OMICRON

Application Note

A Guide for Using PTM and the CPC 100 to test Transformers

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Abstract

This application note is a step-by-step guide for users creating a test plan in the PTM software for electrical diagnostic testing of power transformers. Important settings and tips for obtaining a good measurement are highlighted in the guide for each major test associated with the CPC 100.

General information

OMICRON electronics GmbH, including all international branch offices, is henceforth referred to as OMICRON.

The product information, specifications, and technical data embodied in this Application Note represent the technical status at the time of writing and are subject to change without prior notice.

We have done our best to ensure that the information given in this Application Note is useful, accurate and entirely reliable. However, OMICRON does not assume responsibility for any inaccuracies which may be present.

OMICRON translates this Application Note from the source language English into a number of other languages. Any translation of this document is undertaken for local requirements, and in the event of a dispute between the English and a non-English version, the English version of this note shall govern.

Table of content

1 Safety instructions

This Application Note may only be used in conjunction with the relevant product manuals which contain all safety instructions. The user is fully responsible for any application that makes use of OMICRON products.

Instructions are always characterized by a ▶ symbol, even if they are included in a safety instruction.

DANGER

Death or severe injury caused by high voltage or current if the respective protective measures are not complied with.

- ▶ Carefully read and understand the content of this Application Note as well as the manuals of the systems involved before taking them into operation.
- ▶ Please contact OMICRON support if you have any questions or doubts regarding the safety or operating instructions.
- ▶ Follow each instruction listed in the manuals, especially the safety instructions, since this is the only way to avoid the danger that can occur when working on high voltage or high current systems.
- ▶ Only use the equipment involved according to its intended purpose to guarantee safe operation.
- ▶ Existing national safety standards for accident prevention and environmental protection may supplement the equipment's manual.

Only experienced and competent professionals that are trained for working in high voltage or high current environments may implement this Application Note. Additionally, the following qualifications are required:

- Authorized to work in environments of energy generation, transmission or distribution, and familiar with the approved operating practices in such environments.
- Familiar with the five safety rules.
- Good knowledge/proficient in working with the CPC 100, CP TD1 and Electrical Diagnostic Testing of Power Transformers.

2 PTM Test Procedure Document: Introduction

The purpose of the following document is to provide the user a step-by-step guide for successfully using PTM. The document closely follows the PTM “workflow” concept. The user will be guided through the following process,

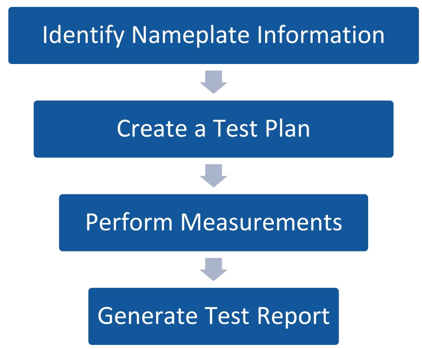


Figure 1: PTM Workflow Concept

In addition to providing a step-by-step guide for using PTM, the intention of this document is to also help the user develop good testing practices, which can help increase the accuracy and quality of the measurements performed, as well as decrease the likelihood of making safety related mistakes.

The home screen of the PTM software is shown in Figure 2, and can be used to complete the following tasks,

- Connect the OMICRON equipment to the laptop via an Ethernet cable
- Access the PTM Database via the “Manage” option
- Create a new test plan

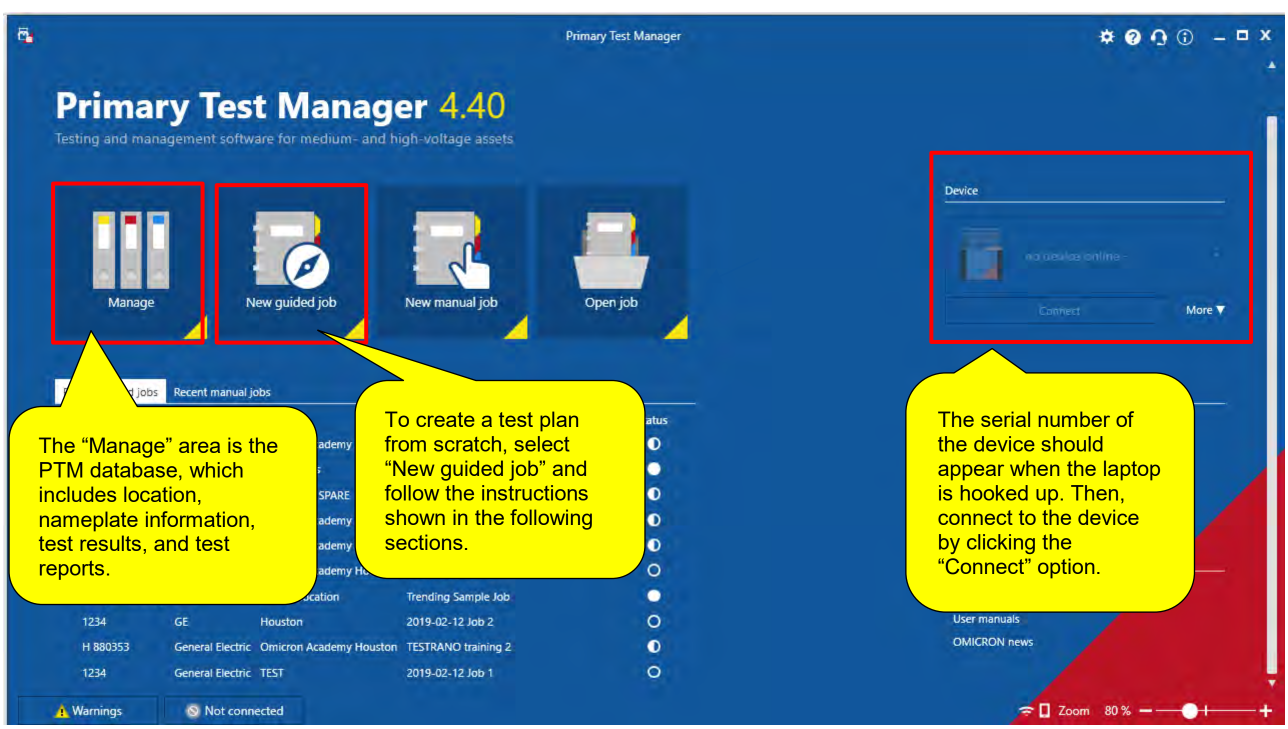


Figure 2: PTM Home Screen

A new test plan can be created either by clicking the “New guided job” or “Manage” button; however, the “New guided job” button is a more direct way of creating a new test plan and allows the user to bypass the data manager. Therefore, to create a new test plan for a power transformer, select the “New guided job” button.

Once a new job is created, the user will have access to the five main sections of the PTM software, which include, the “overview”, “location”, “asset”, “tests”, and “report” section. The five sections can be found on the left panel of PTM (see Figure 3). The user should complete these sections in order from top to bottom, as shown in Figure 3.

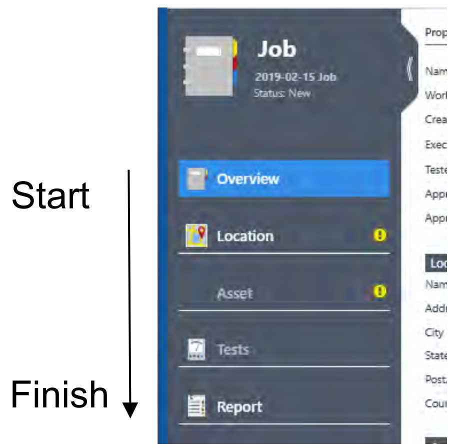


Figure 3: PTM Left Panel- Workflow

3 Overview

Once a new job is created, the first section that will automatically be displayed is the “Overview” section, as shown in Figure 4. Please enter the information outlined in Figure 4.

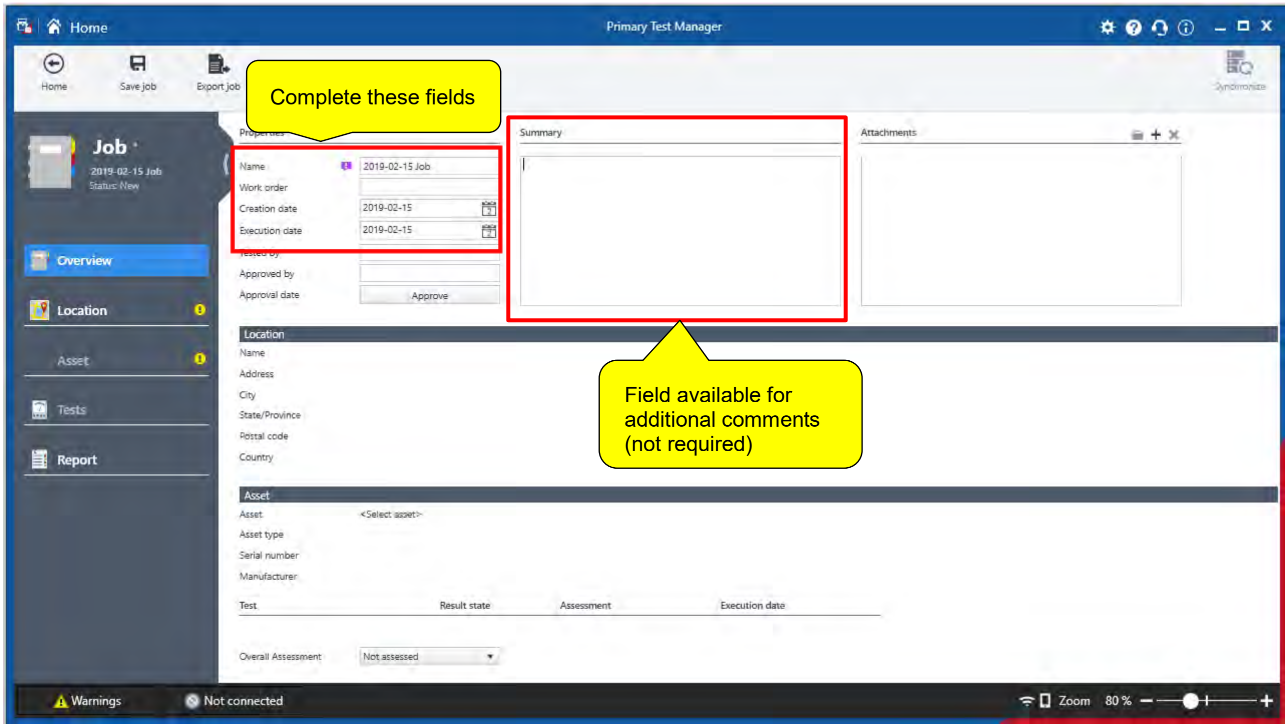


Figure 4: PTM Overview Section

4 Location

Once the overview section is complete, click on the “Location” tab on the PTM left panel, as shown in Figure 5. The “Location” is the name of the job site, substation, etc.… The transformer that you will eventually create within this test plan will be stored at this location within the PTM database.

Please enter the information outlined in Figure 5.

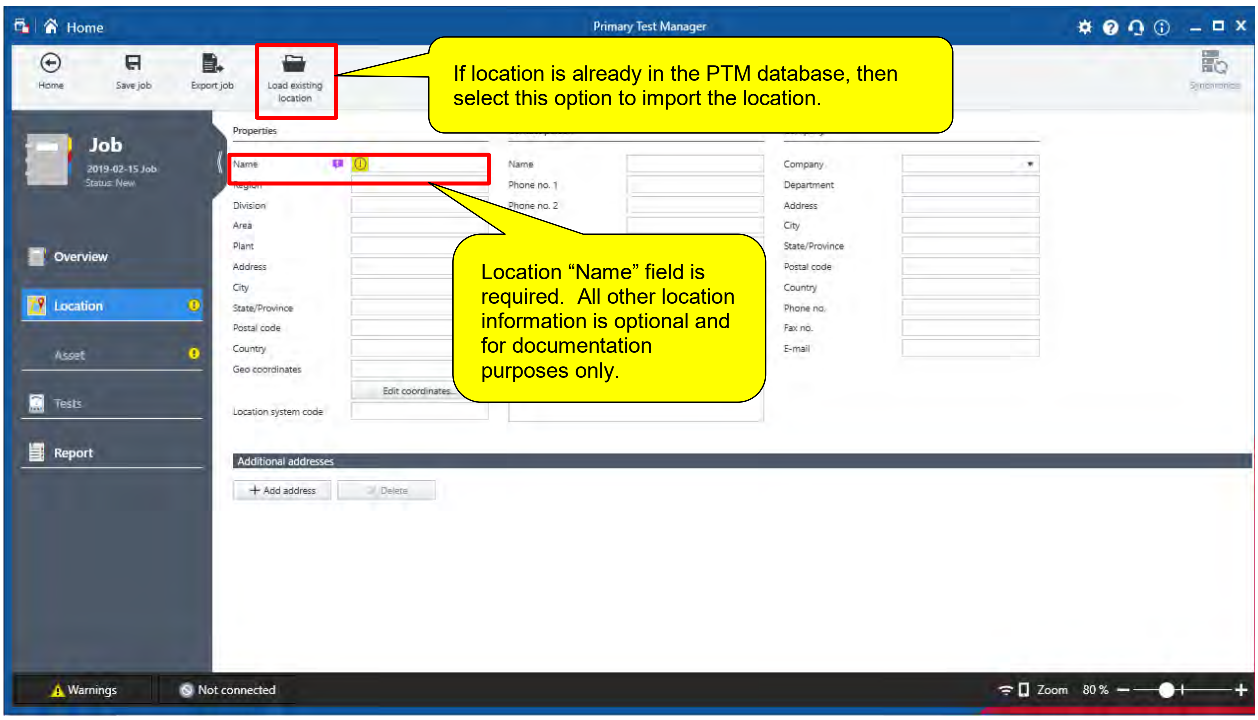


Figure 5: Location Section

5 Asset

Once the “Location” section is complete, click on the “Asset” tab on the PTM left panel, as shown in Figure 6. The “Asset” section of the software is where all the nameplate information of the device under test and its ancillary equipment (i.e. bushings, etc.) will be entered.

NOTICE

Complete fields from top-to-bottom

- It is important that the “Asset” section of the software is completed from top-to-bottom. The “Asset” section may change based on the previous selections you have made, so it is important to enter the information accurately, and in order.

Please complete the sections outlined in Figure 6.

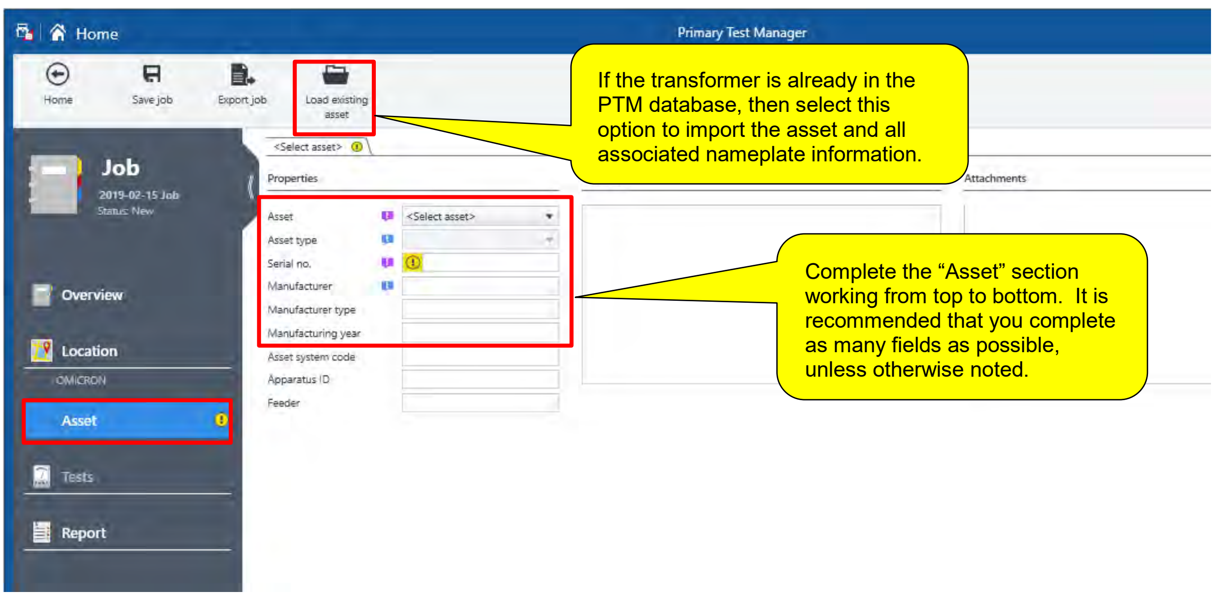


Figure 6: Asset Information

5.1 Asset: Transformer

Once the main transformer nameplate information is complete, notice that the “Asset” section expands into 5 tabs, including the “Transformer”, “Bushings”, “Tap Changers”, “Surge Arresters”, and “DGA Trending” sections, as highlighted in Figure 7. It is recommended that the first four sections are completed from left-to-right, starting with the “Transformer” section. The “DGA Trending” tab automatically documents results of available oil analysis tests in the PTM database for the associated asset.

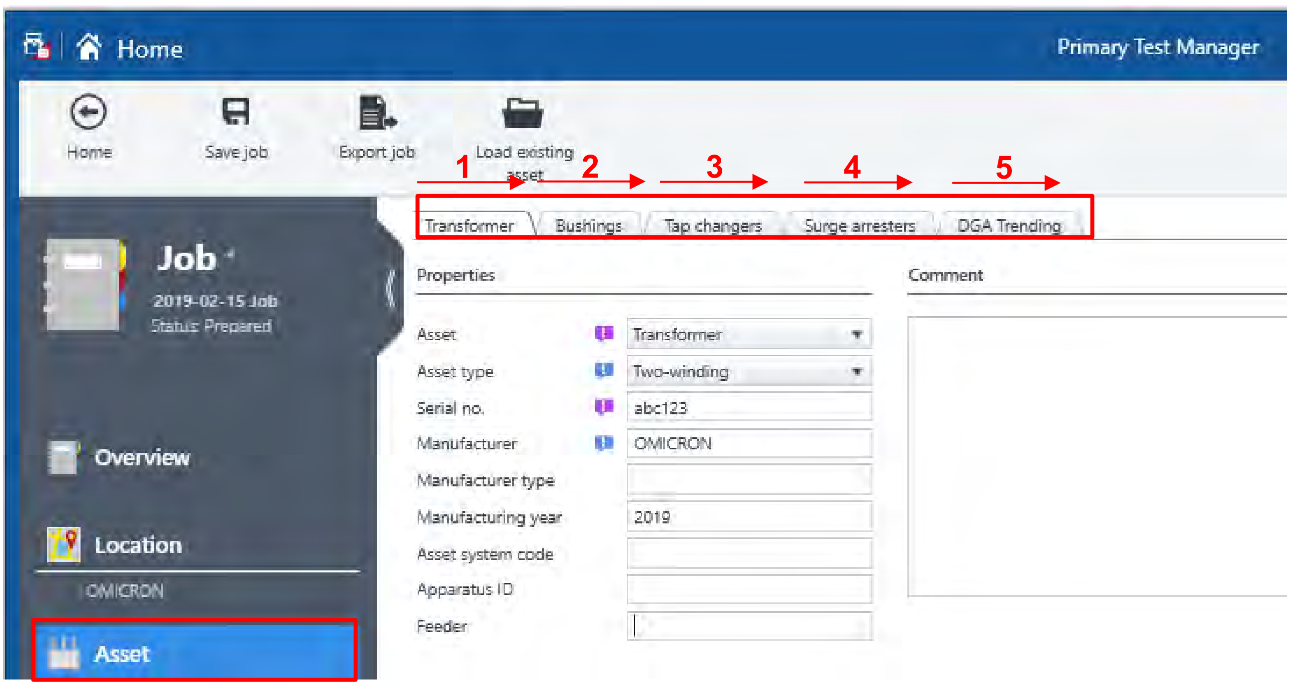


Figure 7: Transformer- Main information

Remain in the “Transformer” section and scroll down to the “Winding configuration” section. The winding configuration section is critical to PTM, and will heavily influence the test plan. By entering the correct winding configuration and vector group of the transformer you would like to test, the PTM software will provide the correct connection diagrams for the available tests.

