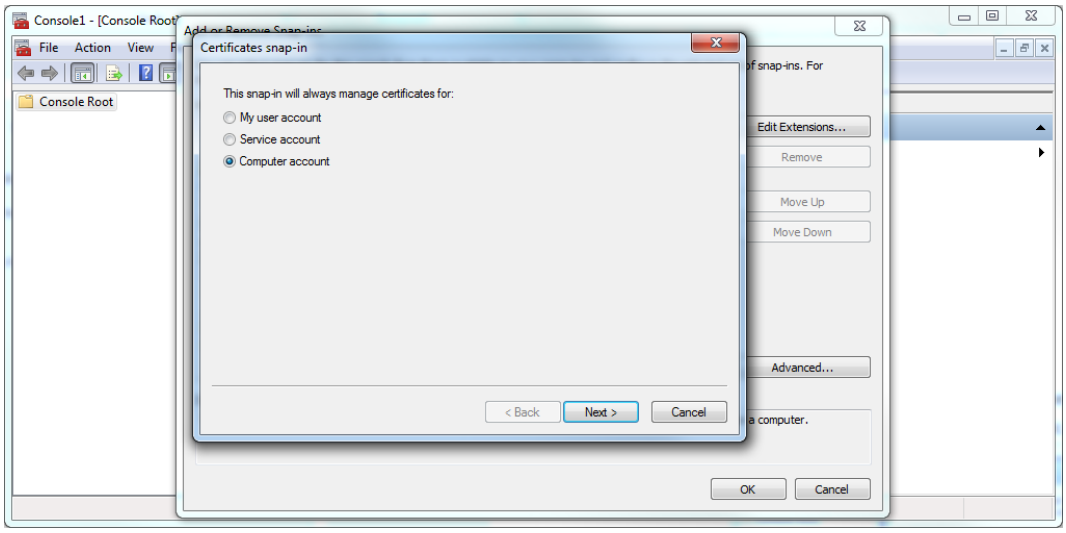


Figure G-12: MMC Certificates snap-in

In the 'Select Computer' dialog box, select the **Local computer** option and click **Finish** as shown in Figure G-13.

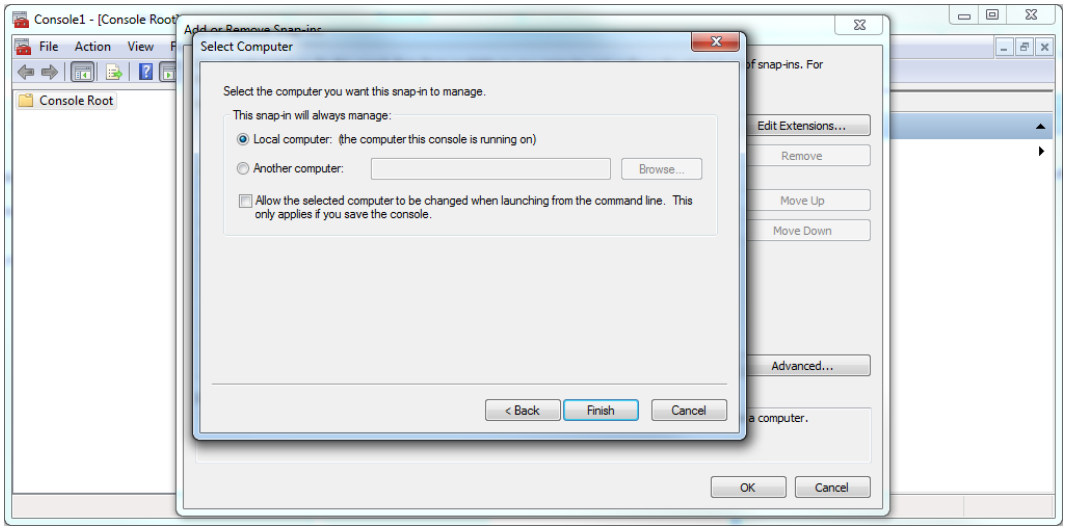


Figure G-13: MMC Select Computer

Click **OK** to close the 'Add or Remove Snap-ins' dialog box as shown in Figure G-14 and return to the MMC main screen.

