HYPERION

OVP Test Procedure

Valid for OPUS Version 6

Procedure Guide

1004100

BRUKER Optics

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This manual is the original documentation for the HYPERION microscope.

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1 General Information

OVP (OPUS Validation Program) is part of the OPUS software and allows the validation[1] of an instrument or a certain instrument configuration by performing the following tests: OQ (Operational Qualification) and PQ (Performance Qualification).

In the course of the OQ test, OVP performs a number of tests (listed below) to ensure that the instrument meets the factory-defined performance specifications. By default, the first OQ test is performed by Bruker at the factory in the course of the acceptance test. In case of a non-validated instrument, it is recommended to repeat the OQ test after the reinstallation of the instrument or the replacement of an optical component (e.g. laser) that may influence the instrument performance. In case of a validated instrument, the OQ test needs to be repeated - in addition to the above mentioned cases - when the defined validity period of the OQ test is over. For the instrument system 'HYPERION coupled to a spectrometer'[2], the OQ test includes the following tests:

- Resolution test
- Sensitivity test
- Wavenumber accuracy test
- Photometric accuracy test[3] (for test channel configuration *HYPERION with ATR objective* only)

A passed and valid OQ test is the precondition for a PQ test. In the course of the PQ test, OVP performs a number of tests (listed below) to ensure that the instrument system consistently performs according to the specifications appropriate for its routine use. The time interval for repeating the PQ test depends on whether you work with a validated or non-validated system. In case of a validated system, it is highly recommended to repeat the PQ test every day for the test channel(s) you intended to use before you start with your measurements. In case of a non-validated system, you can specify a longer time interval (e.g. every 7 days). For the instrument system 'HYPERION coupled to a spectrometer', the PQ test includes the following tests:

- Signal-to-noise-test
- Deviation from 100% line test
- Interferometer peak amplitude test
- Energy distribution test
- Ice band test
- X-axis frequency calibration test

1. Validating an instrument system means to produce documented evidence that the instrument system meets its specifications.
2. The HYPERION microscope can be coupled to Bruker spectrometers of the TENSOR and VERTEX series, for example.
3. This test verifies the absorbance accuracy.

For the instrument system 'HYPERION coupled to a spectrometer', there are three possible test channels that can be validated using OVP:

- HYPERION microscope in transmission mode (and 15x objective)
- HYPERION microscope in reflection mode (and 15x objective)
- HYPERION microscope with ATR 20x objective

The PQ and OQ test procedures for these test channels are described in detail in the following chapters.

Note: The description is valid only for OPUS version 6.

Depending on which test channel(s) you intended to validate, each test channel must be set up separately and the OVP tests have to be performed for each test channel.

Note: Until now, the test channels for the transmission and the reflection mode can only be validated in conjunction with the 15x objective. For objectives with another magnification, the OVP tests are not yet available.

Before starting the OVP tests for the test channels listed above, make sure that for the spectrometer alone (by default for the test channel *Sample Compartment* of the spectrometer in question) the OVP tests have already been performed and passed.

For the OVP tests, the MCT detector needs to be cooled down at its operating temperature. After having cooled the MCT detector by filling in liquid nitrogen, wait about 20 minutes before starting the OVP tests.

The OQ test and the PQ test cannot be run automatically but require the intervention by the user, more precisely, the user needs to prepare the microscope for the OVP tests. For each test channel (transmittance, reflectance and ATR objective) the preparation procedure is different. See the corresponding sections of the following chapters.

In case you replace the PC, ensure that the previously measured data do not get lost. It is of crucial importance that you back up these data already in the run-up to the PC replacement. These data are stored in the following two files: *userdata.mdb* and *usersettings.mdb*. You will find them on your PC hard disk (*OPUS path*\ *Validation**DATABASE*\<*Instrument Type*[1]>).

In case you cannot measure the laser wavenumber (LWN) because your microscope cannot be purged and the air humidity level at your site is too high for the LWN measurement to be successful, OVP uses the last LWN setting.

For more detailed information about OVP, refer to the OPUS Reference Manual.

1. Instrument Type - e.g. Tensor 37

2

TEST PROCEDURE FOR TRANSMISSION

PQ TEST PROCEDURE

Preparing the Microscope in Transmittance for the PQ Test

- Place the 15x objective and the 15x condenser in the beam path.
- Make sure that the beam path is not obstructed, for example, by a polarizer, a sample or the knife-edge aperture (i.e. the knife-edge aperture has to be open).
- Set the microscope to the transmission mode and the viewing (VIS) mode by pressing the corresponding buttons on the microscope control panel. (See the HYPERION User Manual.)
- Swing in the transmission alignment aperture. (This aperture is located behind the condenser. See figure 1.)

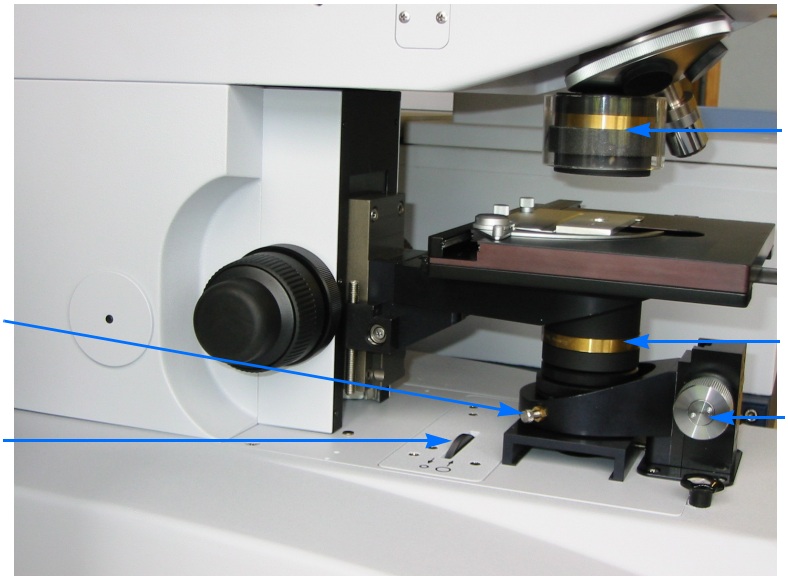


Figure 1: Microscope Setting Control Elements (Left Side View)

- Make sure that the visible light is routed to the binocular.
- While looking through the binocular, adjust the visible light intensity by turning the thumb wheel of the visible light intensity control (figure 2) until you get a well-illuminated image.