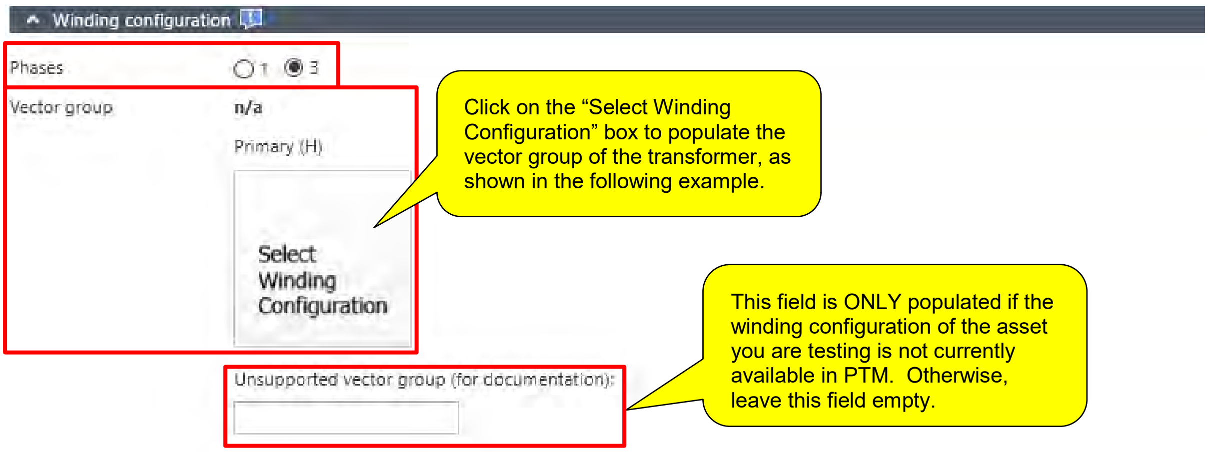


Figure 8: Winding Configuration

For example, if the asset you would like to test is a 3-phase, two-winding, DYn1 transformer, then the vector group shown in Figure 9 would be selected. If you are unsure of the correct vector group, visually match the vector group on the nameplate of the transformer to the options provided below. Once the desired vector group is selected, click the "ok" button in the lower right-hand corner to confirm.

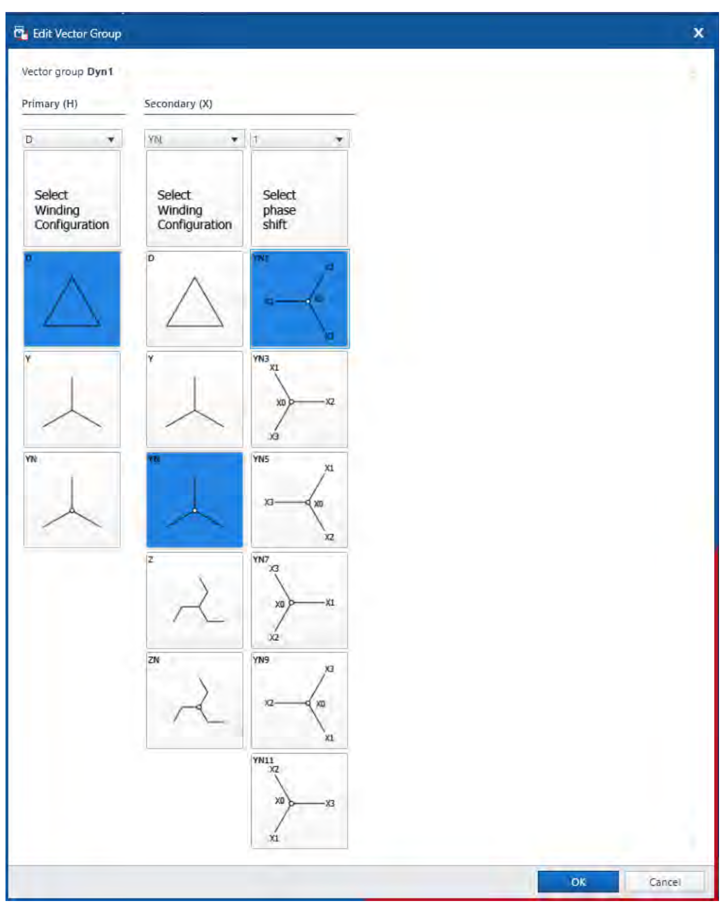


Figure 9: Vector Group Selection

NOTICE

Avoiding Incorrect Test Plan: Y vs Yn

- Please note that from the software's perspective, there is a major difference between a Y-winding (wye winding with no accessible neutral) and a Yn-winding (wye winding with an accessible neutral). To prevent the software from populating the incorrect test plan, please make sure that the vector diagram you select accurately represents the transformer you would like to test.

Once the "winding configuration" section is complete, scroll down to the "Ratings" section.

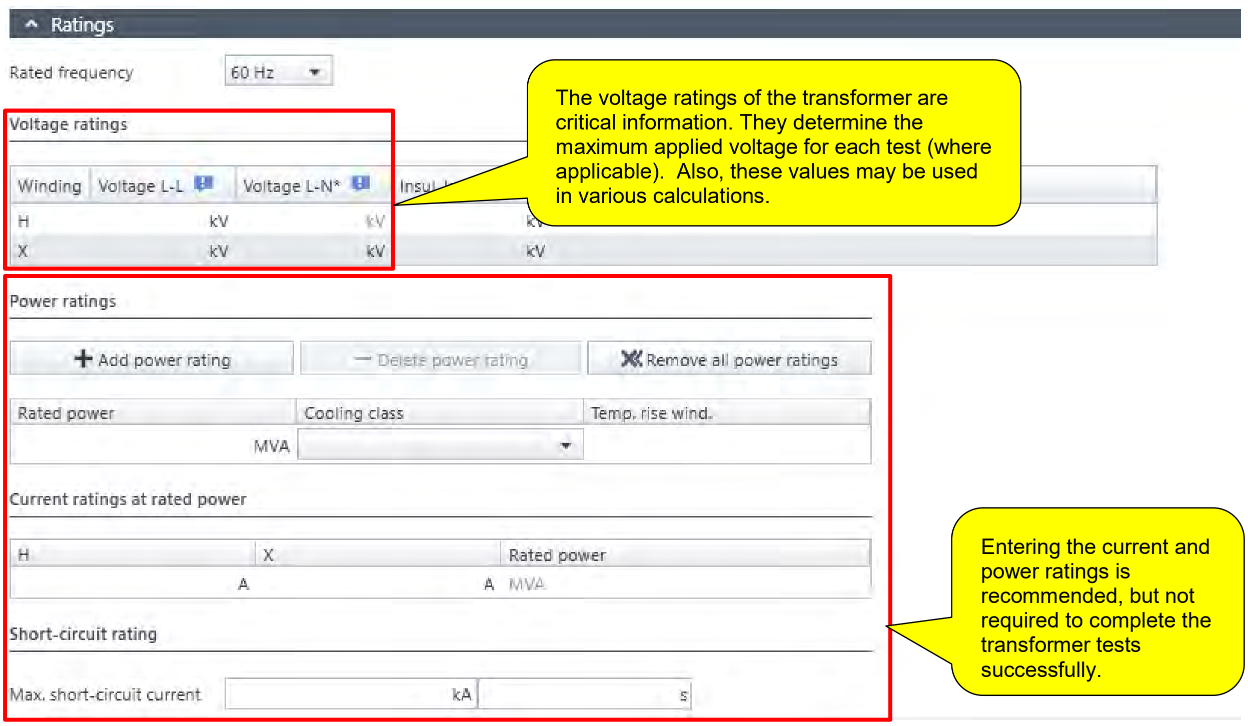


Figure 10: Ratings Section

Once the "Ratings" section is complete, scroll down to the "Impedances" section.

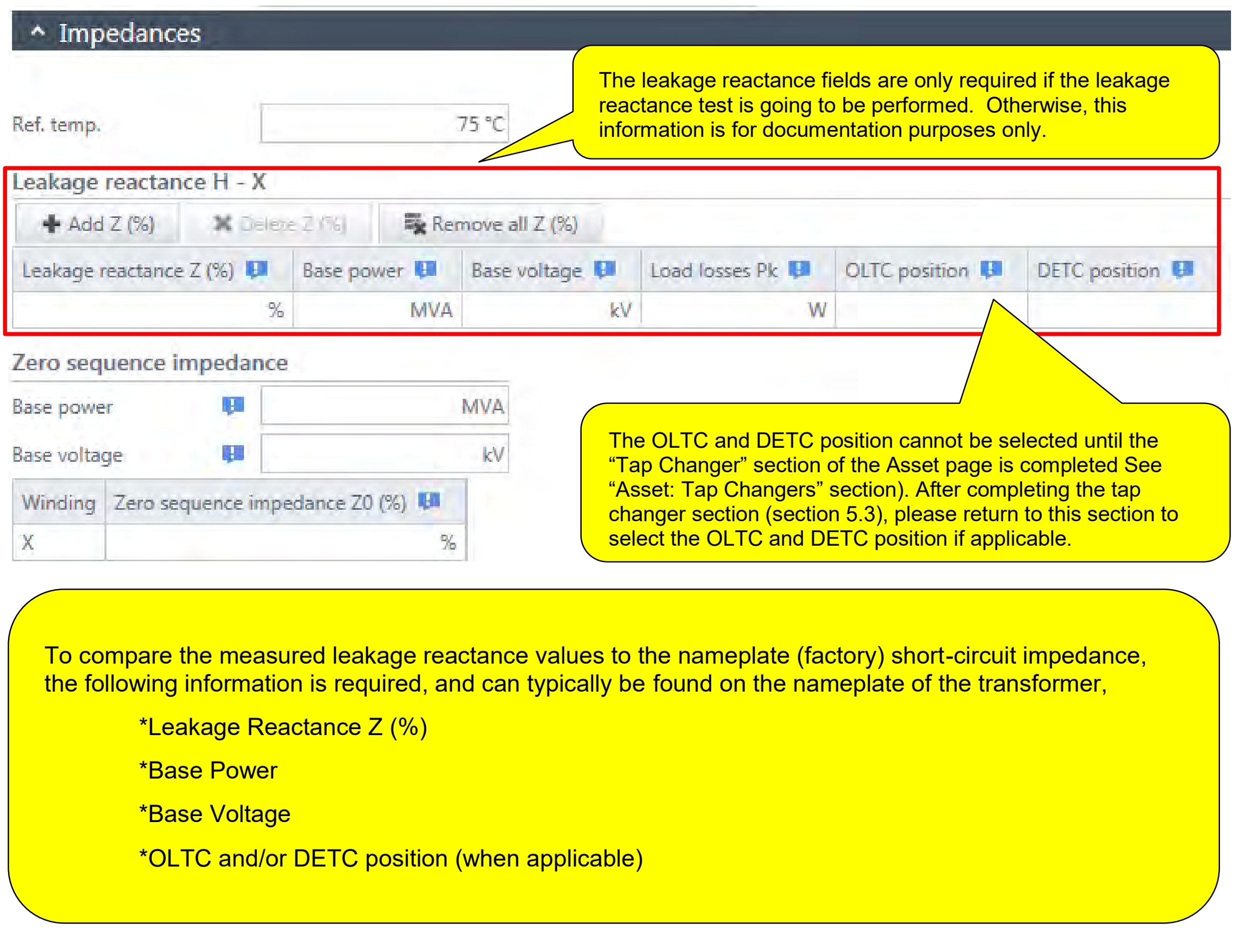


Figure 11: Impedances Section

Once the “Impedances” section is complete, scroll down to the “Others” section.

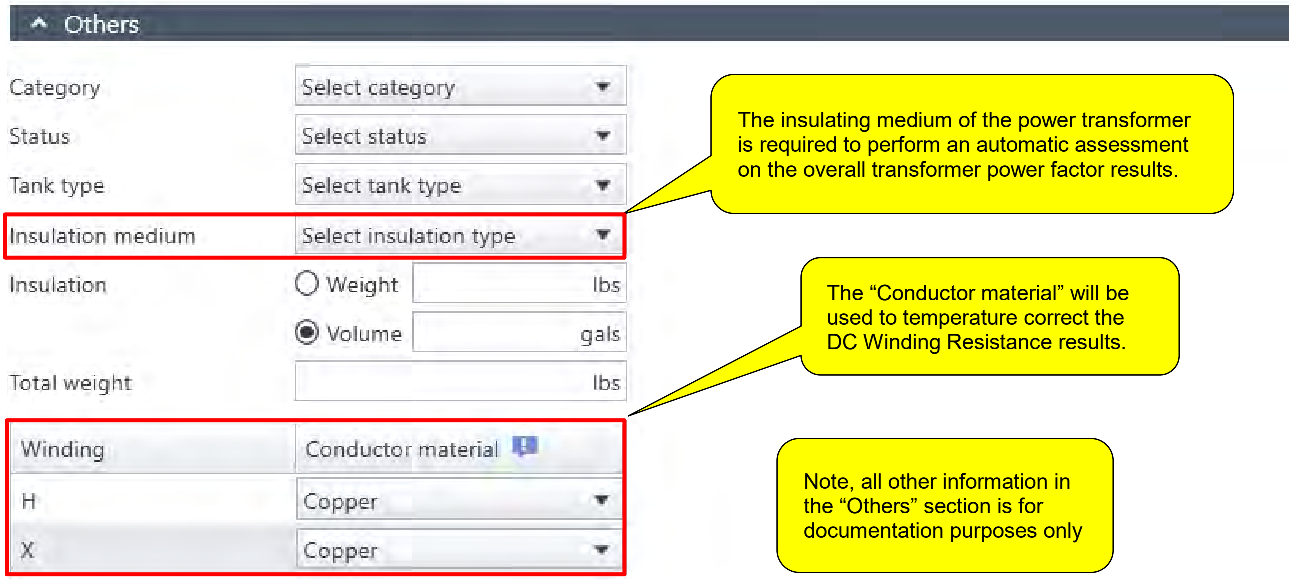


Figure 12: Others Section

5.2 Asset: Bushings

Once the "Transformer" nameplate information is complete, scroll up to view the tabs located at the top of the "Asset" section. If the transformer has bushings that you would like to test, please click the "Bushings" tab (highlighted in Figure 13) to begin populating the nameplate information of the bushings. Otherwise, proceed to the next section.

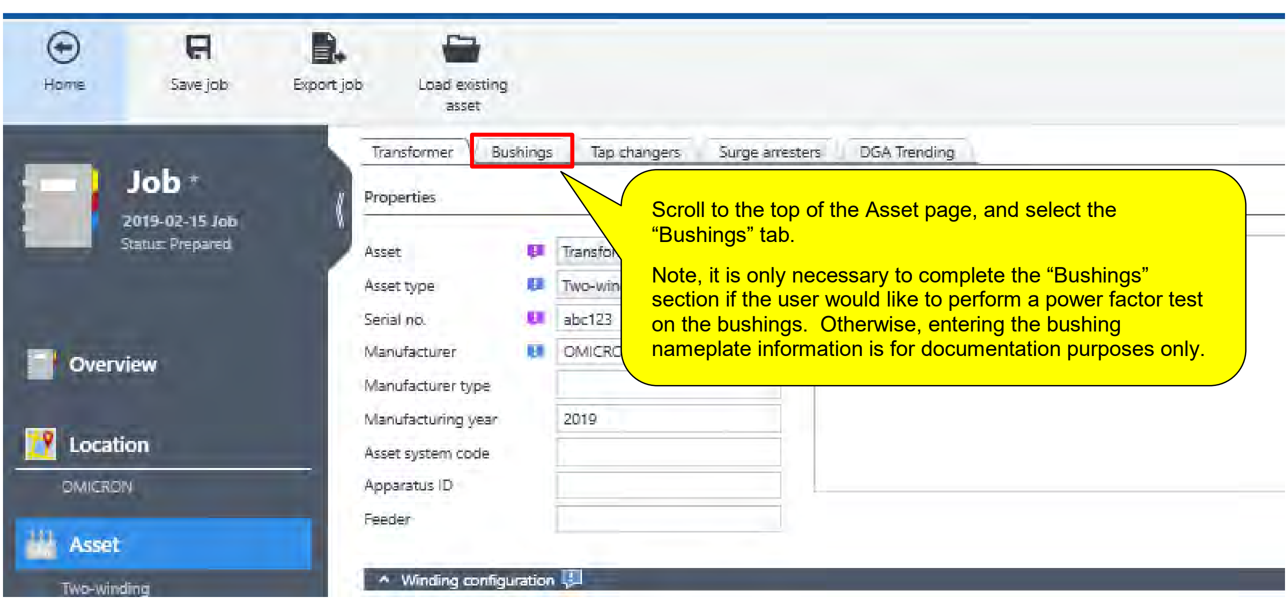


Figure 13: Asset- Four Main Tabs

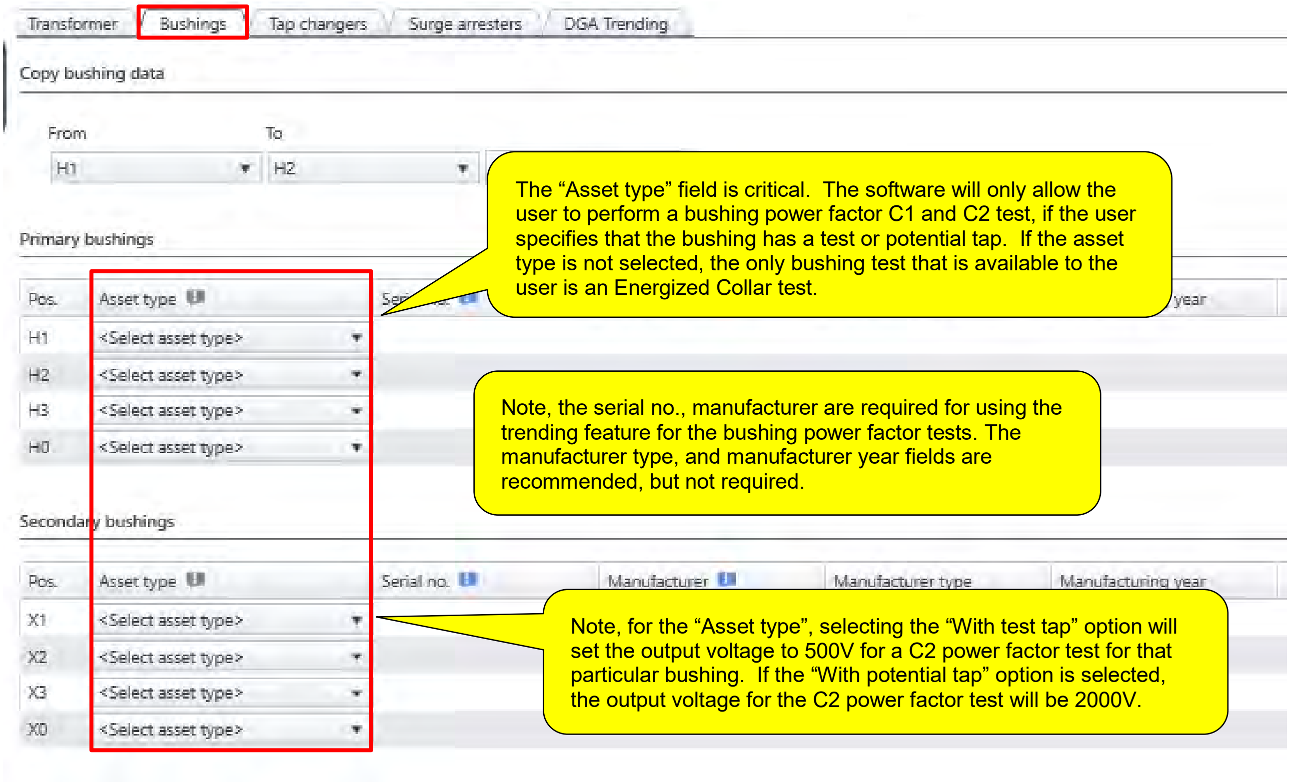


Figure 14: Bushing Nameplate- Part 1

Next, scroll to the right to view more bushing nameplate fields, as shown in Figure 15.