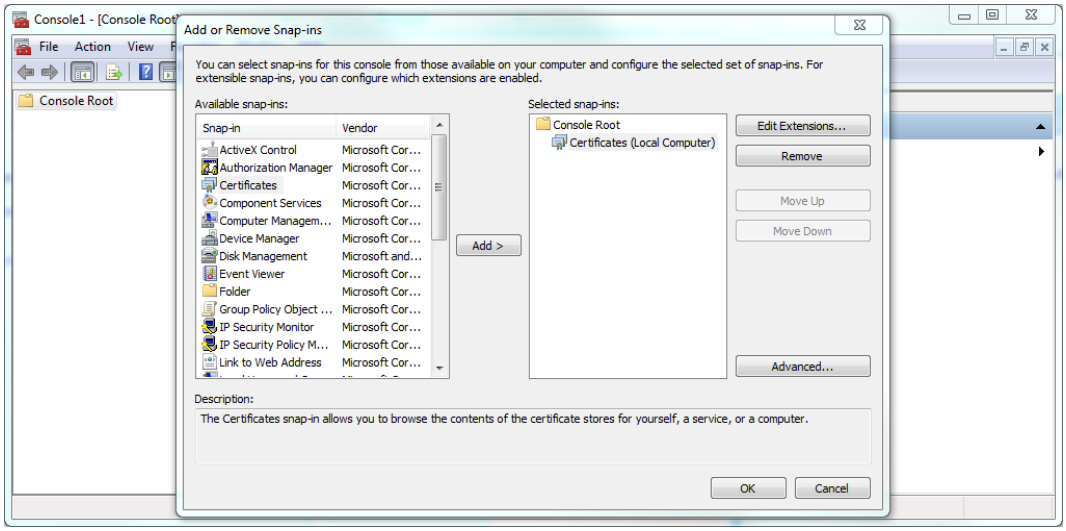


Figure G-14: MMC Certificates added

In the MMC main screen, select **Certificates (Local computer) > Trusted Root Certification Authorities** as shown in Figure G-15.

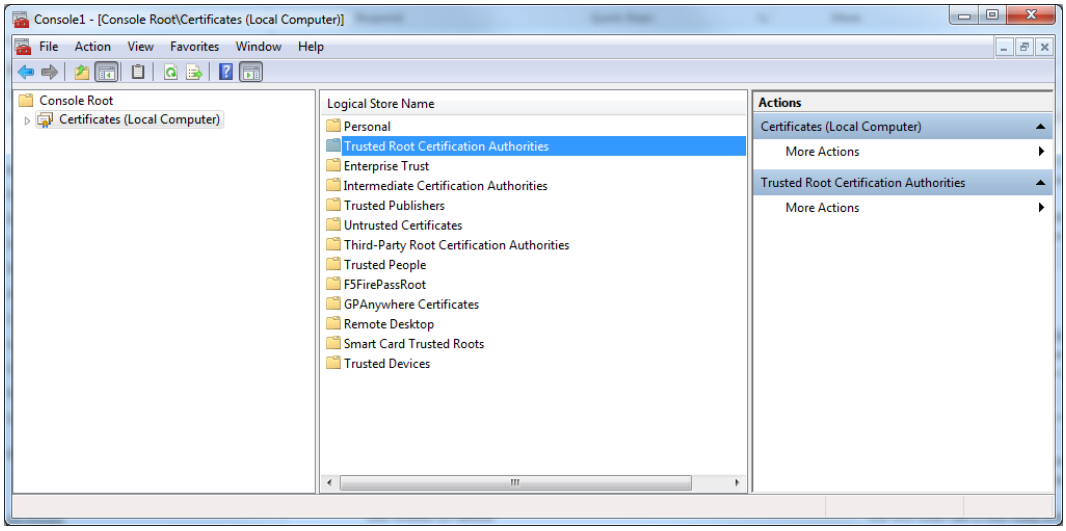


Figure G-15: MMC main screen – Certificates (Local Computer)

On the MMC main menu, select **Action** > **All Tasks** > **Import** to launch the 'Certificate Import Wizard' as shown in Figure G-16. Click **Next**.