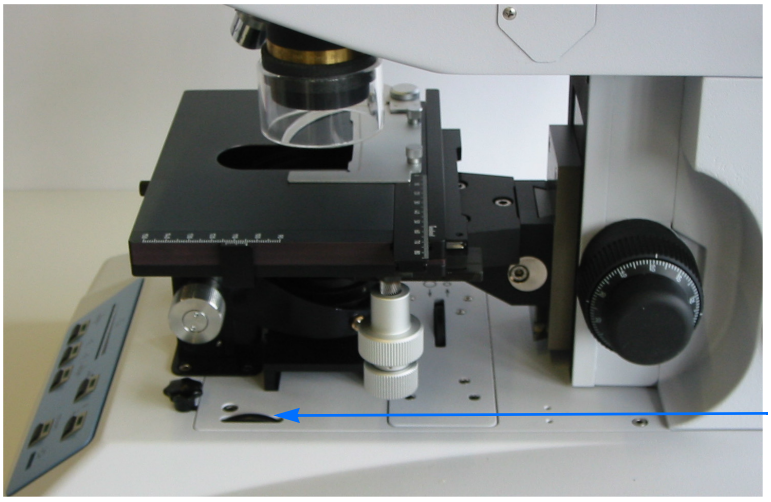


Figure 2: Microscope Setting Control Elements (Right Side View)

- Focus on to the transmission alignment aperture using the condenser focus knobs (figure 1) until you get a sharp image of the alignment aperture as shown in figure 3.
- Center the alignment aperture image with the cross hairs as shown in figure 3 using the two micrometer screws at the rear side of the condenser. See figure 1. (Note: The cross hairs is in the right ocular.)

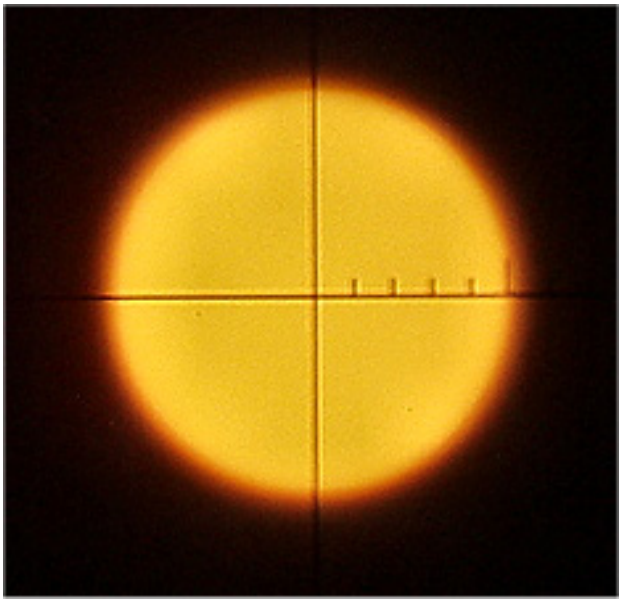


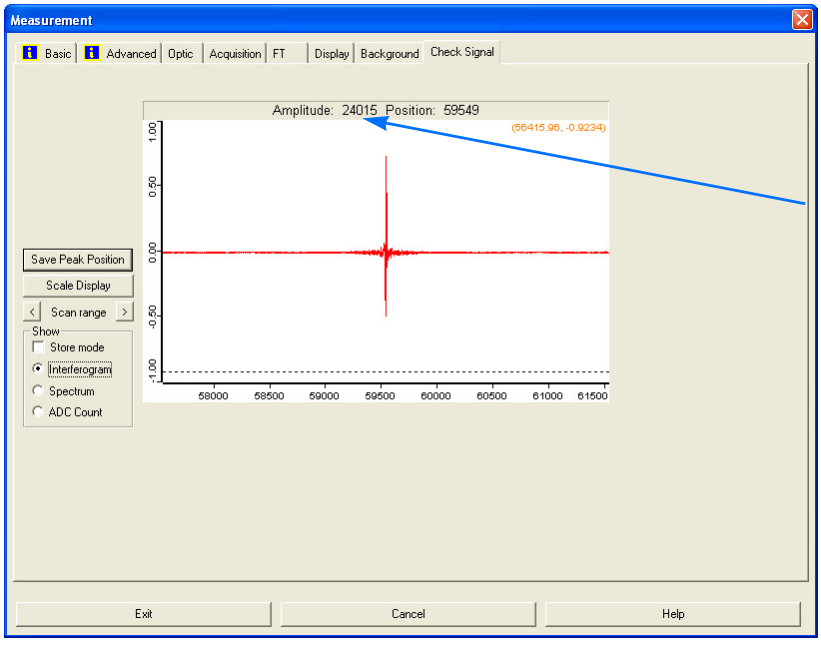
Figure 3: Image of the Transmission Alignment Aperture (focused and centered)

After having prepared the microscope for the PQ test, it is highly recommended to check the signal using OPUS before starting the test. To do this, proceed as follows:

- Switch the microscope to the IR mode by pressing the corresponding button on the microscope control panel.

- Start OPUS and select in the *Measure* menu the *Advanced Measurement* function.
- Load an existing standard experiment file (*.xmp) for transmittance measurements with the microscope. Then click on the *Check Signal* tab. See figure 4. (For detailed information about this dialog window refer to the OPUS Reference Manual.)
- To find out whether the displayed signal is sufficient, compare the displayed amplitude value (see figure 4) with the one written down in the form *Hyperion MIR Acceptance Measurements*. (You will find this form in the blue ring binder containing the final test results delivered with the microscope.) Both values should be more or less the same.