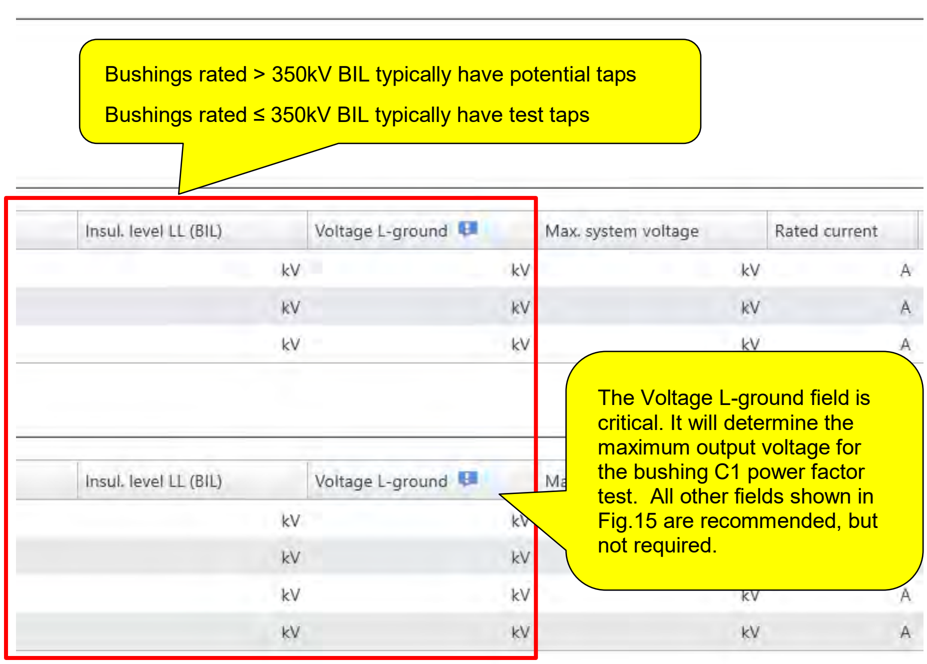


Figure 15: Bushing Nameplate- Part 2

Finally, scroll to the right to view the final bushing nameplate fields, as shown in Figure 16.

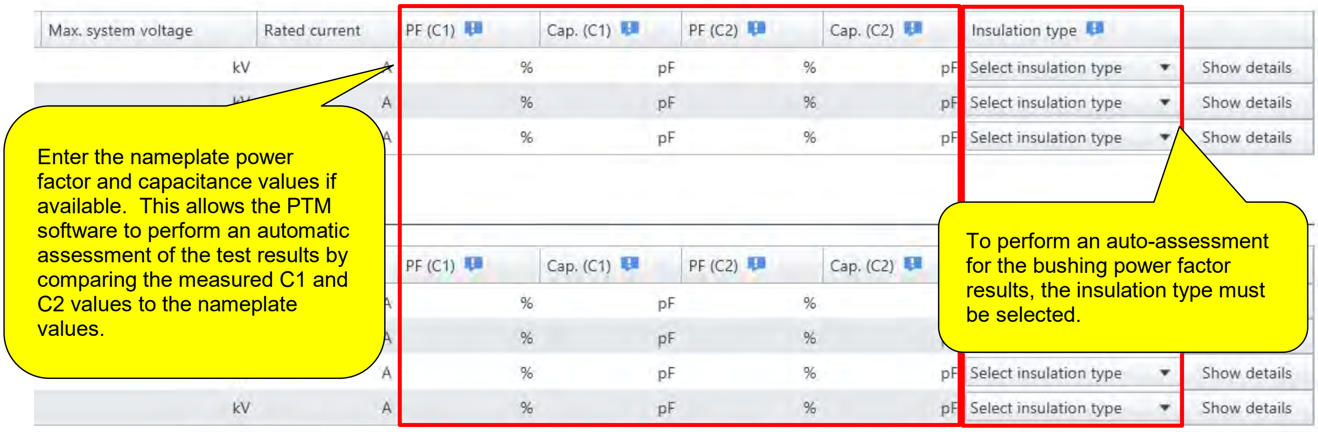


Figure 16: Bushing Nameplate- Part 3

5.3 Asset: Tap Changers

If the transformer you would like to test has a de-energized and/or load tap changer, click on the “Tap changers” tab in the “Asset” section, as shown in Figure 17. If the transformer you would like to test does not have a tap changer, then please proceed to the next section.

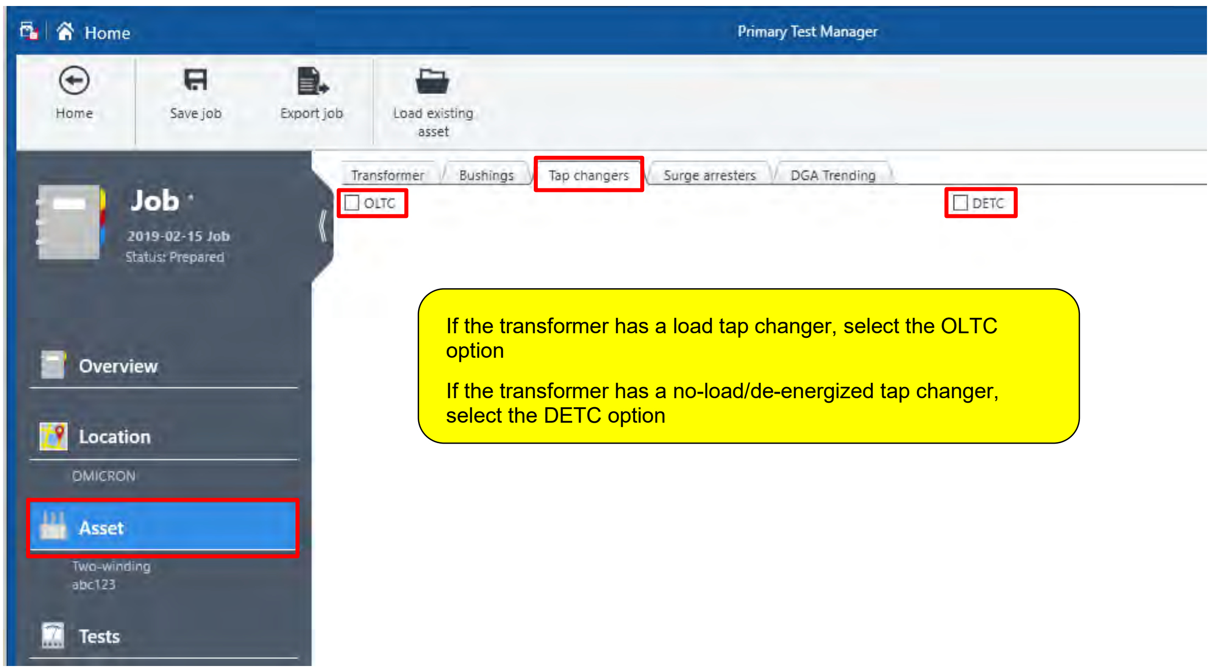


Figure 17: Asset- Tap Changer Section

As an example, let’s say that you would like to test a transformer that has the following tap changer configuration,

> Load Tap Changer (OLTC): 16R-16L located on the low-voltage winding
> No-Load Tap Changer (DETC): 1-5 located on the high-voltage winding

Then, the “Tap Changers” section would be populated as shown in Figure 18.

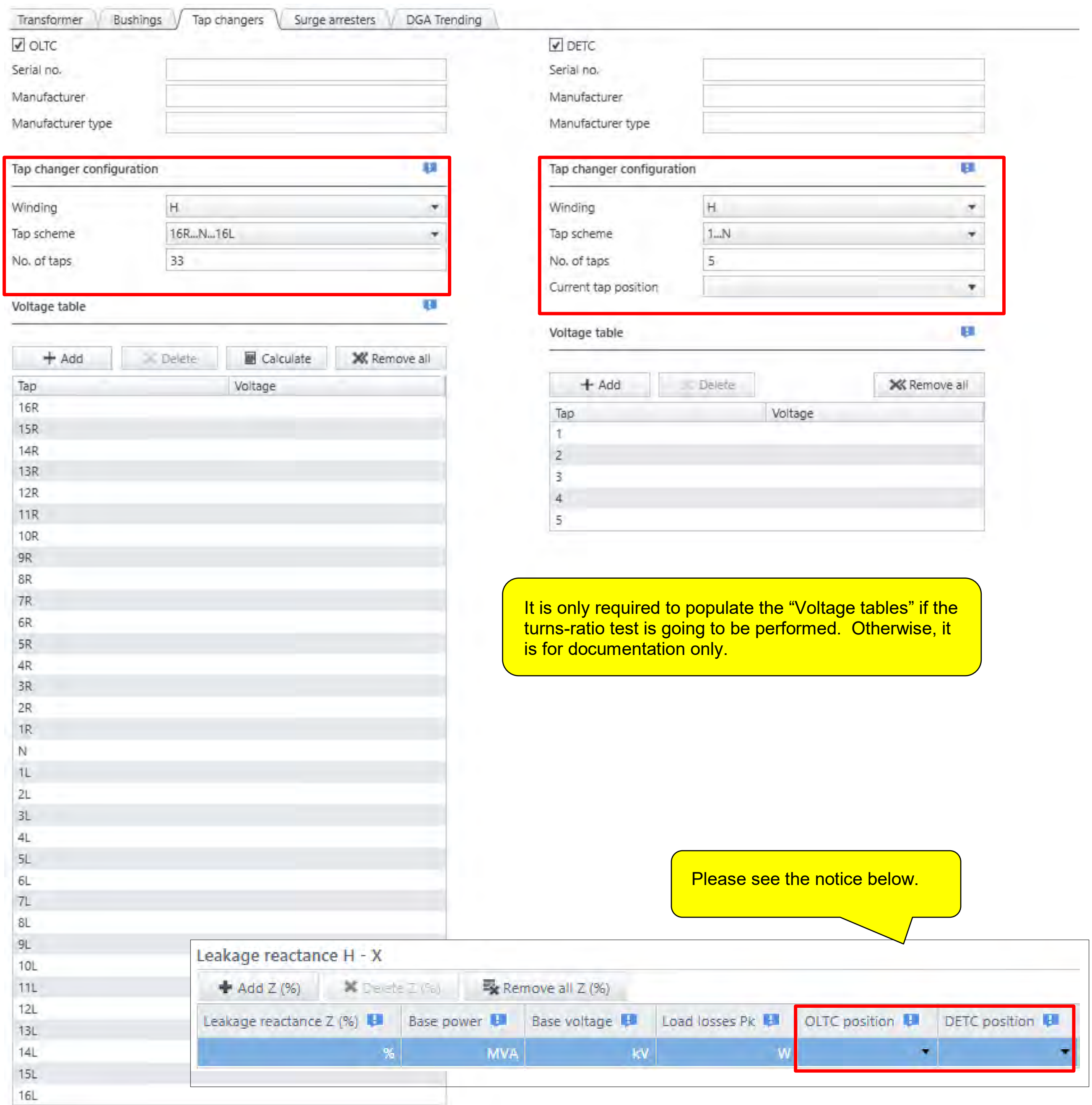


Figure 18: Tap Changer Section - Part 2

NOTICE

For Leakage Reactance Testing Only

- Once the Tap Changer information is complete, click the "Transformer" tab and scroll down to the leakage reactance section. Then, populate the OLTC and/or DETC position that the factory short-circuit impedance test was performed on (most likely the nominal tap positions).

5.4 Asset: Surge Arrester

If the transformer has surge arresters that you would like to test, click on the “Surge arresters” tab in the “Asset” section, as shown in Figure 19. Note, the surge arrester nameplate information is only required if you would like to perform a watts loss test on the surge arresters. Otherwise, entering the arrester information is for documentation.

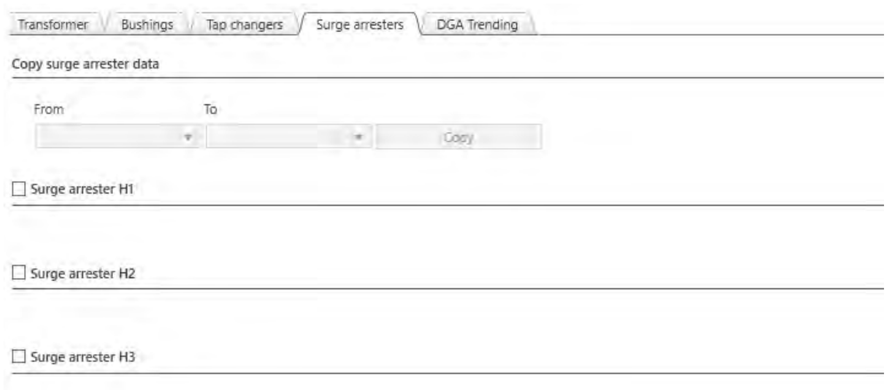


Figure 19: Surge Arrester Nameplate

To enter the nameplate information for one or more surge arresters, click the box next to the surge arrester that you would like to add to the test plan.

- Input the following critical information to correctly perform a watts loss test by using PTM,
  - The number of individual units in the surge arrester stack
  - The rated line-to-ground voltage of the surge arrester(s)
  - The test voltage for the arrester. We recommend that the test voltage does not exceed 20% of the rated line-to-ground voltage for each arrester.

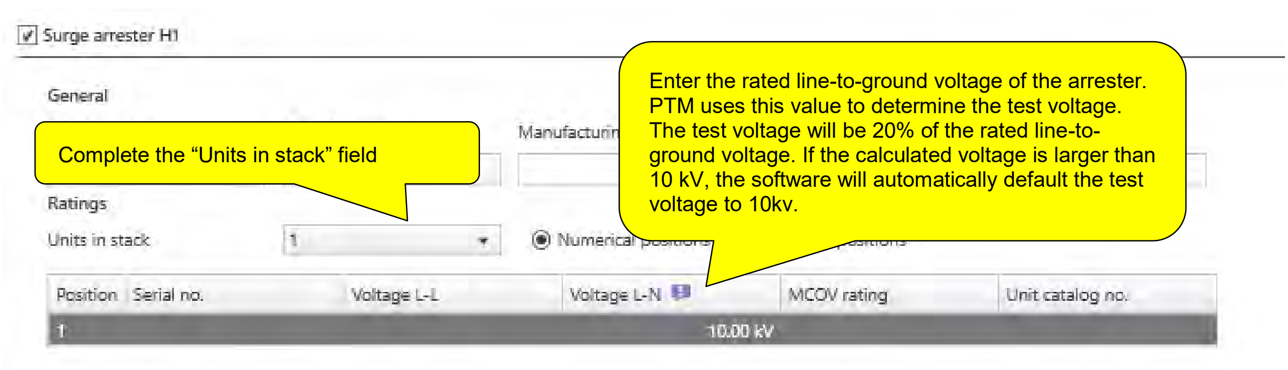


Figure 20: Surge Arrester Nameplate

5.5 Asset: DGA Trending

The DGA Trending Tab documents all available “Oil Analysis” tests in PTM associated with the asset. This tab is only available if the license has been purchased. It is only populated if at least two oil analyses are available for the asset. It assesses DGA results using interpretation methods such as Duval’s triangles or gas ratio methods according to IEEE C57.104 and IEC60599.

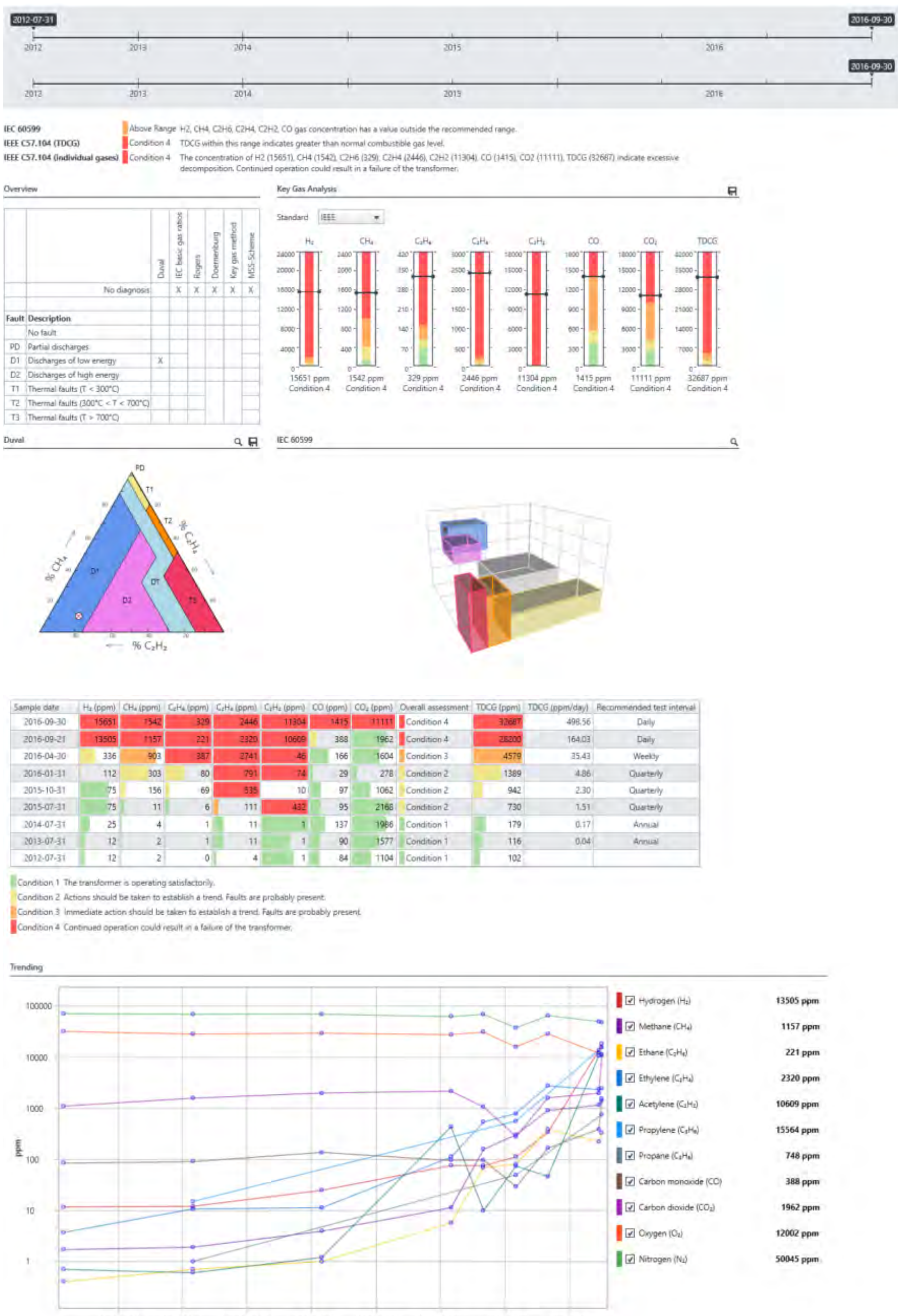


Figure 21: DGA Trending Example

6 Test Plan Creation

Once all the nameplate information for the transformer, bushings, tap changers, and surge arresters have been completed, click on the “Tests” tab located on the left panel of the PTM software. Once the “Tests” tab is selected, the PTM software will automatically generate the “recommended” test plan, based on the nameplate information that was entered in the “Asset” section. Please populate the test plan by following the guidelines provided in Figure 22.