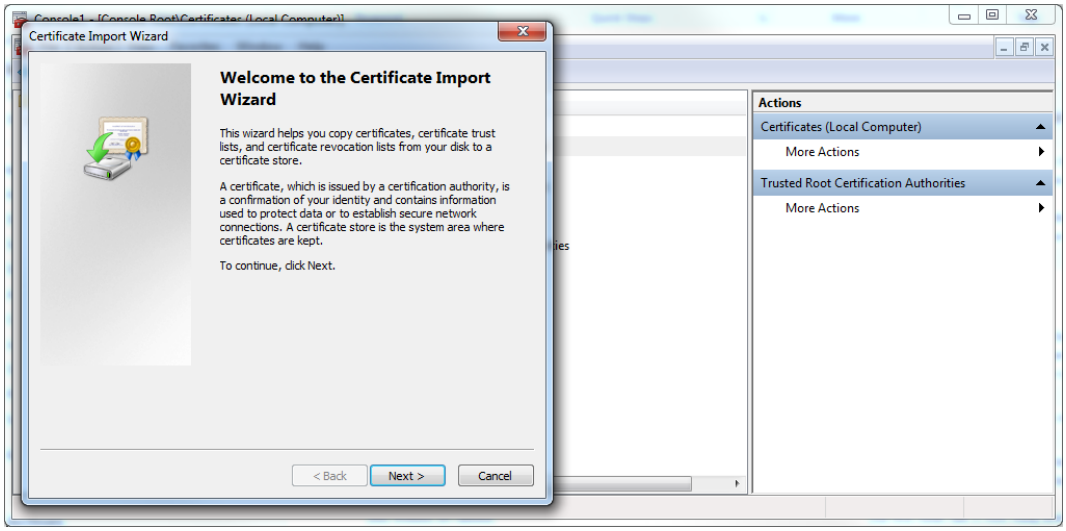


Figure G-16: Certificate Import Wizard

Specify the certificate file name and path (as exported previously) as shown in Figure G-17. Use the default settings and click **Finish** to complete the 'Certificate Import Wizard'.

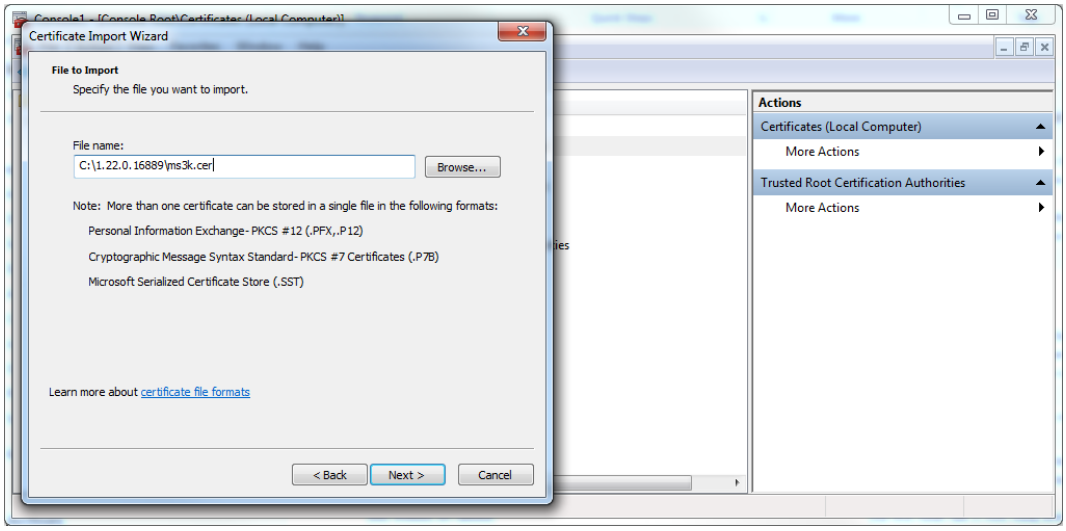


Figure G-17: Certificate Import Wizard – Certificate file name

The 'Certificate Import Wizard' completes with a confirmation message as shown in Figure G-18.

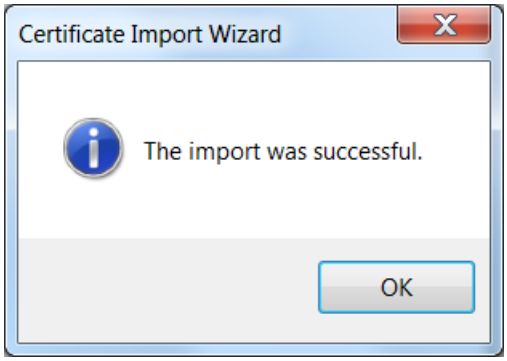


Figure G-18: Certificate Import Wizard – confirmation

This allows you to use the default self-signed certificate and prevents the certificate security warnings when accessing the MS 3000 device.

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