Note: An amplitude value above 32000 counts indicates a detector oversaturation.



Current Amplitude Value

Figure 4: Checking the Signal

- If the signal is OK proceed as described in the following sections.

Note: If you perform the PQ test for the test channel in question for the first time, proceed with the following section *Setting up OVP Test Channel for the PQ Test* in this chapter. In case you have already performed a PQ test for the test channel in question, proceed with section *Running the PQ Test* in this chapter.

Setting up OVP Test Channel for the PQ Test

- Select in the OPUS *Validation* menu the *Setup OVP* function. The follow dialog window opens:

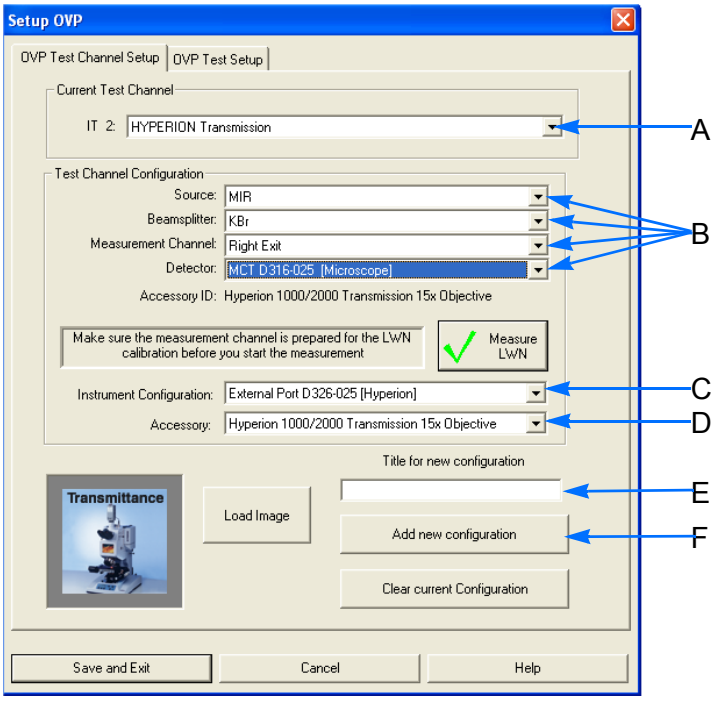


Figure 5: Setup OVP

In case you set up OVP for the first time, enter a descriptive title for the current configuration (e.g. HYPERION transmission) into the entry field *Title for new configuration* (E in figure 5) and click on the *Add new configuration* button (F in figure 5). Moreover, you have to specify the installed source, beamsplitter installed in the spectrometer, the measurement channel (i.e. whether the microscope is coupled to the left or right exit port of the spectrometer) and the detector installed in the microscope (B in figure 5). Then, select the correct option for the instrument configuration (C in figure 5) and the accessory in question (D in figure 5).

Note: Select only an instrument configuration which is designed for the HYPERION microscope. Such a configuration option includes *[Hyperion]* in its name.

In case you have already set up one or more test channel configurations, you can select the test channel in question from the *Current Test Channel* drop-down list (A in figure 5). In this case, the correct options for *Source*, *Beamsplitter* etc. (B in figure 5) are selected automatically and you need not repeat the measurement of the LWN and the reference spectra.

Measuring the Laser Wavenumber

In case you perform an OVP setup for the first time or you have replaced the laser or another optical component you need to measure the laser wavenumber (LWN) by clicking in the *Measure LWN* button. See figure 5. Otherwise, you can leave out this step and proceed with the following section *Setting up the PQ Test Protocol*.

Before starting the laser wavenumber measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope in Transmittance for the PQ test*.

The result of the laser wavenumber measurement is displayed as follows:

Figure 6: LWN Measurement Result

If the newly computed LWN is inside a certain tolerance range no changes are required. In this case, proceed by clicking on the *OK* button.

If the newly computed LWN is outside a certain tolerance range, the window shown in figure 7 appears. This window allows you to set the newly computed LWN by clicking on the *Yes* button.

Figure 7: Setting the new LWN

Warning: If the measured filter band value is 0.000000 (see figure 8) DO NOT click on the *Yes* button because with a LWN based on such a value the OVP tests will fail! In this case, if you click inadvertently on the *Yes* button, the current LWN will get lost irretrievably and with the new LWN no OVP test will be passed!

A measured filter band value of 0.000000 indicates a microscope problem. In this case refer to chapter *Troubleshooting*, section *Problem with the LWN Measurement*.

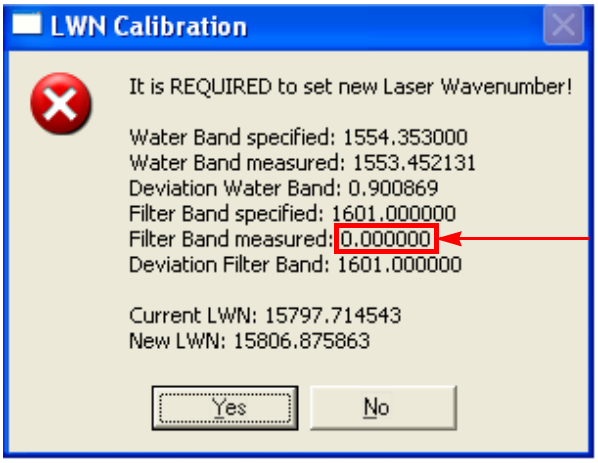


Figure 8: Unacceptable new LWN

If OPUS displays a warning or error message during the LWN measurement refer to chapter *Troubleshooting*, section *Problems with the LWN Measurement*.