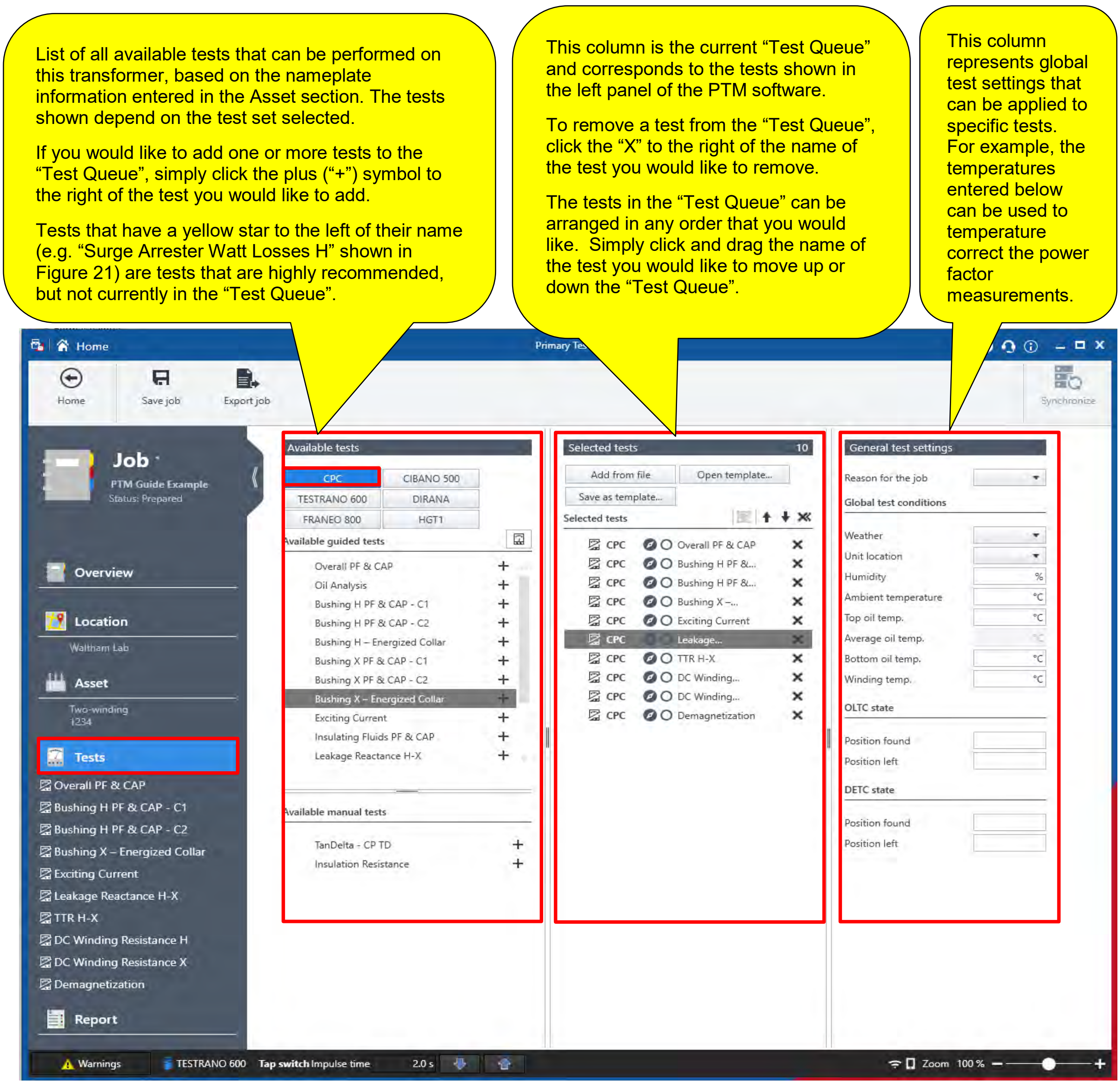


Figure 22: Tests Section -CPC 100 Example

Once the test plan has been created, you are ready to begin testing! Use the left panel of PTM to select the test which you would like to perform first. Note, the tests can be performed in any order that you would like. In addition, you can add more tests to the “Test Queue” at any time by clicking on the “Tests” tab and populating the desired tests (as shown in Figure 22).

7 Tests

7.1 Overall PF & Cap Test

Both the CPC 100 and CP TD1 are required. Before beginning the overall power factor test, please consider the following,

- Properly isolate the bushing terminals from any cable, bus-bar, support insulator, surge arrester, etc.
- Properly ground the transformer tank, CPC 100, and CP TD1
- Short-circuit all high-voltage bushings, including the neutral (if applicable)
- Short-circuit all low-voltage bushings, including the neutral (if applicable)
- Short-circuit all tertiary bushings, including the neutral (if applicable)
- Remove all in-service grounds from all the neutral bushings
- Place the load tap changer in any off-neutral tap position (Note: when investigating a failure, it is recommended to leave the LTC in the as-found position)
- Clean and dry the surface of all bushings
  - If the bushings have a porcelain exterior, use Windex or Colonite
  - If the bushings have a silicone exterior, use a clean, dry rag
- Do not test under the following conditions to avoid bad test results
  - Rain
  - High-humidity situations
  - Oil temperatures close to or below 5ºC

Once these considerations have been confirmed, connect the test set leads to the transformer by using the connection diagram.

- Ensure the HV cable is “in the clear”. The last two feet of the HV cable should not touch any surface of the transformer (transformer tank, the bushing surfaces, etc.)

Note, the connection diagram may change depending on which section of the power factor test you are trying to complete. For example, consider an overall power factor test on a two-winding transformer. First, the user would perform an “Injection at H” test, as shown in Figure 23.

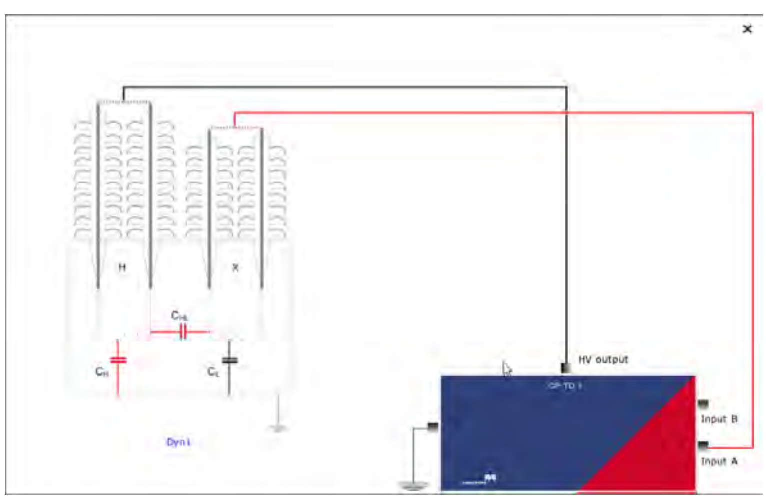


Figure 23: Two-Winding Power Factor Test – Injection at H Connection

Once the “Injection at H” test is completed, the user would proceed to the “Injection at X” test and use the test connections shown in Figure 24.

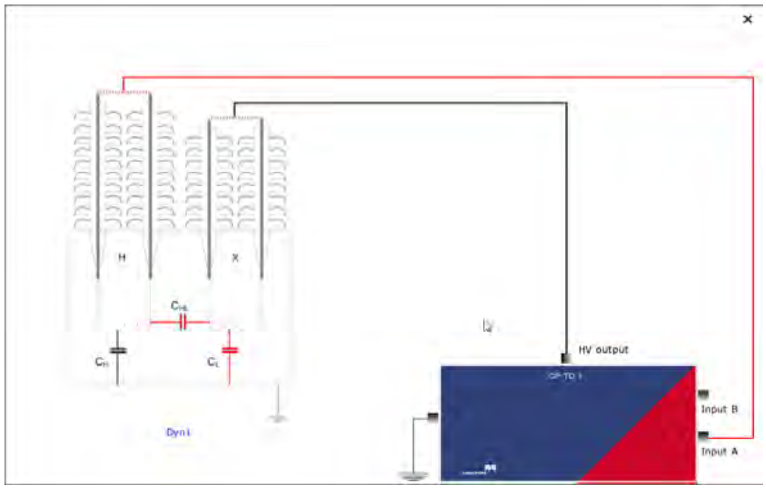


Figure 24: Two-Winding Power Factor Test – Injection at X Connection

Once the test considerations and test connections have been verified for the overall power factor test, scroll down to the “Settings and conditions” section to verify the proper settings for the test.

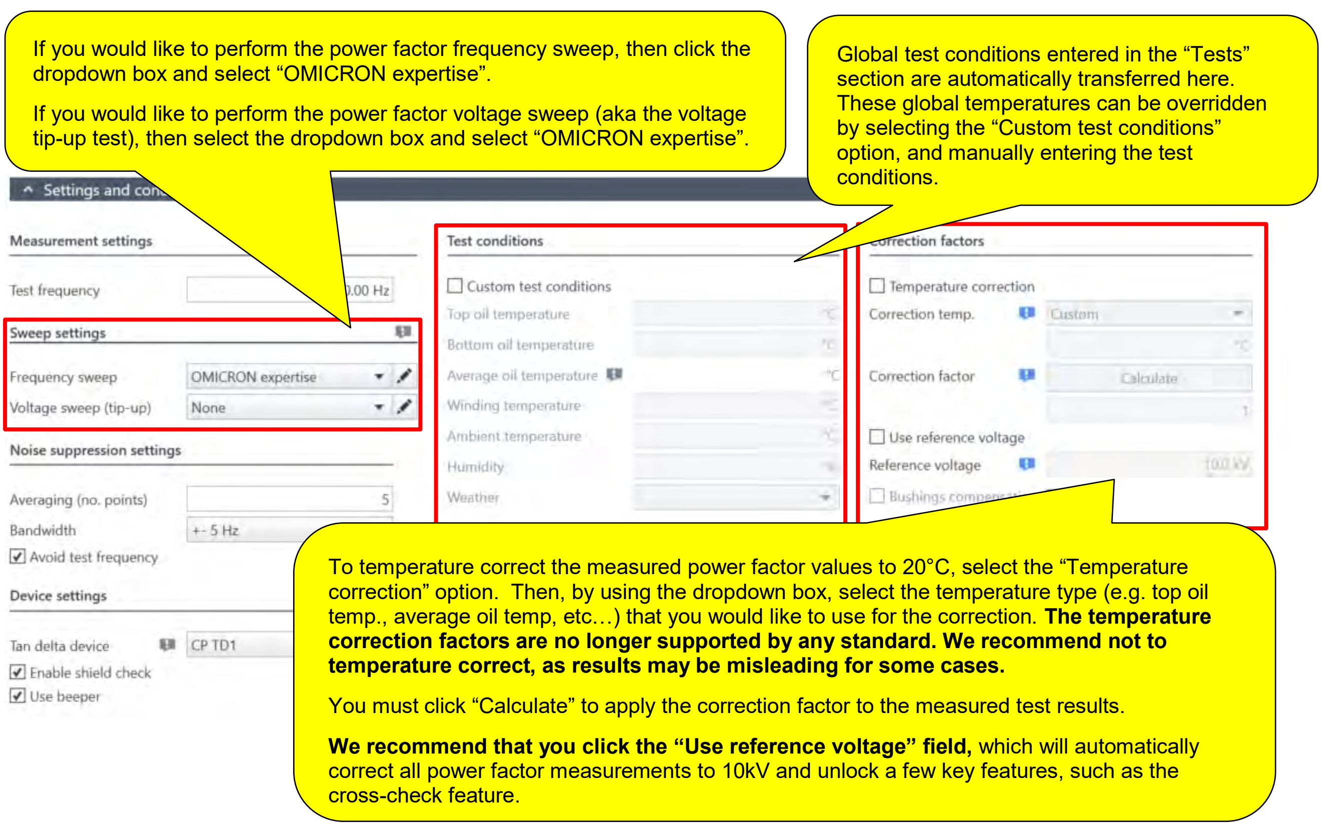


Figure 25: Overall Power Factor Settings and Conditions

Once the desired test settings have been confirmed, scroll down to the “Assessment” section.

NOTICE

Enabling the assessment feature

- Please note that the assessment feature will only be available if the following conditions are met,

  1. The insulating medium of the transformer has been selected in the “Asset – Transformer - Others” section
  2. The “Temperature correction” feature has been enabled (as shown in Figure 25)

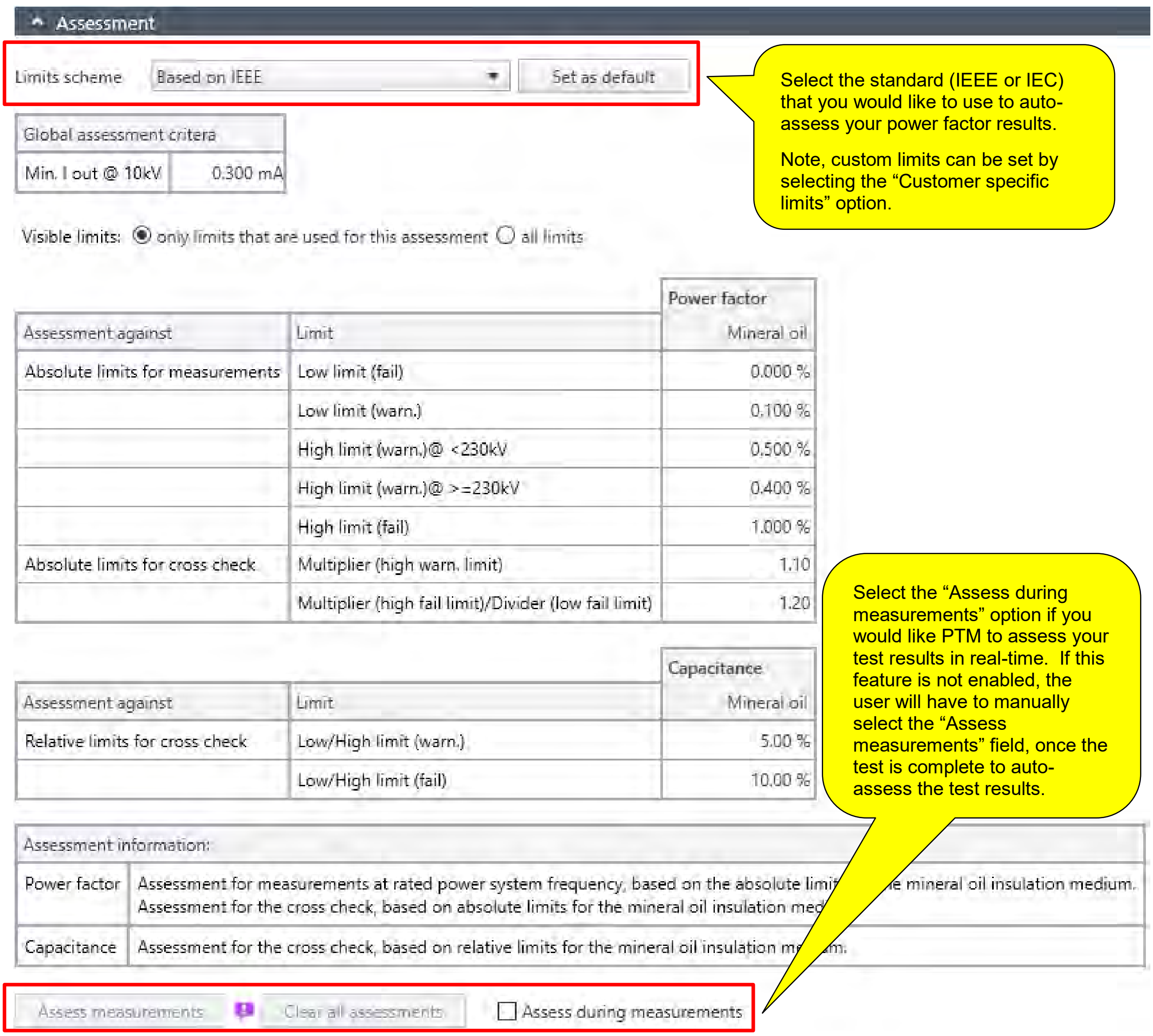


Figure 26: Assessment – Overall Power Factor

Once the "Assessment" section has been completed, scroll down to the "Measurements" section.

NOTICE

Locked in Asset Data after performing measurement

- Please note that once any measurement within this test plan (i.e. the job) has been performed (including the overall power factor measurement), many of the fields within the "Asset" section will be locked and inaccessible. Therefore, it is critical that all the "Asset" (i.e. the nameplate) information is correct before performing the first measurement. In addition, please verify that the "Settings and conditions" section is correct before performing the first measurement.

First, click on the measurement shown in "row No. 1", as highlighted in Fig.27. Once the proper test connections are made for the "row No. 1" measurement, select the "Start all" option for the "Injection at H" test. If the "Start all" option is not green, then the user must connect the CPC 100 to their laptop before beginning the test.

Once all measurements for the "Injection at H" section are complete, click on the measurement for "row No. 4", as highlighted in the following image. Once the proper test connections are made for the "row No. 4" measurement, select the "Start all" option for the "Injection at X" test. If the "Start all" option is not green, then the user must connect the CPC 100 to their laptop before beginning the test.

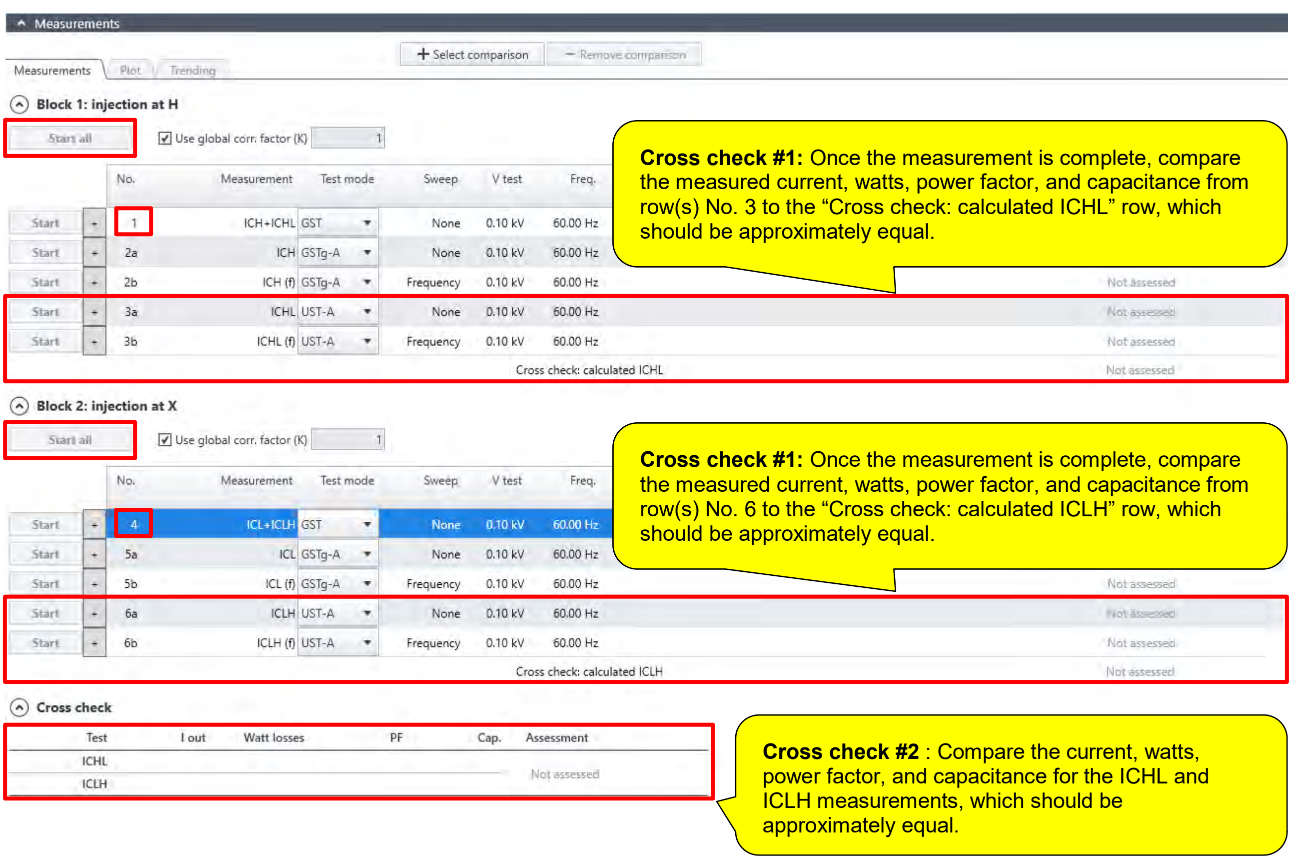


Figure 27: Overall Power Factor - Measurements

Once the power factor measurements are complete, perform the two “sanity checks” to verify the validity of the test results. The two “cross check” features are enabled after checking “Use reference voltage” box in the “Settings and conditions” section to correct the measured values to 10kV. The two “sanity checks” that must be performed include,

- Cross check #1: calculated ICHL/ICLH vs measured ICHL/ICLH (see comments in Figure 27)
- Cross check #2: measured ICHL vs ICLH (see comments in Figure 27)

If either of the two sanity checks are not valid, then investigate the following possibilities, and repeat the test,

- Poor test connection, poor ground connection, and/or poor test procedure
- Possible voltage sensitive defect within insulation (please repeat test and perform the voltage sweep)

7.2 Bushing PF & Cap- C1 Test

Both the CPC 100 and CP TD1 are required. Before beginning the bushing C1 power factor test, please consider the following,

- Properly isolate the bushing terminals from any cable, bus-bar, support insulator, surge arrester, etc.
- Properly ground the transformer tank, CPC 100, and CP TD1
- Ensure the bushings remain short circuited as in the Overall PF test
- Remove all in-service grounds from all the neutral bushings
- Clean and dry the surface of each bushing before testing
  - If the bushings have a porcelain exterior, use Windex or Colonite
  - If the bushings have a silicone exterior, use a clean, dry rag
- Do not test under the following conditions to avoid bad test results
  - Rain
  - High-humidity situations
  - Oil temperatures close to or below 5ºC
- Confirm the Test Mode is UST-A (automatically configured by PTM)
- Confirm the Test voltage does not exceed line-to-ground voltage rating of bushing (automatically configured by PTM)
- Remove one bushing tap cap at a time (i.e. only for the bushing currently under test)

Once these considerations have been confirmed, connect the test set leads to the apparatus by using the connection diagram in PTM,

- Place High-voltage lead on bushing center-conductor and Red-A lead on bushing test or potential tap
- Ensure the HV cable is “in the clear”. The last two feet of the HV cable should not touch any surface of the transformer (transformer tank, the bushing surfaces, etc.)

Figure 28 shows the test connections for a C1 power factor test for the H1 bushing. Note, the connection diagram may change depending on which bushings you are testing. Once the proper test considerations and test connections have been confirmed, scroll down to the “Settings and conditions” section.

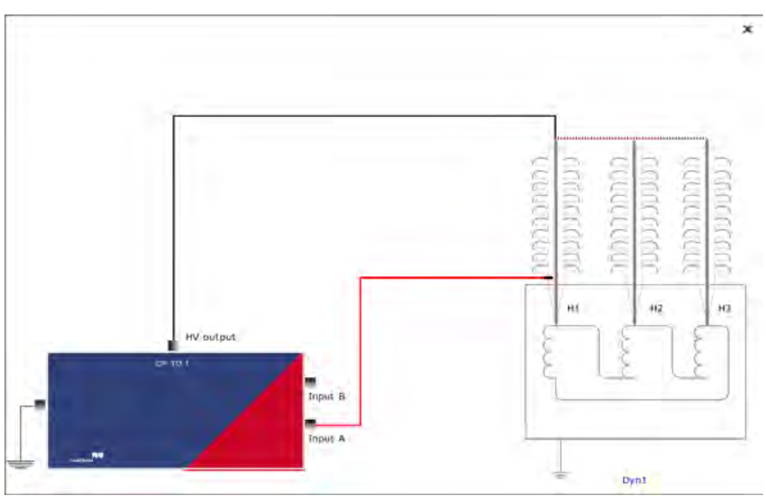


Figure 28: H1 C1 Power Factor – Test Connections

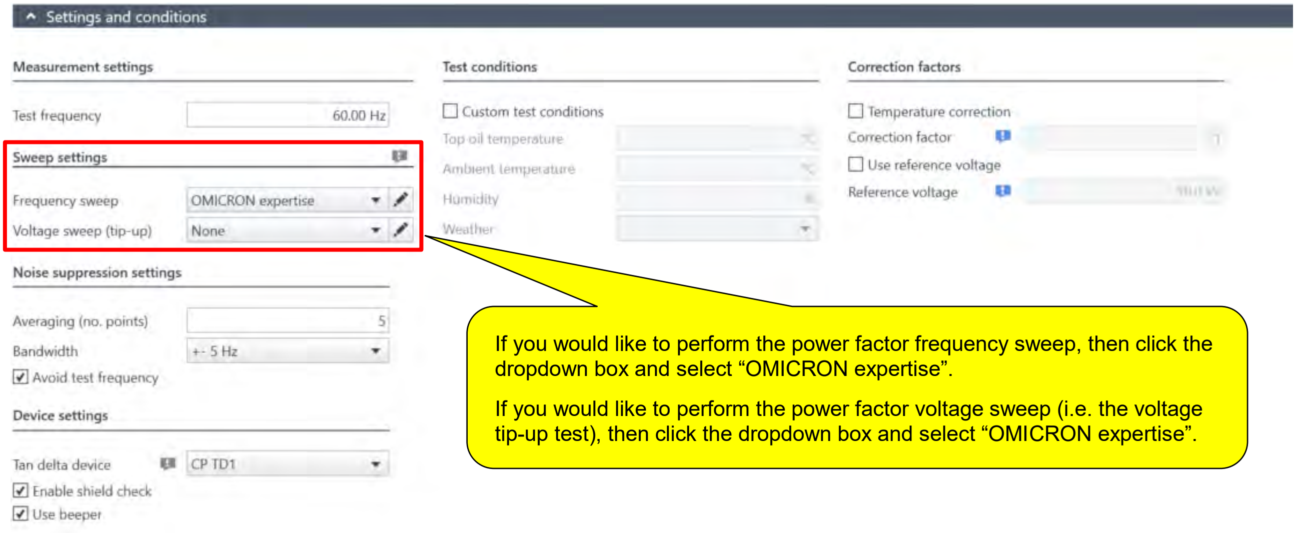


Figure 29: Bushing C1 Power Factor – Settings and Conditions

Once the desired test settings have been confirmed, scroll down to the “Assessment” section.

NOTICE

Locked in Asset Data after performing measurement

- Note, once a C1 power factor measurement has been completed, many of the “Settings and conditions” fields will be locked and cannot be changed, so please verify that the settings are correct before proceeding.

NOTICE

Enabling the assessment feature

- Please note that the assessment will only be available if the insulation type of the bushing was selected in the “Asset - Bushings” section of the PTM software (see Figure 16).

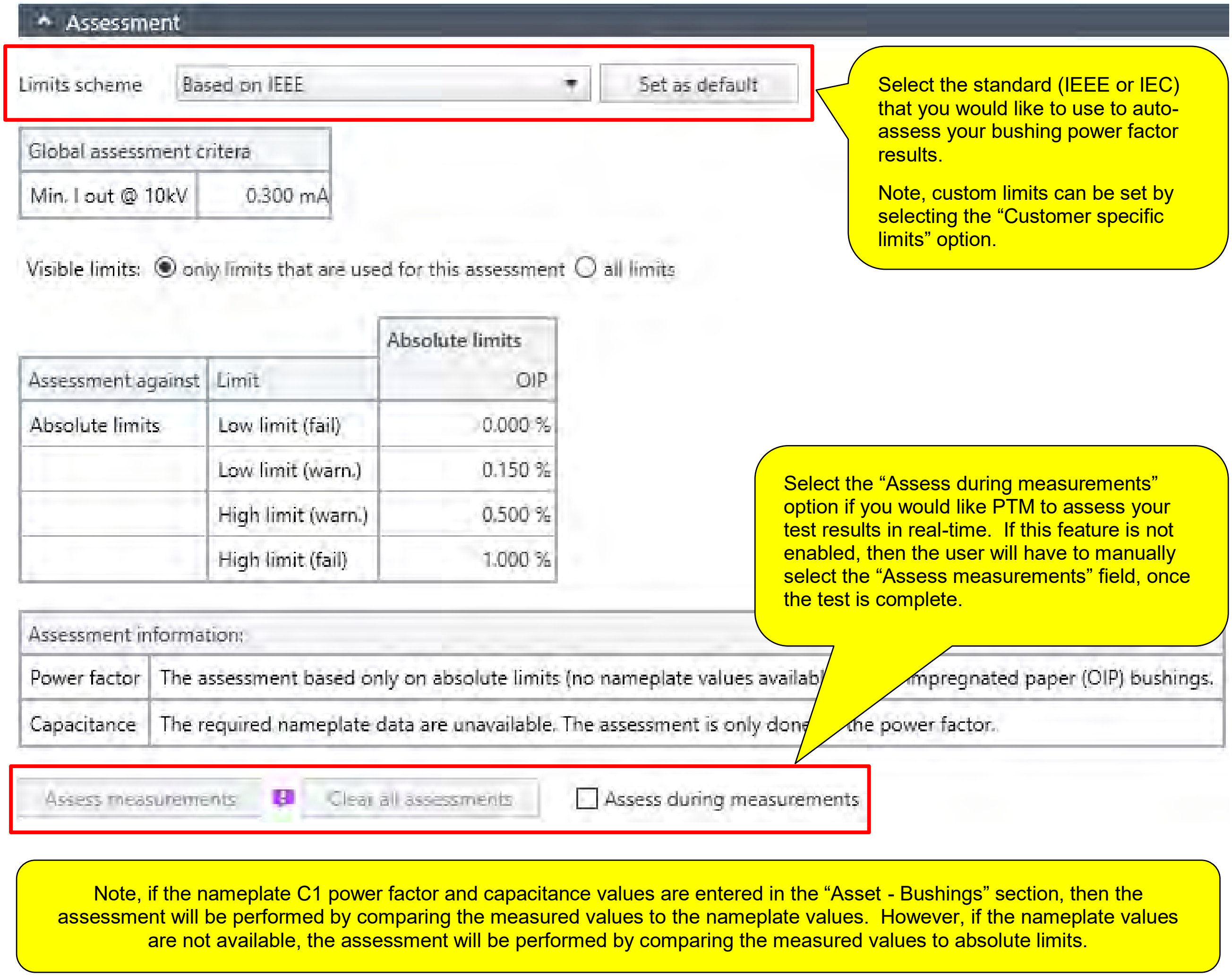


Figure 30: Bushing C1 Power Factor – Assessment Section

Once the “Assessment” section is complete, scroll down to the “Measurements” section and select the “Start” option for the measurement you would like to perform. For example, selecting the “Start” option highlighted in Figure 31 would begin the H1 C1 power factor test. Note, if the “Start” option is not green, then the user must connect their laptop to the CPC 100 to begin the test.

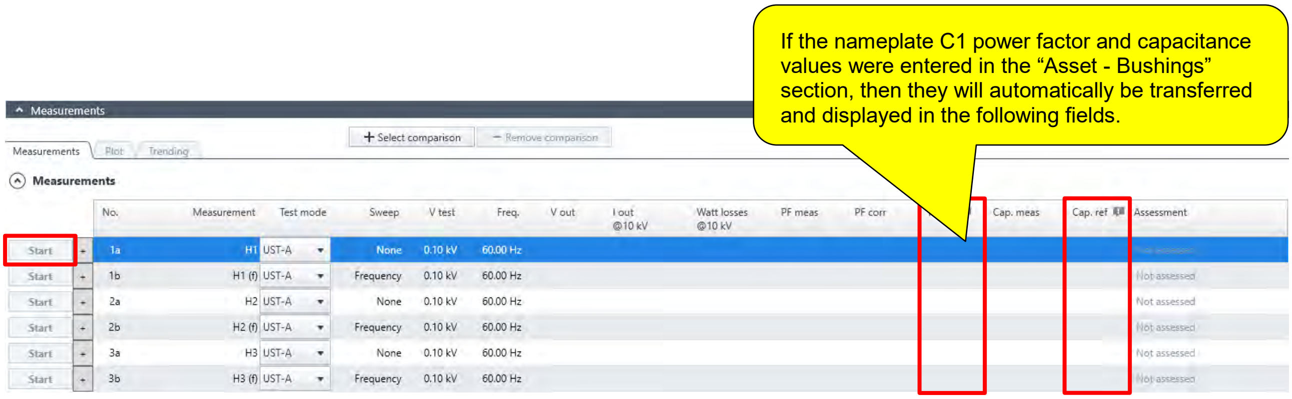


Figure 31: Bushing C1 Power Factor – Measurements Section

Once all the bushing C1 Power Factor measurements are complete, the user should verify the validity of the measurements, before proceeding to the next test. To help confirm the validity of the test results consider the following,

- Are the capacitance values for each bushing > 200pF? Typically, the measured capacitance for a bushing C1 power factor test is >200pF.
- Do the measured capacitance values compare well to the nameplate capacitance values? They should compare well.
- Do the measured capacitance values of each bushing compare well to each other? (assuming they are the same make, model, etc…) They should compare well.

If the measurements do not appear to be valid, then consider the following possibilities, and repeat the test,

- Poor test connection, poor grounding, and/or poor test procedure (please see considerations at the beginning of the section)

7.3 Bushing PF & Cap- C2 Test

Both the CPC 100 and CP TD1 are required. Before beginning the bushing C2 power factor test, please consider the following,

- Properly isolate the bushing terminals from any cable, bus-bar, support insulator, surge arrester, etc.
- Properly ground the transformer tank, CPC 100, and CP TD1
- Ensure the bushings remain short circuited as in the Overall PF test
- Clean and dry the test tap area of each bushing before testing
- Confirm the Test Mode is GSTg-A (automatically configured by PTM)
- Confirm the correct test voltage for the C2 power factor test depending on whether the bushing has a test (500V) or potential (2000V) tap.

Once these considerations have been confirmed, connect the test set leads to the apparatus according to the connection diagram in PTM,

- Place the High-voltage lead on test or potential tap of bushing. The high-voltage lead adapter shown in Figure 32 should be used to help make the test connection to the bushing tap.
- Place the Red-A lead on center-conductor of bushing
- Ensure the HV cable is “in the clear”. The last two feet of the HV cable should not touch any surface of the transformer (transformer tank, the bushing surfaces, etc.)

Once these considerations have been confirmed, connect the test set leads to the apparatus by using the connection diagram. For example, Figure 33 shows the test connections for a C2 power factor test for the H1 bushing. Note, the connection diagram may change depending on which bushings you are testing. Once the proper test considerations and test connections have been confirmed, scroll down to the “Settings and conditions” section.

Figure 32: High-Voltage Lead Adapter for C2 Power Factor

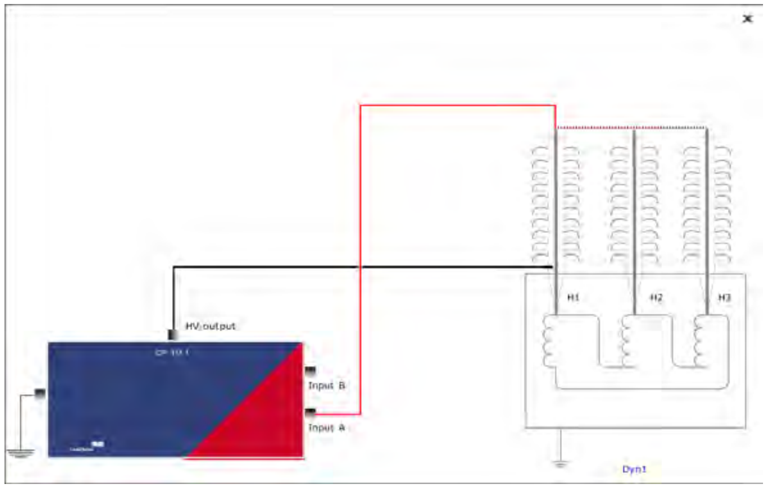


Figure 33: C2 Power Factor – H1 Test Connections

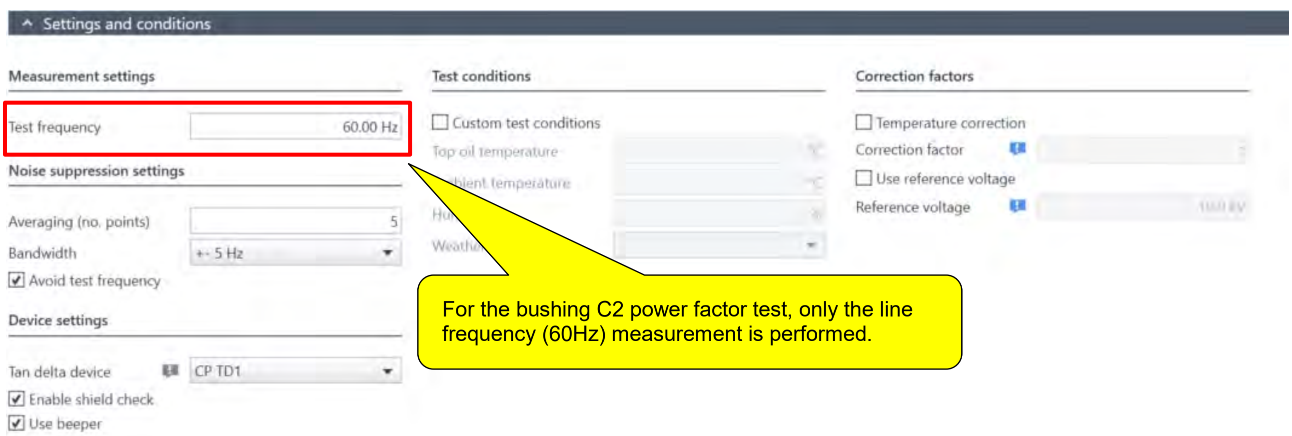


Figure 34: C2 Power Factor Test Settings

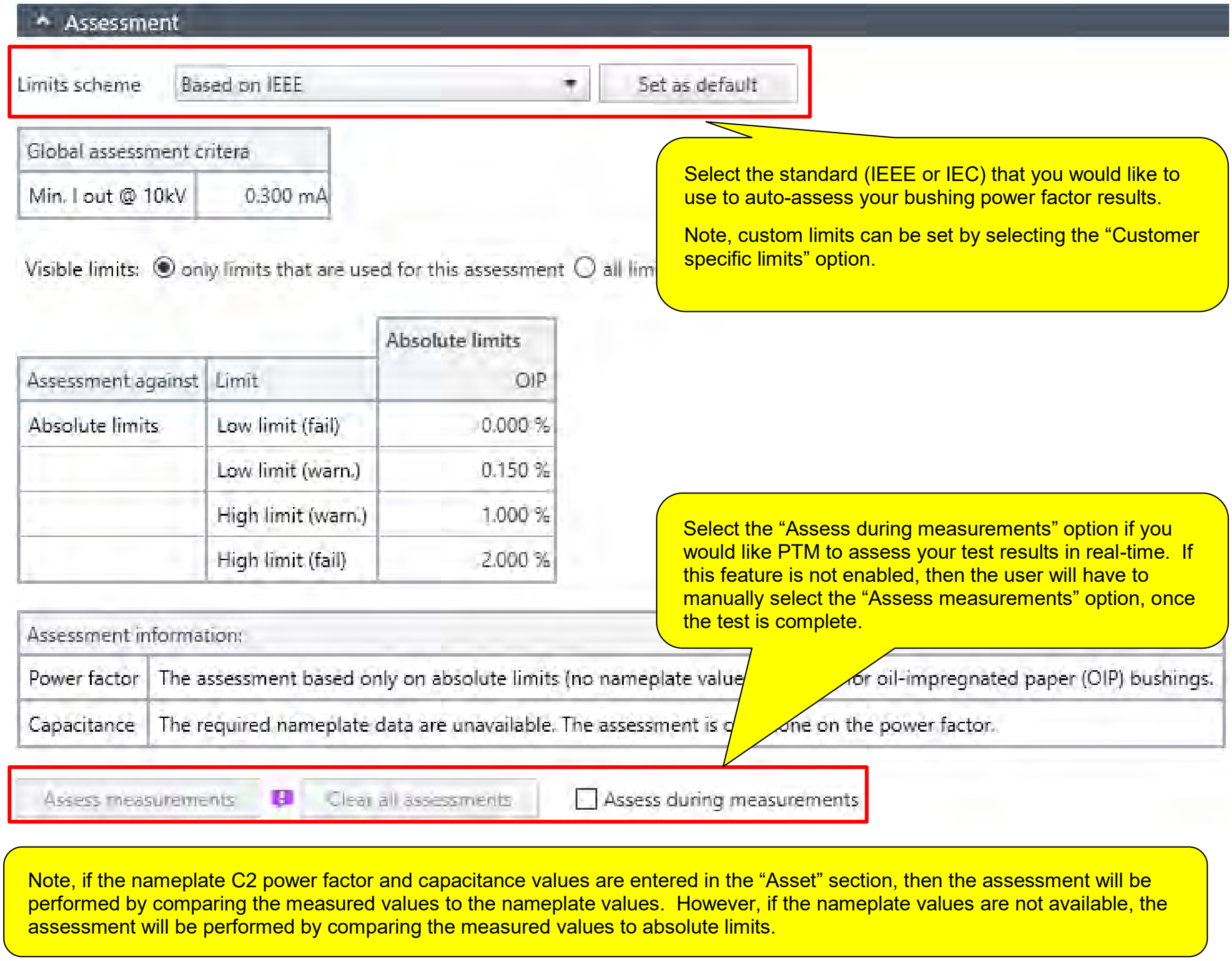


Figure 35: C2 Power Factor Test – Assessment Section

Once the "Assessment" section is complete, scroll down to the "Measurements" section and select the "Start" option for the measurement you would like to perform. For example, selecting the "Start" option highlighted in Figure 36 would begin the H1 C2 power factor test. Note, if the "Start" option is not green, then the user must connect their laptop to the CPC 100 to begin the test.