Note: For each test channel configuration (transmittance, reflectance and ATR objective), the laser wavenumber needs to be remeasured in order to ensure the wavenumber accuracy of the spectral data.

For detailed information about the laser wavenumber measurement refer to the OPUS Reference Manual.

Setting up the PQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run PQ Test every* check box and specify the validity period for the PQ test (i.e. when the specified validity period is over the PQ test needs to be repeated). See figure 9.

For a validated system, the recommended time interval for repeating the PQ test is 24 hours. In case of a non-validated system, you can specify a longer time interval (e.g. every 7 days).

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has expired or failed.

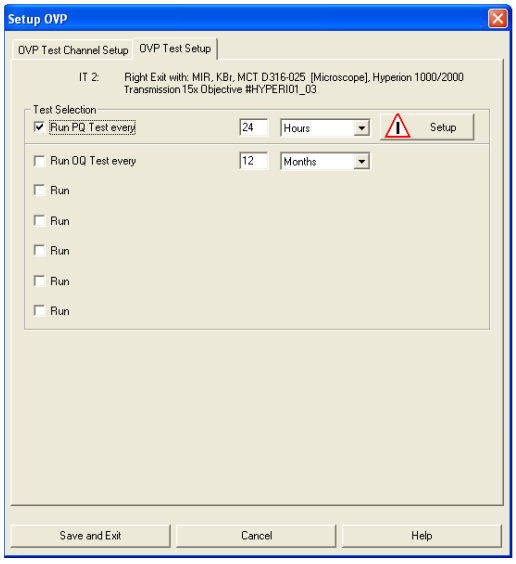


Figure 9: Specifying the Validity Period for the PQ Test

- Then, click on the *Setup* button. (The warning symbol on this button indicates that the PQ test protocol needs to be set up and/or the reference spectra, required for the PQ test, need to be measured.) The following dialog window appears:

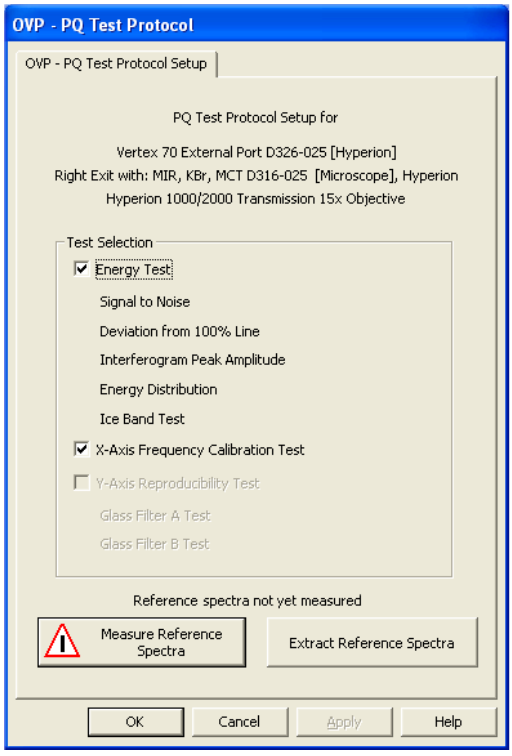


Figure 10: Setting up the PQ Test Protocol

Note: All tests available for this particular test channel are automatically selected. It is recommended to use this default setting. Only in exceptional cases, you should deactivate a test of the PQ test protocol.

A warning symbol on the *Measure Reference Spectra* button indicates that reference spectra need to be measured. See figure 10. The cases, in which new reference spectra need to be measured, are listed in the following section.

- If a reference spectra measurement is not required click on the *OK* button and proceed with the PQ test as described in the section *Running a PQ Test*. Otherwise, you need to measure the reference spectra first. See the following section.

Measuring Reference Spectra

The measurement of the reference spectra is only required in the following cases:

- after the installation of the instrument,
- after a major repair,
- after the replacement of an optical component (e.g. HeNe laser, source, beamsplitter, detector) or
- after the evacuation of the MCT detector.

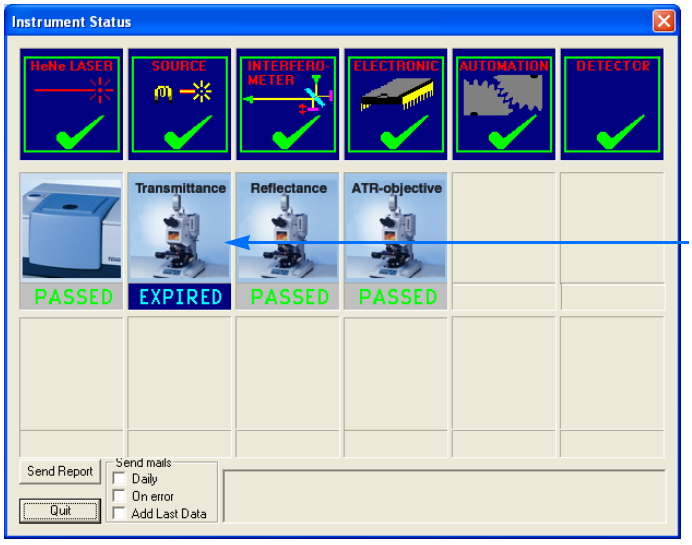
The necessity for a reference spectra measurement is indicated by a warning symbol on the *Measure Reference Spectra* button. (See figure 10.) Otherwise, you can leave out this step, click in the *Setup OVP* window on the *Save and Exit* button (see figure 5) and proceed with the section *Running the PQ Test*.

For the reference spectra measurement, proceed as follows:

- Before starting the reference spectra measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope in Transmittance for the PQ Test*. Check whether the microscope is set to the transmission mode. Additionally, you need to press the IR button on the microscope control panel.
- Click on the *Measure Reference Spectra* button.
- After the measurement is finished, click on the *OK* button.
- Then, click in the *Setup OVP* window (figure 5) on the *Save and Exit* button.