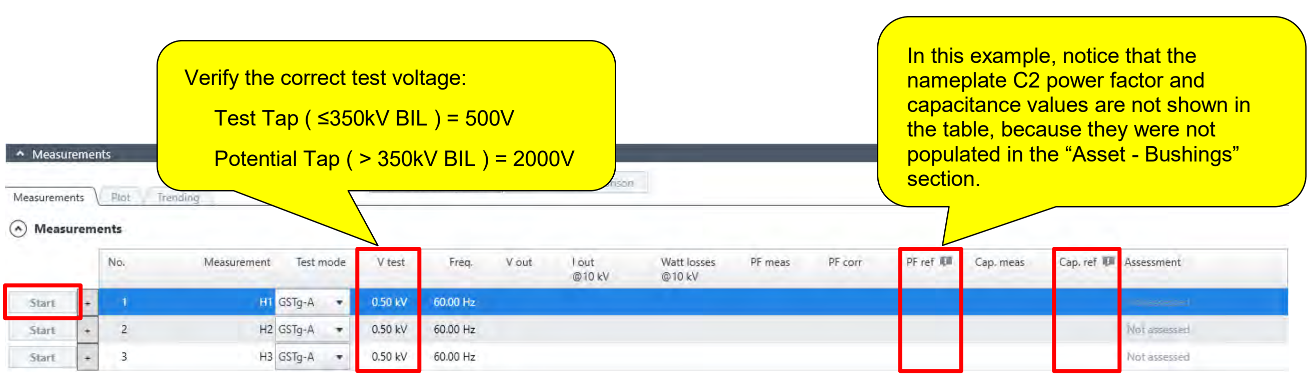


Figure 36: C2 Power Factor – Measurements

Once all the bushing C2 Power Factor measurements are complete, the user should verify the validity of the measurements, before proceeding to the next test. To help confirm the validity of the test results consider the following,

- Are the capacitance values for each bushing > 200pF? Typically, the measured capacitance for a bushing C2 power factor test is >200pF.
- Do the measured capacitance values compare well to the nameplate capacitance values? They should compare well.
- Do the measured capacitance values of each bushing compare well to each other? (assuming they are the same make, model, etc…) They should compare well.

If the measurements do not appear to be valid, then consider the following possibilities, and repeat the test,

- Poor test connection, poor grounding, and/or poor test procedure (please see considerations at the beginning of the section)

7.4 Bushing Energized Collar Test

Both the CPC 100 and CP TD1 are required. Before beginning the bushing energized collar test, please consider the following,

- Properly isolate the bushing terminals from any cable, bus-bar, support insulator, surge arrester, etc.
- Properly ground the transformer tank, TESTRANO 600, and CP TD1
- Clean and dry the surface of each bushing before testing
  - If the bushings have a porcelain exterior, use Windex or Colonite
  - If the bushings have a silicone exterior, use a clean, dry rag
- Confirm the Test Mode is UST-A (automatically configured by PTM)

Once these considerations have been confirmed, connect the test set leads to the apparatus by using the connection diagram in PTM,

- Place the High-voltage lead on conductive collar. The high-voltage lead adapter shown in Figure 32 should be used to help make the test connection to the collar.
- Placed the conductive strap tightly around the bushing under test below the top skirt
- Place the Red-A lead on center-conductor of bushing
- Ensure the HV cable is “in the clear”. The last two feet of the HV cable should not touch any surface of the transformer (transformer tank, the bushing surfaces, etc.)

Figure 37 shows an example test connections for an energized collar test on the H1 bushing.

Note, the connection diagram may change depending on which bushings you are testing. Once the proper test considerations and test connections have been confirmed, scroll down to the “Settings and conditions” section.

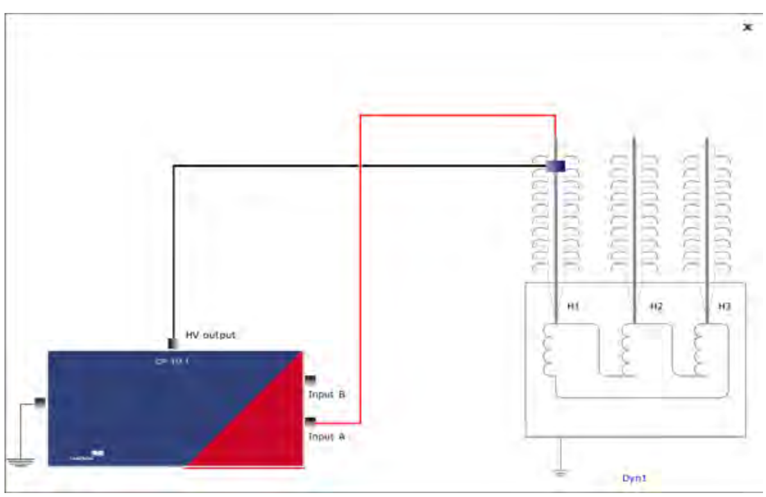


Figure 37: Energized Collar Test Connections

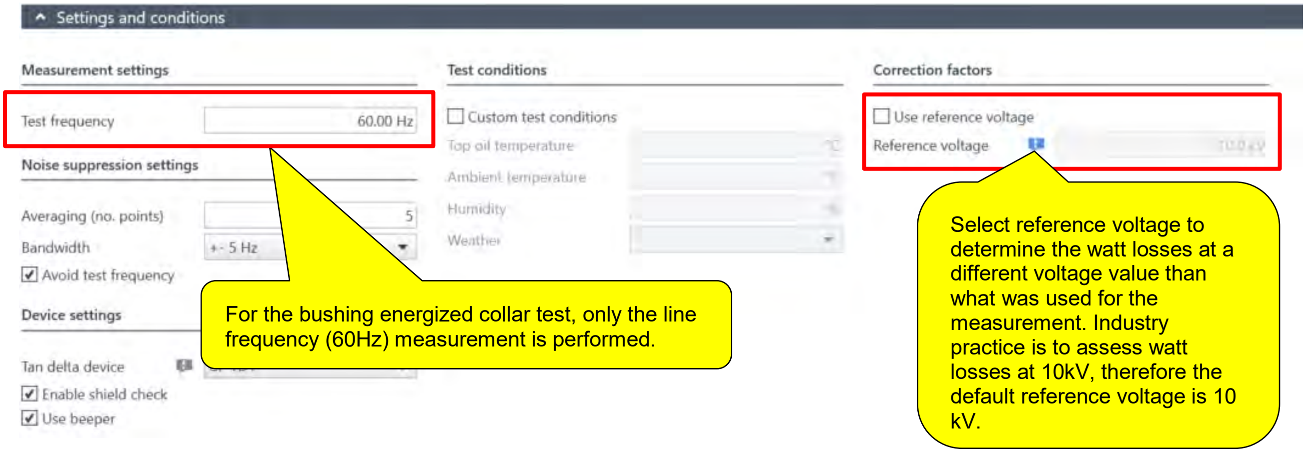


Figure 38: Energized Collar Test Settings

Once the correct test settings have been confirmed, scroll down to the "Measurements" section and select the "Start" option for the measurement you would like to perform. For example, selecting the "Start" option highlighted in Figure 39 would begin the H1 energized collar test. Note, if the "Start" option is not green, then the user must connect their laptop to the CPC 100 to begin the test.

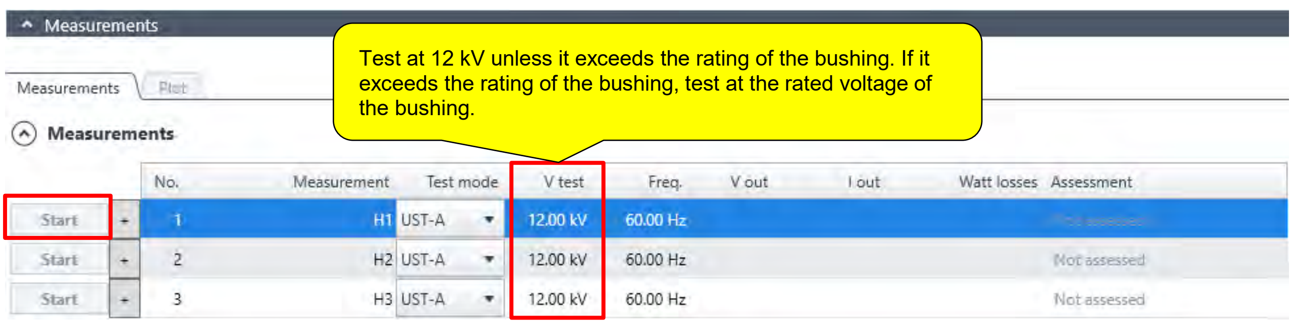


Figure 39: Energized Collar Test – Measurements Section

NOTICE

Automatic assessment not possible

- Please note the energized collar test does not provide an automatic assessment. The results of this test can be assessed by the following methods:
  - Compare the measured current and watt losses of each bushing to each other (assuming they are the same make, model, etc…)
  - Compare the measured current and watt losses to previous test results.
  - Ensuring the watts losses at 10kV is <100 mW

7.5 Exciting Current Test

Both the CPC 100 and CP TD1 are required. Before beginning the exciting current test, please consider the following,

- Remove all the shorting jumpers used previously in the power factor test, since the exciting current test is an “open circuit test”
- Follow the connection diagram, and pay close attention to the external ground leads that may be required for certain winding configurations.

Figure 40 shows the test connection for the Phase-A measurement of a DYn1 transformer. Notice that there are two external ground leads required (H2 and X0) to complete the measurement successfully. However, keep in mind that these ground connections may change depending on the phase being tested. Note, the connection diagram may change once another phase is selected.

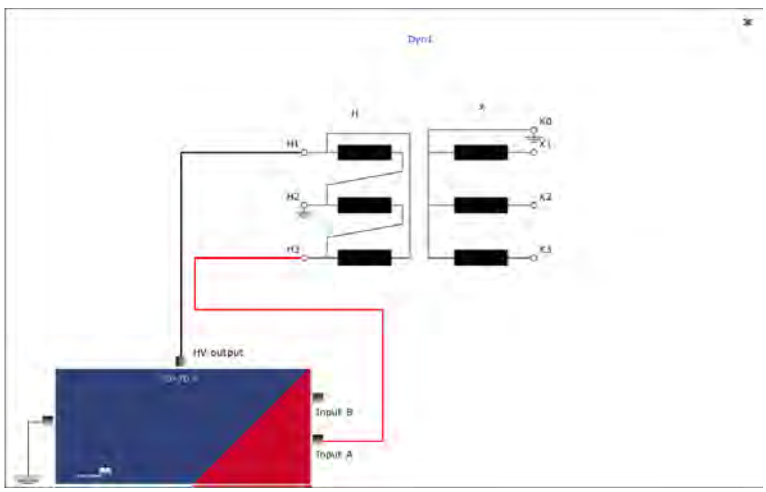


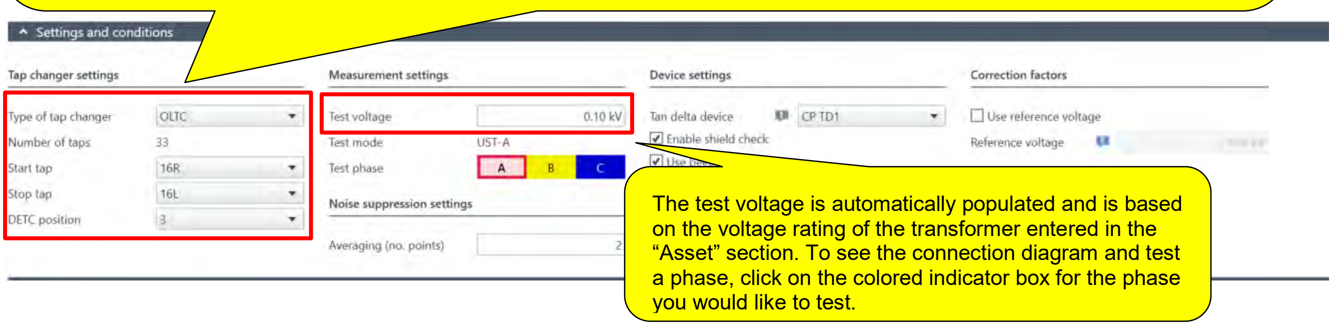
Figure 40: Exciting Current – Dyn1 Phase A Test Connections

Once the proper test connections have been made, scroll down to the “Settings and conditions” section.

If a DETC and/or LTC was entered in the "Asset – Tap Changers" section, then indicate which tap changer you would like to change during the exciting current measurement. If a tap changer was not entered in the "Asset – Tap Changers" section, then these fields require no action.

For example, let's say that we would like to keep the DETC position fixed on position 3, and test from 16R-16L on the LTC, then the settings highlighted below would be selected.

Note, once the measurement begins, the start and stop tap positions can be changed "on the fly". For example, let's say that once I started the test, I decided that I only wanted to test the 1L, N, 1R, and 16R positions, I can do so without stopping the measurement or altering these fields.



The test voltage is automatically populated and is based on the voltage rating of the transformer entered in the "Asset" section. To see the connection diagram and test a phase, click on the colored indicator box for the phase you would like to test.

Figure 41: Exciting Current – Settings and Conditions

Once the correct test settings have been confirmed, scroll down to the "Measurements" section. Select the phase that you would like to test and then click the "Start" option, which is highlighted in Figure 42. If the "Start" option is not green, then the user must connect the CPC 100 to their laptop.

The phase that you would like to test can also be selected by clicking on the colored toolbar of each phase. Please note, the connection diagram will change once a particular phase is selected.

To begin the test, click on the phase that you would like to measure, and then select the "Start" option.

Once the measurements are complete, these options can be used to delete or clear certain test results from the measurement table.

Figure 42: Exciting Current – Measurements Section

7.6 Turns-Ratio (TTR) Test

Only the CPC 100 is required. Additionally, the CP SB1 is an optional accessory that may be used to aid with the turns-ratio test. The turns-ratio test can be performed with the CPC 100 using two methods, which include,

1) Single-Phase Test Connection: CPC 100 only with a maximum output voltage of 2000V

2) Three-Phase Test Connection: CPC 100 + CP SB1 with a maximum output voltage of 300V

NOTICE

Equipment damage or compromised measurement possible

- Do not exceed the overvoltage rating of the V1 AC input of 300V. If this rating is exceeded, the accuracy of the measurement will be compromised. Before beginning the turns-ratio test, ensure the voltage measured on the secondary (or tertiary) of the transformer will not exceed 300V. If the CP SB1 is being used to perform the turns-ratio test, then the secondary voltage should always be less than or equal to 300V, since the maximum output voltage of the CP SB1 is 300V. However, if the single-phase test connection method is being used, then please use the following equation to calculate the maximum test voltage allowed during the turns-ratio test,

$$Vtest\ (\text{maximum}) = 300\text{V} * \frac{Vprimary\ (L - G\ Rating)}{Vseconary\ (L - G\ Rating)}$$

*Vtest is the maximum test voltage entered in the “Settings and conditions” section
*Vprimary (L-G rating) is the line-to-ground voltage rating of the primary winding

*Vsecondary (L-G rating) is the line-to-ground voltage rating of the secondary winding

The single-phase test connection method is the default setting; however, if you would like to use the CP SB1 to perform the turns-ratio measurement, then the “Use CP SB1” option must be selected within the “Settings and conditions” section, as shown in Figure 44. Note, the connection diagram will change if the “Use CP SB1” option is selected. Figure 43 displays an example of the “single-phase” test connection for phase A of a Dyn1 transformer.

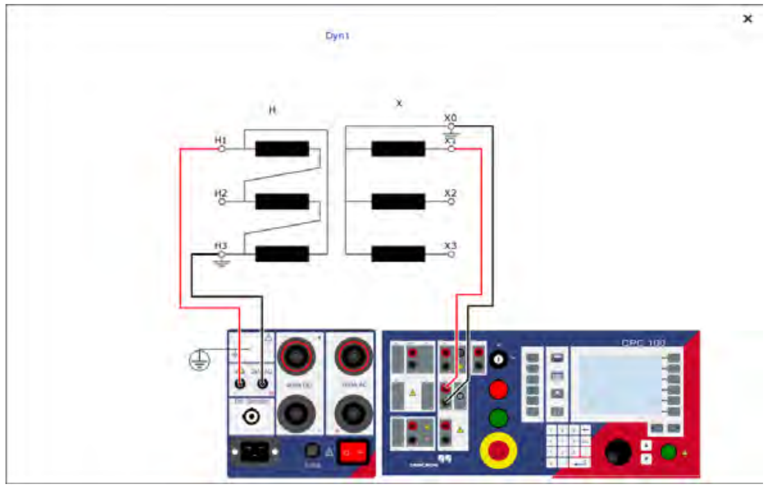


Figure 43: Turns-Ratio Test – Dyn1 Phase A Test Connection

Once the proper test connections have been made, scroll down to the “Settings and conditions” section.

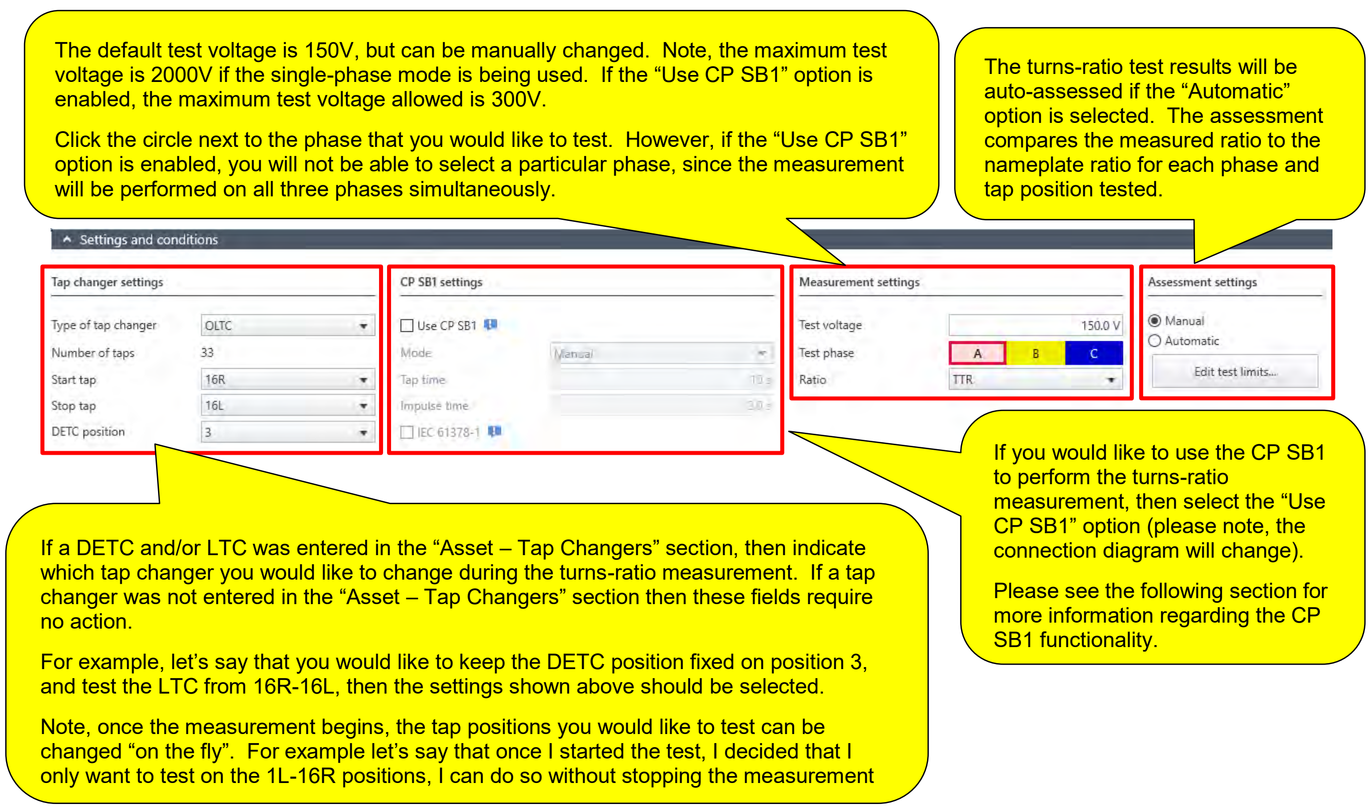


Figure 44: Turns-Ratio Test – Settings and Conditions

If the “Use CP SB1” option is enabled, then please be aware of the settings outlined in Figure 45.