Running the PQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the test channel *HYPERION in Transmittance Mode*. See figure 11.



Icon for the test channel *HYPERION in Transmittance mode*; (For this channel, the validity period of an OVP has expired.)

Figure 11: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 12.

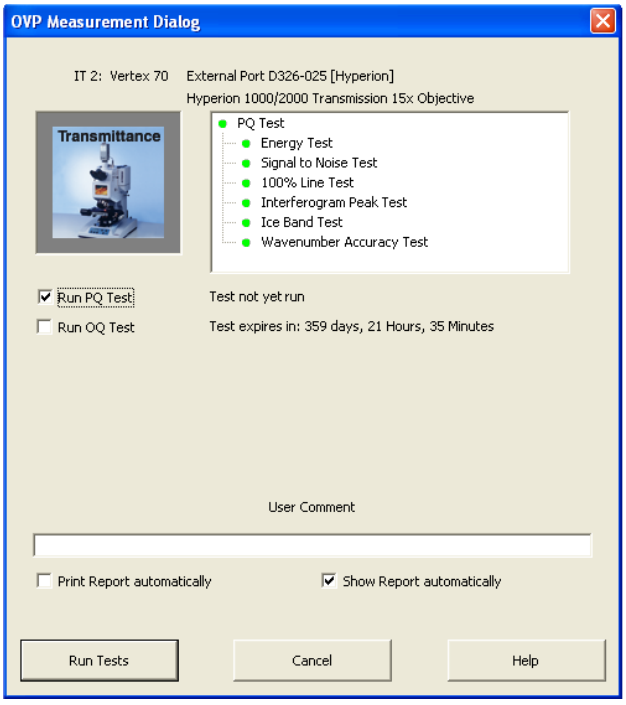


Figure 12: Starting the PQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not select it.

- Activate the *Run PQ Test* check box.
- Decide whether you want the PQ test report either been printed automatically after or shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 13 appears reminding you to check whether the microscope is prepared as described in the above section *Preparing the Microscope in Transmittance for the PQ Test*.

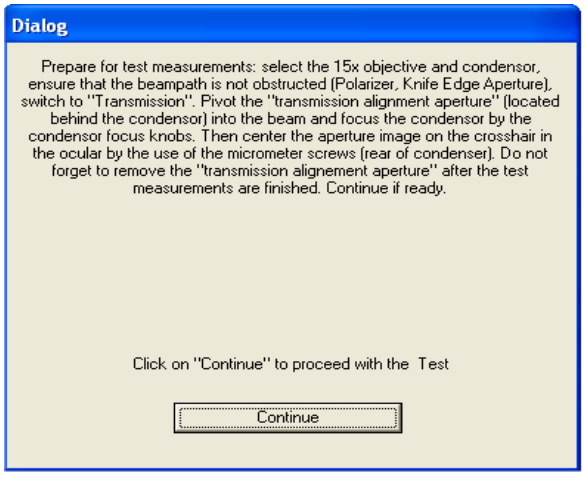


Figure 13: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the PQ test.
- If the warning message shown in figure 14 appears, it is highly recommended to check whether the current water vapor spectrum ((with spectrum file name, for example: *PQ_Tensor_37_External_Port_D316-025_Hyperion_Frequency.1*) is OK. You will find the spectrum in the following directory: *OPUS path\VALIDATION \Data \YYYYMMDD*[1]*\HHMMSS*[2]. (For information about the file name of the test spectra refer to the OPUS Reference Manual.)

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and S = second.

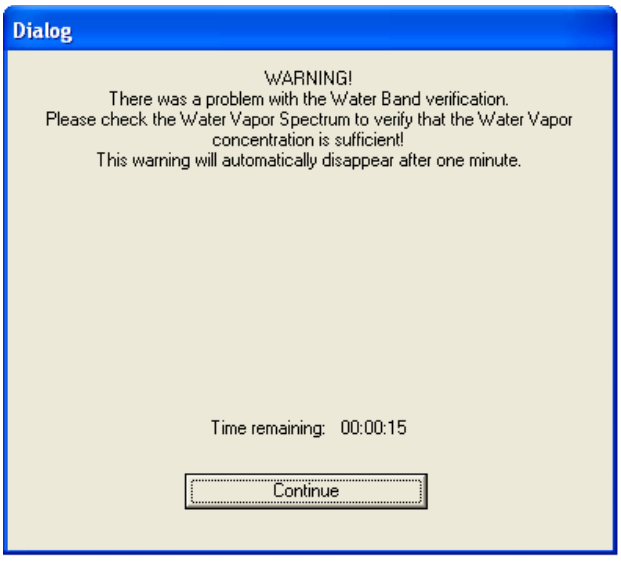


Figure 14: Warning Message regarding the Water Vapor Concentration

Note: After the PQ test is completed, do not forget to swing the transmission alignment aperture out of the beam path again.

PQ Test Results

The PQ test protocol is stored as pdf file in the directory *OPUS Path/VALIDATION/REPORTS*.

Note: For the display of the report make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 12), the test report is displayed and/or printed automatically immediately after the PQ test.