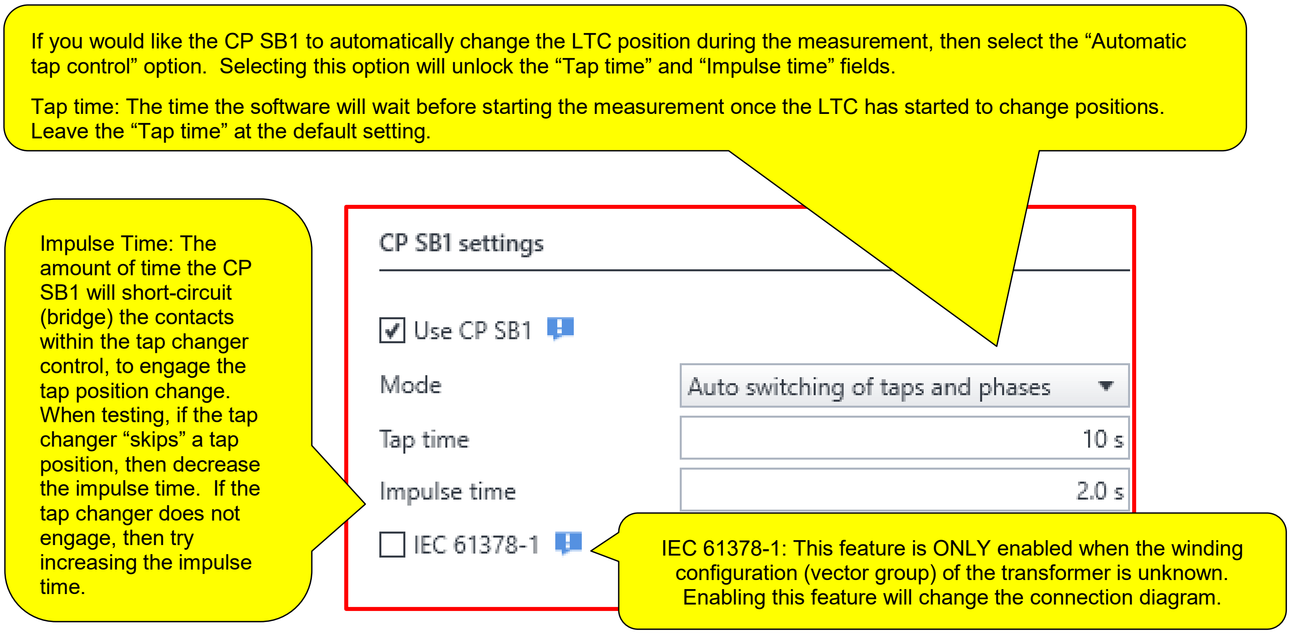


Figure 45: Turns-Ratio Test – CP SB1 Settings

An example of the connection diagram for a turns-ratio test when using the CP SB1 is shown in Figure 46.

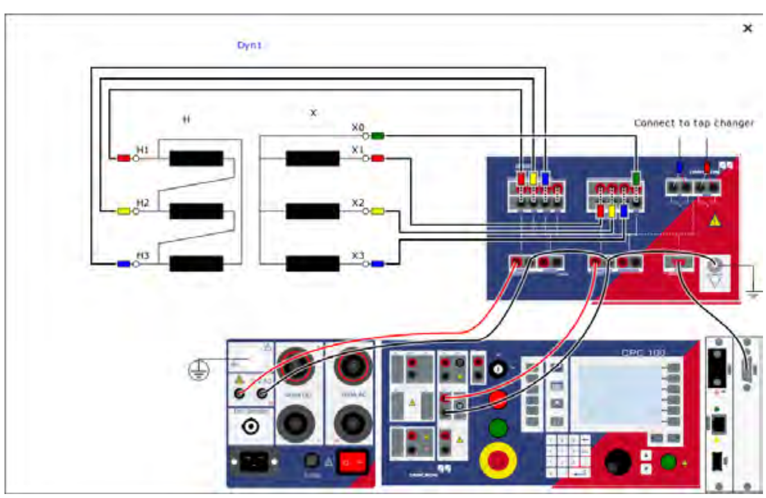


Figure 46: Turns-Ratio Test – Dyn1 Test Connection with CP SB1

Once the correct settings and test connections have been confirmed, scroll down to the “Measurements” section. Select the phase that you would like to test and then click the “Start” option, which is highlighted in Figure 47. If the “Start” option is not green, then the user must connect the CPC 100 to their laptop. Note, if the “Use CP SB1” option is enabled, the user will not be able to select a phase, since it is assumed that all three phases will be tested simultaneously.

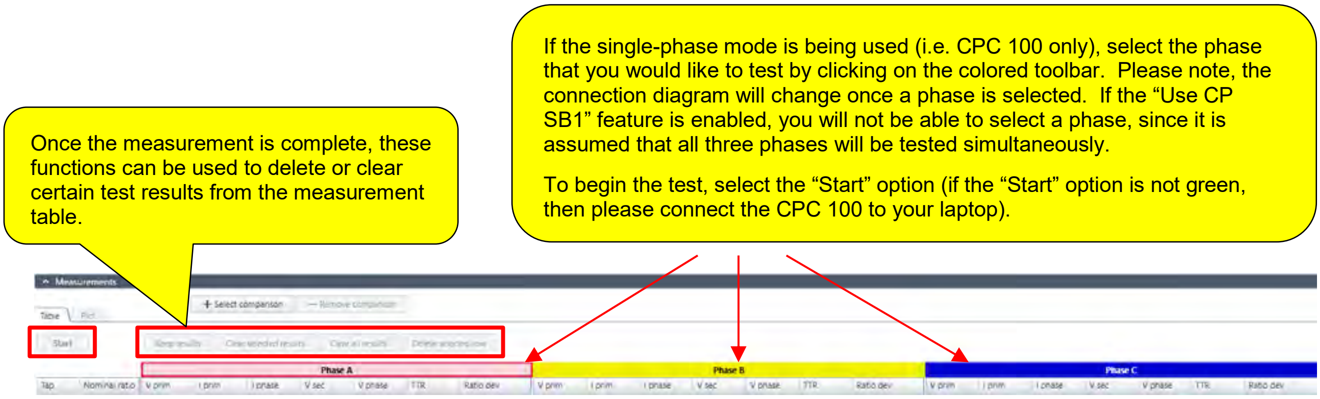


Figure 47: Turns-Ratio Test – Measurements Section

7.7 DC Winding Resistance Test

Only the CPC 100 is required. Before beginning the DC Winding Resistance test, please consider the following,

- The CP SB1 is an optional accessory which may be used to aid in the DC Winding Resistance test.
- The DC Winding Resistance Test should always be the last test performed on a power transformer. It typically is also followed by a demagnetization test.
- The DC Winding Resistance test can be performed with the CPC 100 using three methods, which include,

  1) 400A DC Method – Recommend for measuring resistances < 50mΩ and (e.g. typically useful for performing a low-voltage winding resistance measurement)

  2) 6A DC Method – Recommended for measuring resistances > 50mΩ and <10Ω (e.g. typically useful for performing a high-voltage winding resistance measurement). Note, CP SB1 may be used to aid with 6A DC method

  3) 2-Wire Method – Recommended for measuring resistances >10Ω only

NOTICE

Selecting the proper test current

- Please note that the DC winding resistance test can be "stubborn" at times due to difficulties with saturation. The measurement can still be completed in a reasonable amount of time if the following guidelines are observed to select the proper "Test current". In general, the lower the resistance of the winding to be measured, the higher the recommended "Test current".
- The user should first obtain a "ballpark estimate" of the resistance under test. Based on the magnitude of the resistance under test, please refer to the three "test methods" outlined above, and select the source which you would like to use. The 6A source is typically useful for performing a winding resistance test on a high-voltage winding (higher resistance), whereas the 400A source is typically useful for performing a winding resistance test on a low-voltage winding (lower resistance).

If the 6A source has been selected, then please observe the following,

– To avoid "overloading" the 10V DC voltmeter of the CPC 100, ensure that the measured voltage does not exceed 10V DC once the resistance measurement has stabilized. The maximum test current can be calculated by using Ohm's law, as shown below,

$$Itest(maximum) = \frac{10V}{Rwinding}$$

$$Itest(maximum) = maximum\ test\ current\ allowed\ for\ this\ particular\ measurement$$

$$Rwinding = resistance\ of\ the\ winding\ (note, a\ ballpark\ estimate\ is\ fine)$$

– Limit the maximum test current to 5A when using the 6A source
– Note, exceeding a measured voltage of 10V DC will not typically damage the CPC 100; however, if the measurement is recorded when the measured voltage is > 10V DC, then the accuracy of the measurement will be compromised.

If the 400A source has been selected, then please observe the following,

– Ensure the “Test current” does not exceed 10% of the rated current of the winding under test (note, this is a conservative limit)

– Select the test current, so the measured voltage does not exceed the 6.5V DC “compliance voltage” of the 400 A source once the resistance measurement has stabilized.

$$Itest(maximum) = \frac{6.5V}{Rwinding}$$

Note, a test current ranging from 25A-50A is generally sufficient for a low-voltage winding test

NOTICE

Compromised results possible for resistances lower than 50mΩ

- Do not use the CP SB1 for resistance measurements lower than 50mΩ, due to the 6A DC limitation of the CP SB1. We recommend using the 400A DC source for resistances lower than 50mΩ.

Figure 48 displays an example of the single-phase test connection for Phase-A on the low voltage winding of a Dyn1 transformer.

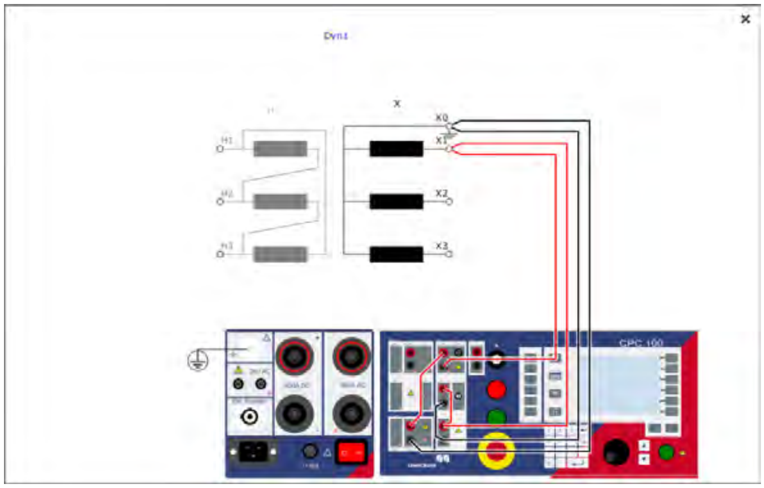


Figure 48: DC Winding Resistance Test – Low Voltage Winding Phase A Connection

Once the proper test connections have been made, scroll down to the “Settings and conditions” section.

NOTICE

Compromised results possible if measurement not stable

- Please note that it is critical that the resistance measurement stabilizes before the measurement is recorded, so if the “Automatic result” feature is enabled (see Figure 49), we recommend setting the “Tolerance R dev” to 0.05%, which can be found in the “Settings and conditions section (see Figure 49).

If you would like to use the CP SB1 to perform the winding resistance measurement, then select the "Use CP SB1" option (please note, the connection diagram will change). Please see Figure 50 for more information regarding the CP SB1 functionality.

Select the "Up/Down test" option if you would like to perform the winding resistance test on all LTC positions in both the up and down (i.e. raised and lowered) directions.

The measured resistance values can be temperature corrected by selecting the "Temperature correction" field. If the winding temperature was previously entered in the "Tests" section (see Figure 22), it will automatically be transferred and applied. However, if the winding temperature was not entered, the user must select the "Custom test conditions" option and manually enter the temperature that they would like to correct from.

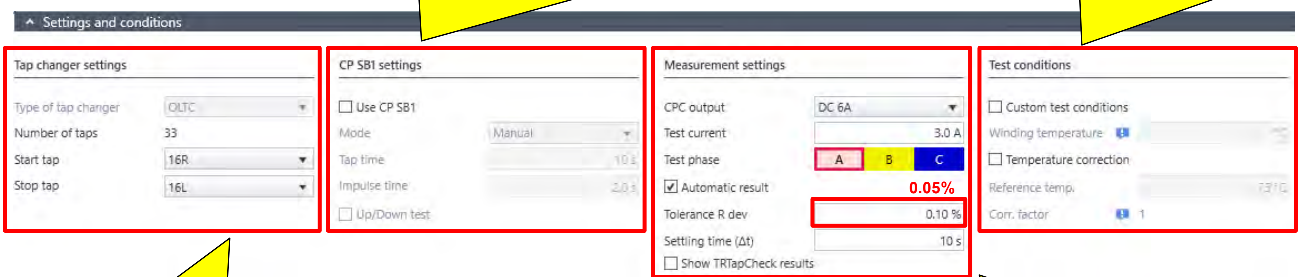


Figure 49: DC Winding Resistance Test – Settings and Conditions

If a DETC and/or LTC was entered in the "Asset – Tap Changers" section, then indicate which tap position you would like to start and stop testing on. If a tap changer was not entered in the "Asset – Tap Changers" section then these fields require no action.

Note, once the measurement begins, the tap positions you would like to test can be changed "on the fly". For example let's say that once I start the test, I decide that I only want to test on the 16R-1L positions, I can do so without stopping the measurement or altering the settings.

The "CPC output" field will allow you to switch between the 6A DC source, 400A DC source, and 2-wire method. Select the desired "Test current".

Click on the circle next to the phase which you would like to test (single-phase mode only). If the "Use CP SB1" feature is enabled, a particular phase cannot be selected, since it is assumed that you will test all three phases consecutively (starting with Phase A).

"Automatic result": The resistance measurement will be automatically recorded once the resistance has stabilized based on the selected criteria (i.e. based on the "Tolerance R dev" and "Settling time").

"Tolerance R dev": The maximum deviation percentage that the resistance can change over the given "Settling time", before the measurement is recorded. The lower the tolerance deviation, the more accurate the measurement, but also the longer the test may take. We recommend always setting the "Tolerance R dev" to 0.05%.

The "Settling time" can also be increased to increase the accuracy of the measurement; however, we recommend keeping the default value of 10s.

If the “Use CP SB1” option is enabled, then please be aware of the settings outlined in Figure 50. Once the “Use CP SB1” option is enabled, the connection diagram will change, as shown in Figure 51.

If you would like the CP SB1 to automatically change the LTC position during the measurement, then select the “Automatic tap control” option. Selecting this option will unlock the “Tap time” and “Impulse time” fields.

Tap time: The time the software will wait before starting the measurement once the LTC has started to change positions. Leave the “Tap time” at the default setting.

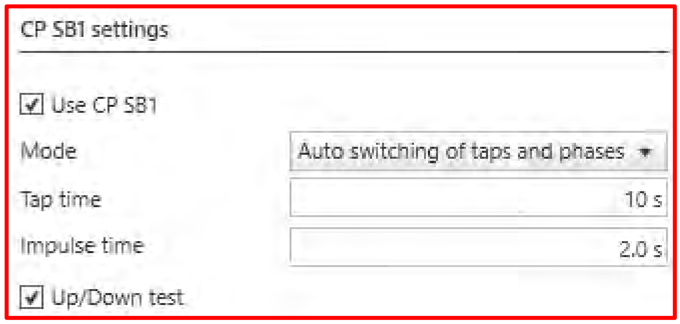


Figure 50: DC Winding Resistance Test – CP SB1 Settings

Impulse Time: The amount of time the CP SB1 will short-circuit (bridge) the contacts within the tap changer control, to engage the tap position change. When testing, if the tap changer “skips” a tap position, then decrease the impulse time. If the tap changer does not engage, then try increasing the impulse time.

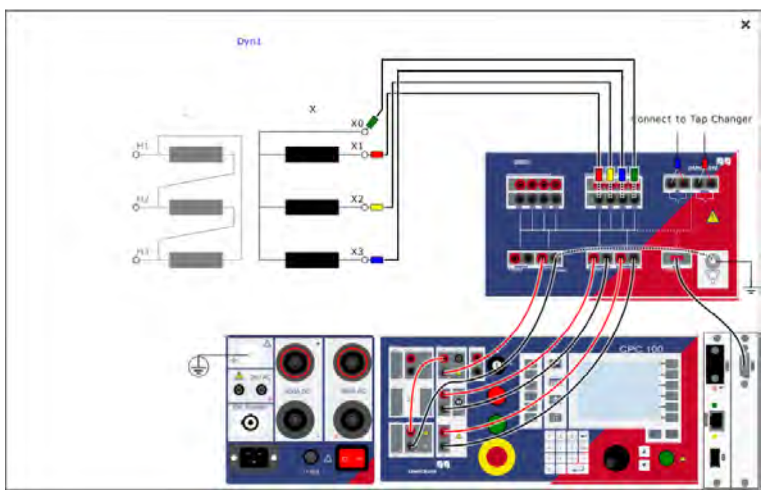


Figure 51: DC Winding Resistance Test – Dyn1 Test Connection with CP SB1

Next, scroll down to the “Assessment” section of the DC Winding Resistance test.

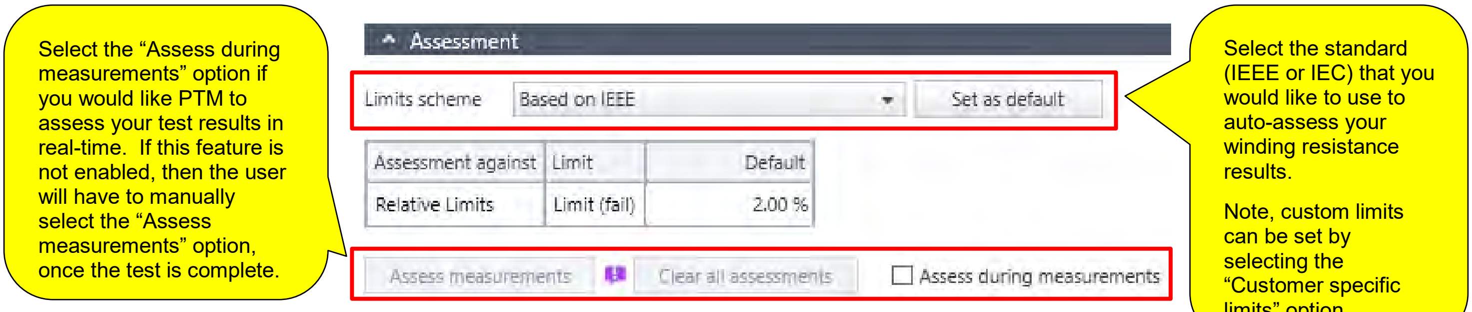


Figure 52: DC Winding Resistance Test – Assessment

Once the correct settings, test connections and assessment have been confirmed, scroll down to the “Measurements” section. Select the phase that you would like to test and then click the “Start” option, which is highlighted in Figure 53. If the “Start” option is not green, then the user must connect the CPC 100 to their laptop. Note, if the “Use CP SB1” option is enabled, the user will not be able to select a particular phase, since it is assumed that all three phases will be tested consecutively.

If the single-phase mode is being used, select the phase that you would like to test by clicking on the colored toolbar. Please note, the connection diagram will change once a particular phase is selected. If the “Use CP SB1” feature is enabled, you will not be able to select a particular phase, since it is assumed that all three phases will be tested consecutively.

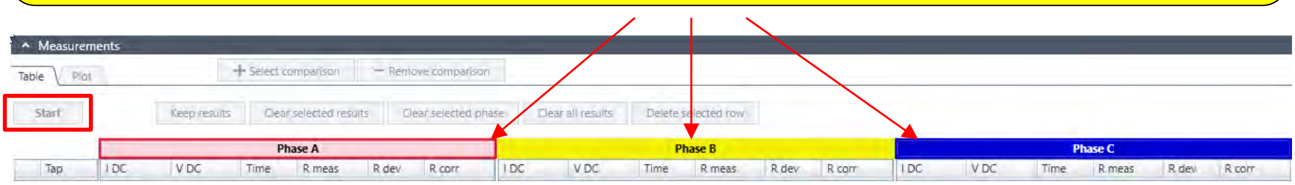


Figure 53: DC Winding Resistance test- Measurements Section

7.8 Demagnetization Test

For the Demagnetization test, the CPC 100 and the CP SB1 accessory are required. Before beginning the Demagnetization Test, please consider the following,

- This test is used to reduce the amount of residual magnetism in the transformer core, not to analyze the health of the transformer. It is typically performed after events which magnetize the core (i.e. after a DC Winding resistance test or if transformer taken out of service has experienced a fault)

The test connection example shown in figure 54 displays the wiring diagram for a DYn1 transformer.

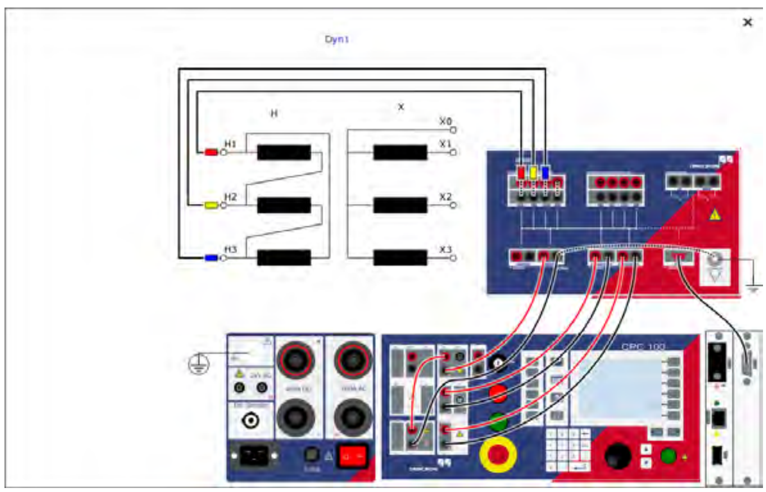


Figure 54: Demagnetization Test – Dyn1 Test Connection

Once the proper test connections have been made, scroll down to the “Settings and conditions” section.

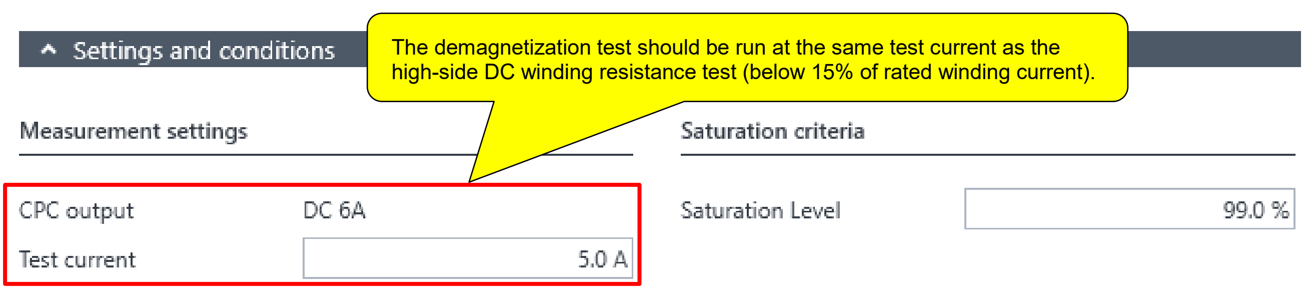


Figure 55: Demagnetization Test – Settings and Conditions

Once the correct settings have been verified, scroll down to the “Measurements” section and click “Start”. If the “Start” option is not green, then the user must connect the CPC 100 to their laptop.

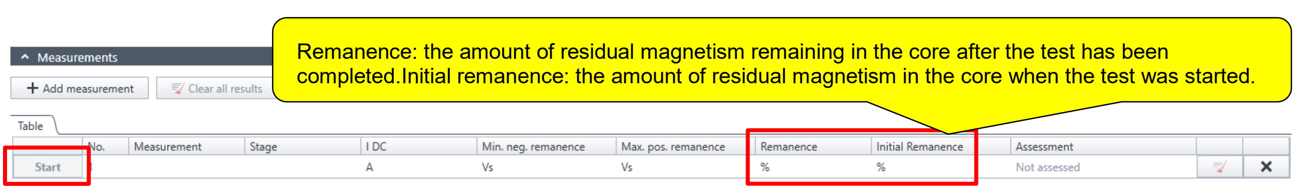


Figure 56: Demagnetization test- Measurements

7.9 Leakage Reactance Test

Only the CPC 100 is required. The leakage reactance test consists of two test types, which include,

- 3-Phase Equivalent Test: The purpose of this test is to reproduce the factory short-circuit impedance value. Therefore, once the 3-phase equivalent measurement is performed, the PTM software will automatically calculate and compare the measured field value to the nameplate value. The factory short-circuit impedance value can typically be found on the nameplate of the transformer, as shown in the example in Figure 57.

- Per-Phase Equivalent Test: The results from this test may not compare well to the nameplate short-circuit impedance, but is valuable because it helps isolate and test one individual phase at a time, in order to identify a fault localized to one particular phase. The PTM Software will automatically compare the results among phases.

NOTICE

Improper shorting jumpers may affect results

- Please note that it is critical that the resistance and reactance of the shorting jumpers used to short-circuit the secondary (or tertiary) of the transformer is negligible relative to the test circuit. We recommend using a wire gauge of #4 or less. In addition, the length of the shorting jumpers should be as short as possible from bushing terminal to bushing terminal. Finally, the shorting jumpers should be solidly bonded to the bushing terminals, to avoid creating additional resistance within the test circuit.

NOTICE

Incorrect tap position in asset settings may affect assessment

- Please note that to compare the measured 3-phase equivalent value to the factory short-circuit impedance, the DETC and/or LTC must be tested on the same tap position(s) as the factory. Otherwise, the measured field values and nameplate values may not compare well.

Please follow the connection diagram closely when changing between phases, and the two test types outlined above.

VOLTAGE RATING 67000-4160Y/2400
KVA RATING 7500 CONTINUOS 55 C RISE SELF COOLED
KVA RATING 9375 CONTINUOS 55 C RISE FORCED AIR
KVA RATING 10500 CONTINUOS 65 C RISE FORCED AIR
IMPEDANCE VOLTS 8.61% 67000-4160Y VOLTS AT 7500 KVA

HV WINDING CONNECTION		
VOLTS	AMP 10500 KVA	DIAL POS
70600	85.9	1
68800	88.1	2
67000	90.5	3
65200	93.0	4
63400	95.6	5

ITEM				BIL KV
H_1	H_2	H_3		250
X_0	X_1	X_2	X_3	75

HV WOG.LV WOG SERIES UNIT
WOGS.REACTOR ALUMINUM
LCT TAP WOG COPPER

Figure 57: Nameplate Short-Circuit Impedance Example

An example wiring diagram for a 3-Phase Equivalent Test on a DYn1 transformer is shown in figure 58.

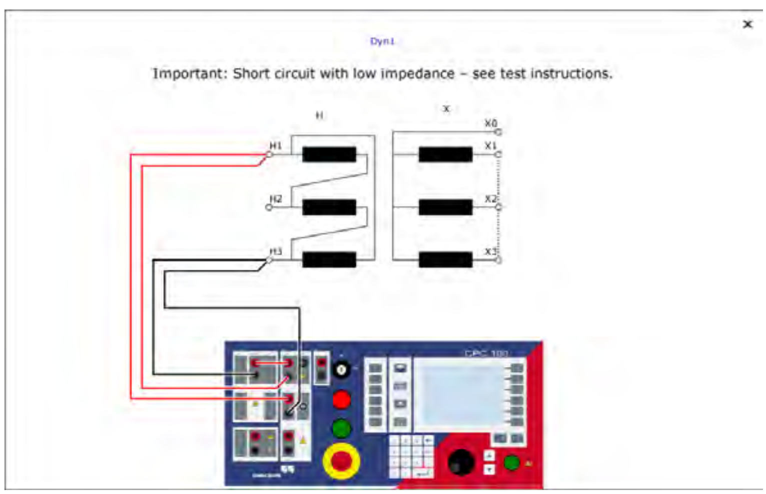


Figure 58: Leakage Reactance - 3-Phase Equiv. Dyn1 Phase A Test Connection

Once the proper test connections have been made, scroll down to the “Settings and conditions” section.

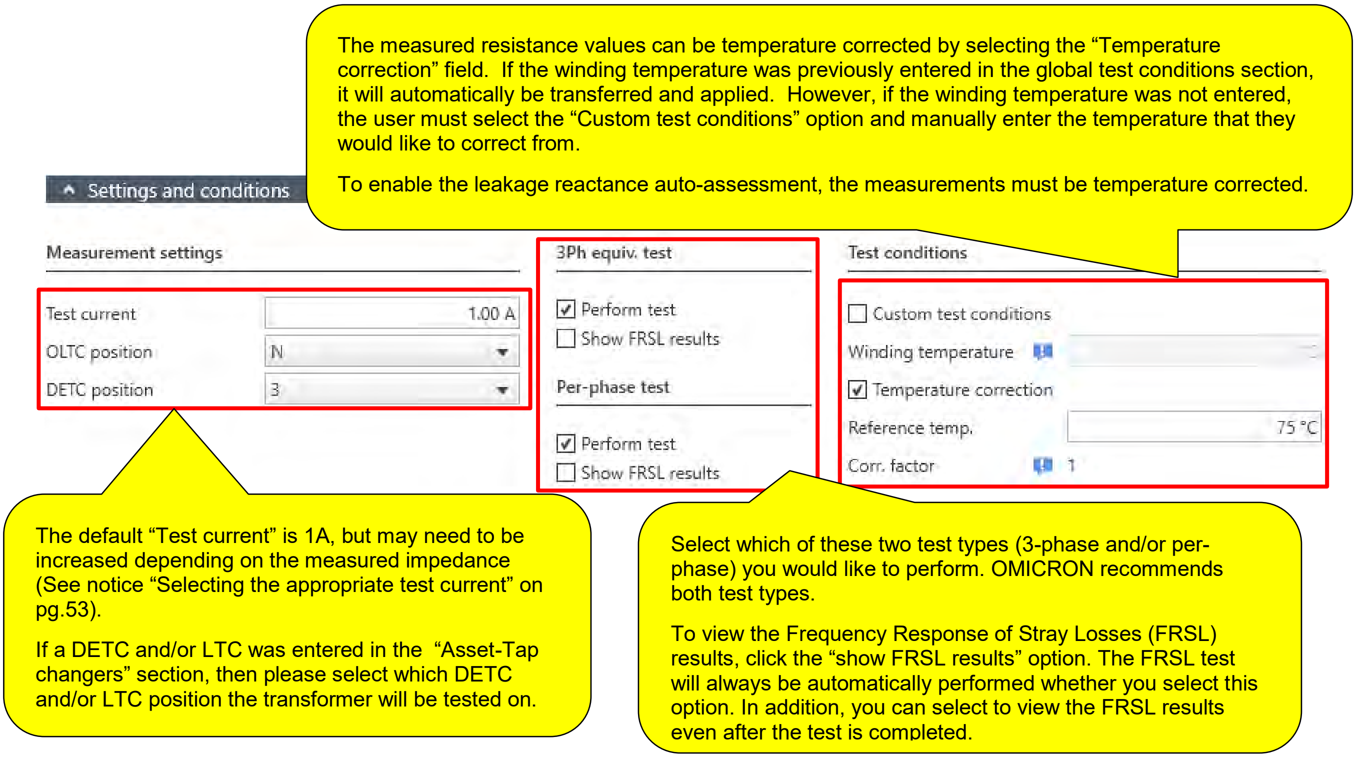


Figure 59: Leakage Reactance – Settings and Conditions

NOTICE

Enabling the auto-assessment

- Please note that to enable the leakage reactance auto-assessment, the following conditions must be met,
  - The “Temperature correction” setting must be enabled as shown in Figure 59.
  - The DETC and/or LTC position(s) selected on the transformer must be identical to the DETC and/or LTC position(s) entered to the “Asset – Transformer - Leakage Reactance” section (Figure 11,60).
  - The nameplate short-circuit impedance, base power, and base voltage must be entered in the “Asset – Transformer - Leakage Reactance” section (Figure 11, 60).

Figure 60: Leakage Reactance – Asset Information

Once the test settings have been verified, scroll down to the “Assessment” section

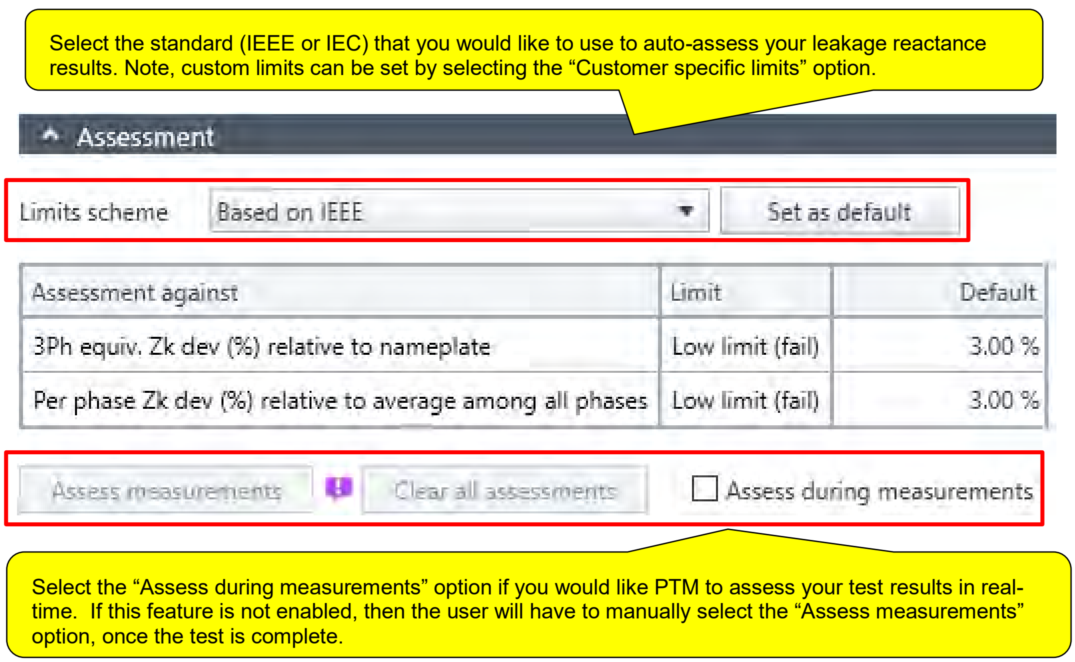


Figure 61: Leakage Reactance – Assessment Section

Once the “Assessment” section is complete, scroll down to the “Measurements: 3Ph equiv.” section. Next, click on the Phase-A measurement, and observe the connection diagram to make the correct test connections. When the test connections have been verified and you are ready to begin the test, click the “Start” option next to the Phase-A measurement.

NOTICE

Selecting the appropriate test current

Adjust the “Test current” (fig.59) depending on the measured impedance of the transformer. We recommend performing the first measurement at a “Test current” of 1A, and monitoring the measured voltage during the line-frequency (60Hz) test. We recommend that the measured voltage at 60Hz is >50V. If the measured voltage is <50V, then increase the test current and repeat the test until one of the following occurs,

- The measured test voltage is >50V (at 60Hz)
- The “Test current” has reached 5A

Once the “Test current” has been adjusted, repeat this procedure for the remaining phases (i.e. B and C), keeping in mind that the connection diagram may be different for each measurement.

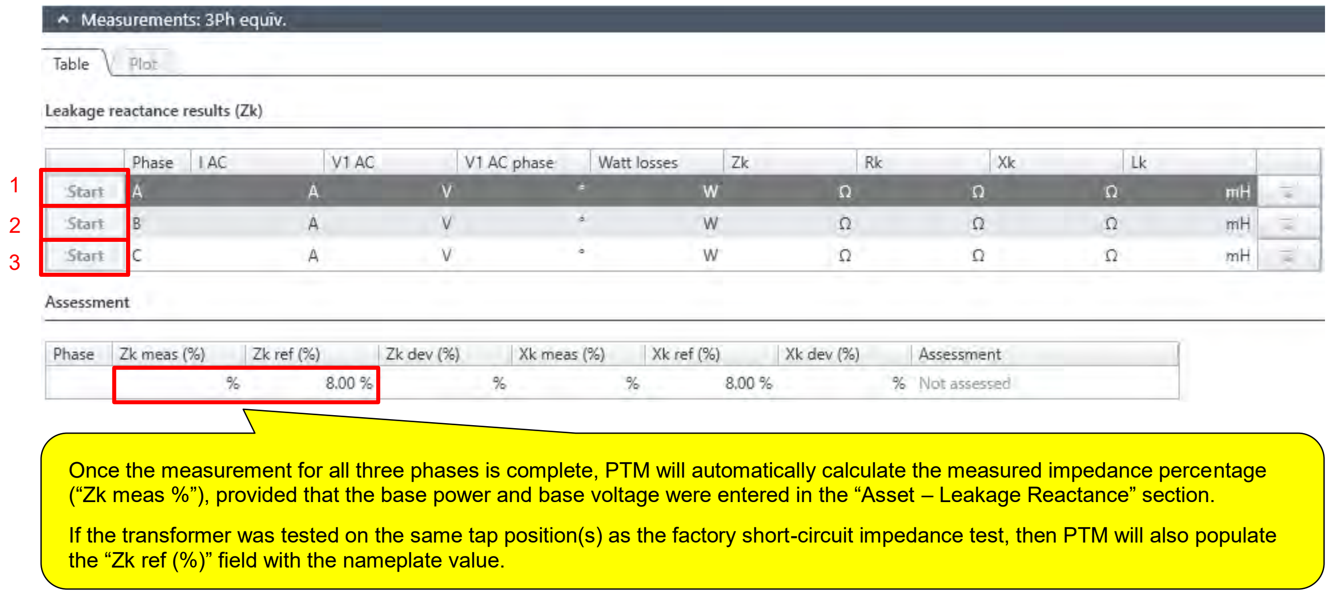


Figure 62: Leakage Reactance – 3-Phase Equivalent Measurement

Once all three 3-phase equivalent measurements are complete, please scroll down to the “Measurements: per-phase” section. Next, click on the Phase-A measurement, and observe the connection diagram to make the correct test connections. An example of a per-phase equivalent test connection is shown in Figure 63. When you are ready to begin the test, click the “Start” option next to the Phase-A measurement. Repeat this procedure for the remaining phases (i.e. B and C), keeping in mind that the connection diagram may be different for each measurement.

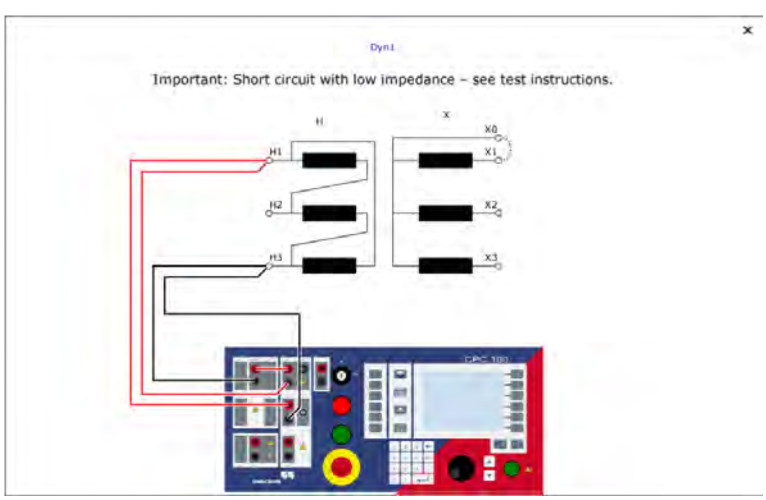


Figure 63: Leakage Reactance – Per-Phase Test Connection Dyn1 Phase A

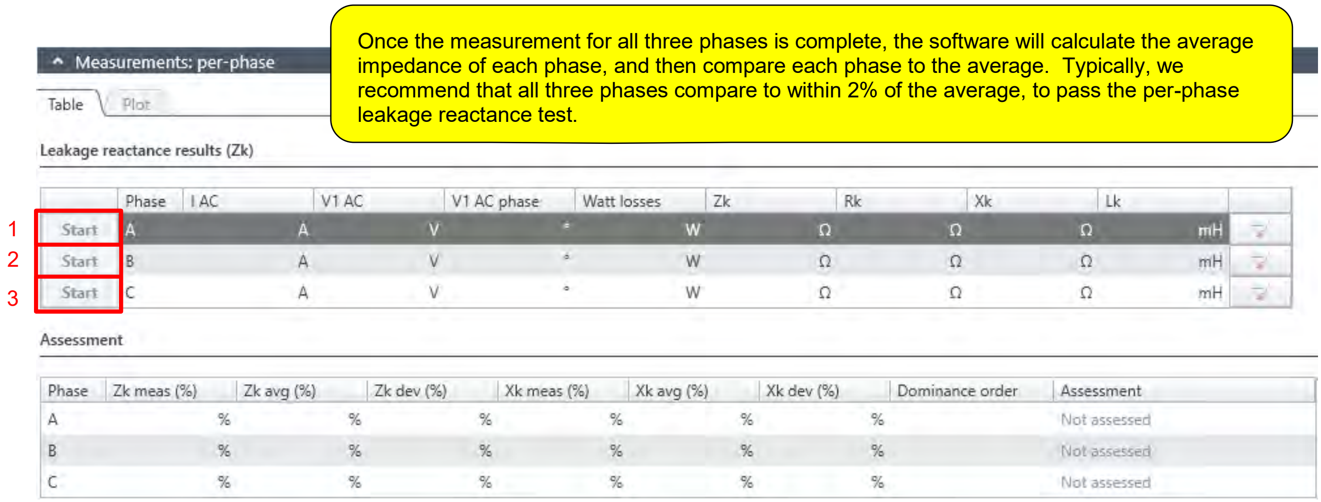


Figure 64: Leakage Reactance – Per-Phase Measurement

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