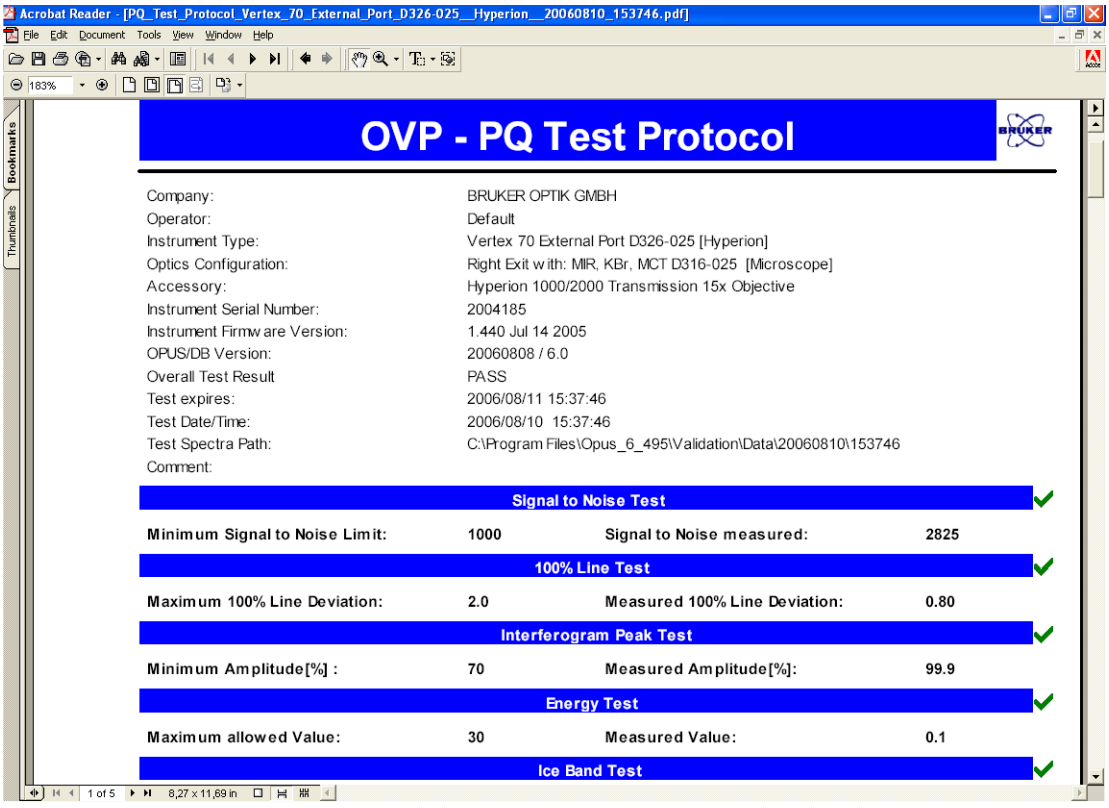


Figure 15: PQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the PQ test protocol failed, refer to chapter *Troubleshooting*.

OQ TEST PROCEDURE

Preparing the Microscope in Transmittance for the OQ test

Prepare the microscope as described in the above section *PQ Test Procedure*, subsection *Preparing the Microscope in Transmittance for the PQ Test*. The preparation procedure is identical for both OVP tests.

Setting up the OVP Test Channel for the OQ Test

Set up the OVP test channel as described in the above section *PQ Test Procedure*, subsection *Setting up OVP Test Channel for the PQ Test.* The procedure for setting up the OVP test channel is identical for both OVP tests.

Measuring the Laser Wavenumber

In case you perform the OQ test for the first time or you have replaced the laser or another optical component, you need to measure the laser wavenumber (LWN). See section *PQ Test Procedure*, subsection *Measuring the Laser Wavenumber*. Otherwise, you can leave out this step and proceed with the following subsection *Setting up the OQ Test Protocol*.

Setting up the OQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run OQ Test every* check box.

In case you work with a validated system, specify the validity period for the OQ test (i.e. when the specified validity period is over the OQ test needs to be repeated). See figure 9. It is recommended to use the default setting (12 month).

In case of a non-validated instrument, the OQ test needs to be repeated only after the reinstallation of the instrument or the replacement of an optical component (e.g. laser) that may influence the instrument performance.

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has expired or failed.

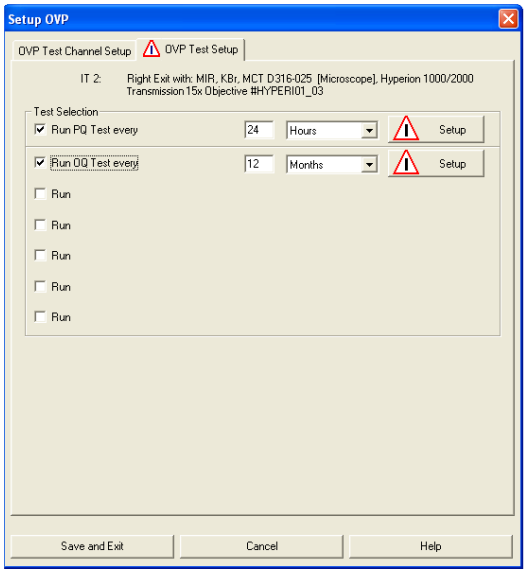


Figure 16: Specifying the Validity Period for the OQ Test

- Then, click in the *Setup* button. (The warning symbol on this button indicates that the OQ test protocol is not yet set up.) The following dialog window appears:

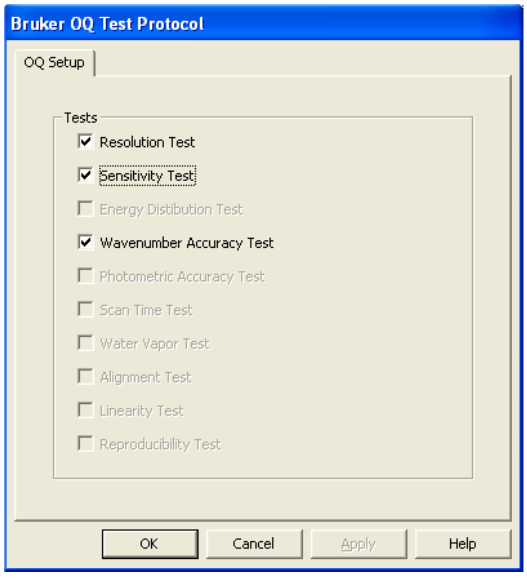


Figure 17: Setting up the OQ Test Protocol

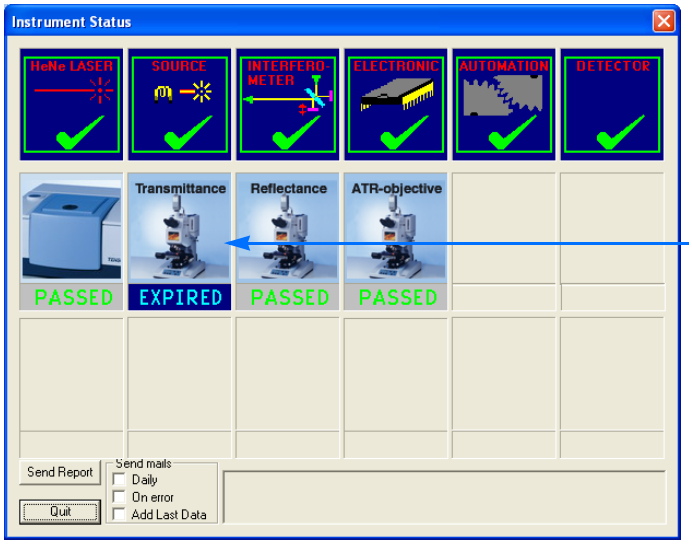
All tests available for this particular test channel are automatically selected.

Note: For the OQ test, the HYPERION microscope needs to be purged with dry air or nitrogen gas (flow rate: 100 to 200 l/hour). If your microscope is not equipped with this feature, deactivate the *Wavenumber Accuracy Test* of the OQ test protocol. See figure 17.

- Click on the *OK* button.
- Then, click on the *Save and Exit* button.

Running the OQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the test channel *HYPERION in Transmittance Mode*. See figure 18.



Icon for the test channel *HYPERION in Transmittance mode*; (For this channel, the validity period of an OVP has expired.)

Figure 18: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 19.

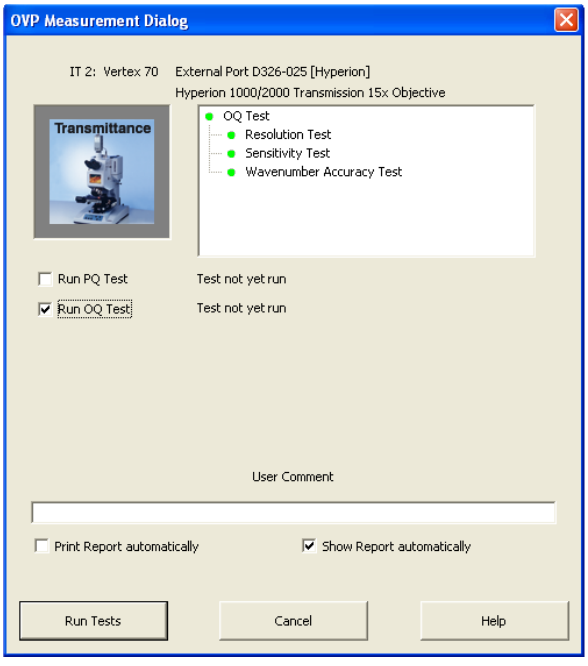


Figure 19: Starting the OQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not to select it.

- Activate the *Run OQ Test* check box.
- Decide whether you want the OQ test report either been printed automatically after the measurement or only shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 20 appears reminding you to check whether the microscope is prepared as described in section *PQ Test Procedure*, subsection *Preparing the Microscope in Transmittance for the PQ Test*.

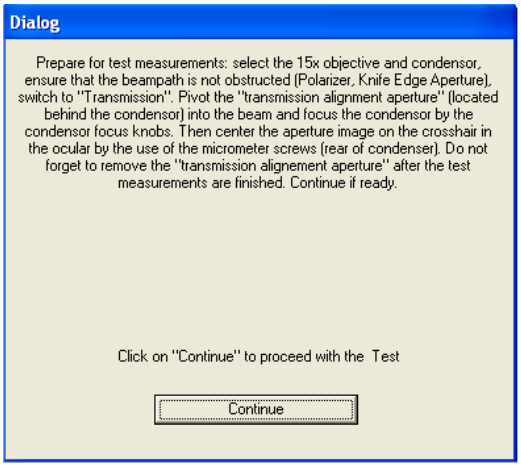


Figure 20: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the OQ test.
- If the warning message shown in figure 21 appears, it is highly recommended to check whether the current water vapor spectrum (with the following file name, for example: *PQ_Tensor_37_External_Port_D316-025_Hyperion_WnAccuracy.x*) is OK. You will find the spectrum in the following directory: *OPUS path**VALIDATION**Data* *YYYYMMDD*[1]*HHMMSS*[2]. (For information about the file name of the test spectra refer to the OPUS Reference Manual.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and S = second.

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

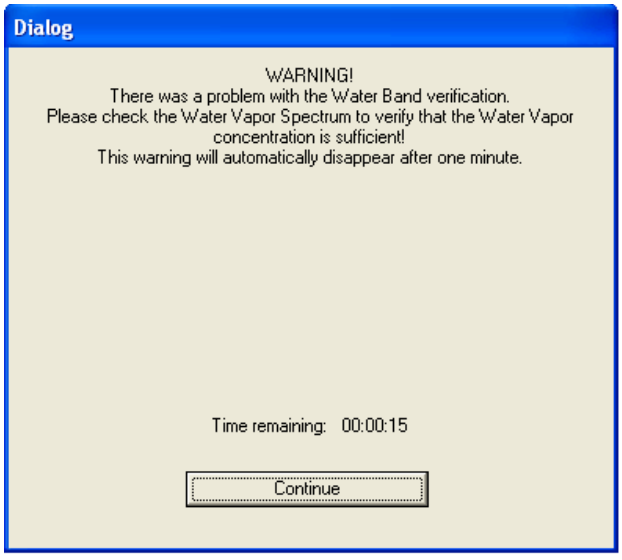


Figure 21: Warning Message regarding the Water Vapor Concentration

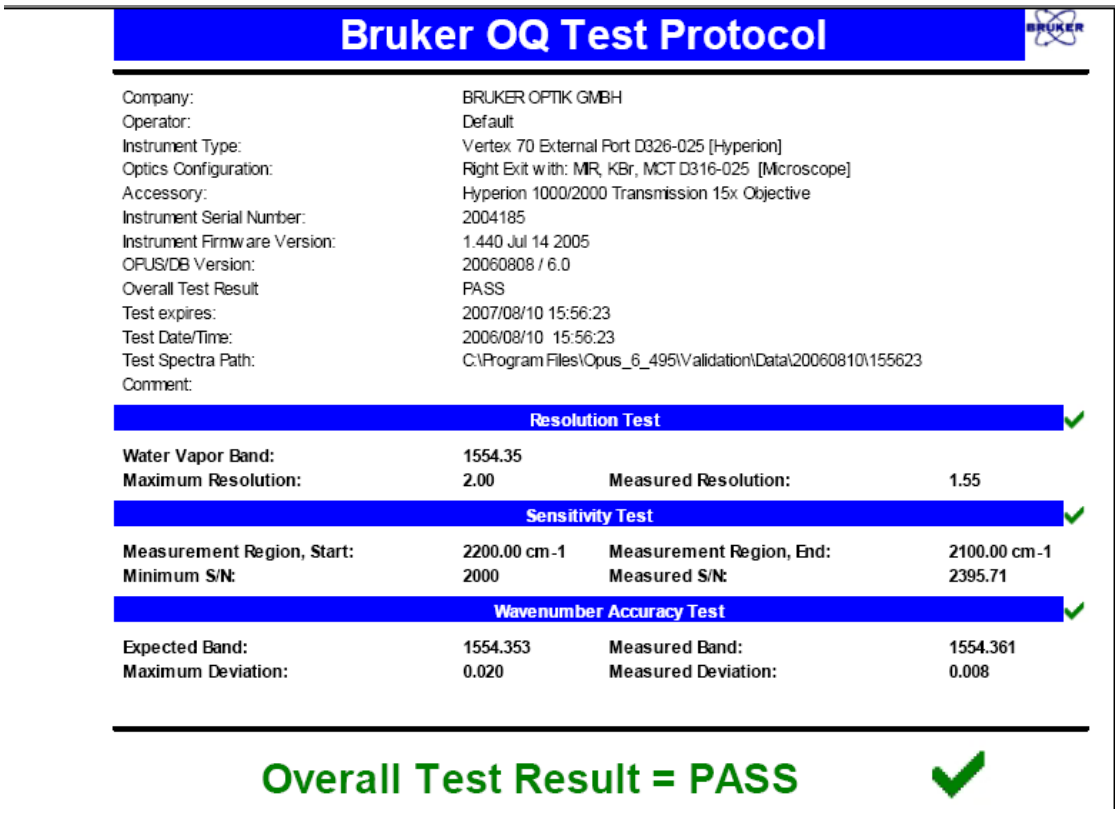
Note: After the OQ test is completed, do not forget to swing the transmission alignment aperture out of the beam path again.

OQ Test Results

The OQ test protocol with the test results is stored as pdf file in the directory *OPUS Path/VALIDATION/REPORTS*.

Note: For the display of the report, make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 12), the test report is displayed and/or printed automatically immediately after the OQ test is finished.



Bruker OQ Test Protocol

Company:	BRUKER OPTIK GMBH
Operator:	Default
Instrument Type:	Vertex 70 External Port D326-025 [Hyperion]
Optics Configuration:	Right Exit with: MIR, KBr, MCT D316-025 [Microscope]
Accessory:	Hyperion 1000/2000 Transmission 15x Objective
Instrument Serial Number:	2004185
Instrument Firmware Version:	1.440 Jul 14 2005
OPUS/DB Version:	20060808 / 6.0
Overall Test Result	PASS
Test expires:	2007/08/10 15:56:23
Test Date/Time:	2006/08/10 15:56:23
Test Spectra Path:	C:\Program Files\Opus_6_495\Validation\Data\20060810\155623
Comment:	

Resolution Test

Water Vapor Band:	**1554.35**		
Maximum Resolution:	**2.00**	**Measured Resolution:**	**1.55**

Sensitivity Test

Measurement Region, Start:	**2200.00 cm-1**	**Measurement Region, End:**	**2100.00 cm-1**
Minimum S/N:	**2000**	**Measured S/N:**	**2395.71**

Wavenumber Accuracy Test

Expected Band:	**1554.353**	**Measured Band:**	**1554.361**
Maximum Deviation:	**0.020**	**Measured Deviation:**	**0.008**

Overall Test Result = PASS

Figure 22: OPQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the OQ test protocol failed, refer to chapter *Troubleshooting*.

3 Test Procedure for Reflection

PQ TEST PROCEDURE

Preparing the Microscope in Reflectance for the PQ Test

Note: Depending on whether you work with a validated or a non-validated system, the preparation procedure is slightly different because a validated microscope is equipped by default with a reflection alignment aperture (figure 26), whereas, a non-validated system is not. And if your microscope is equipped with the optional automatic knife-edge aperture, the preparation procedure is different again.

- Place the 15x objective in the beam path.
- Make sure that the beam path is not obstructed, for example, by a polarizer, a sample or the knife-edge aperture (i.e. the knife-edge aperture has to be open).
- Set the microscope to the reflection mode and the viewing (VIS) mode by pressing the corresponding buttons on the microscope control panel. (See the HYPERION User Manual.)
- Put the reference mirror on the sample stage below the 15x objective. (Note: The reference mirror is included in the accessory box.)
- Make sure that the visible light is routed to the binocular.
- While looking through the binocular, adjust the visible light intensity by turning the thumb wheel of the visible light intensity control (figure 2) until you get a well-illuminated image.
- Focus on the mirror surface using the coarse and fine focus knobs. See figure 23. (Note: In case the mirror surface is free of scratches first focus on a mirror edge.)

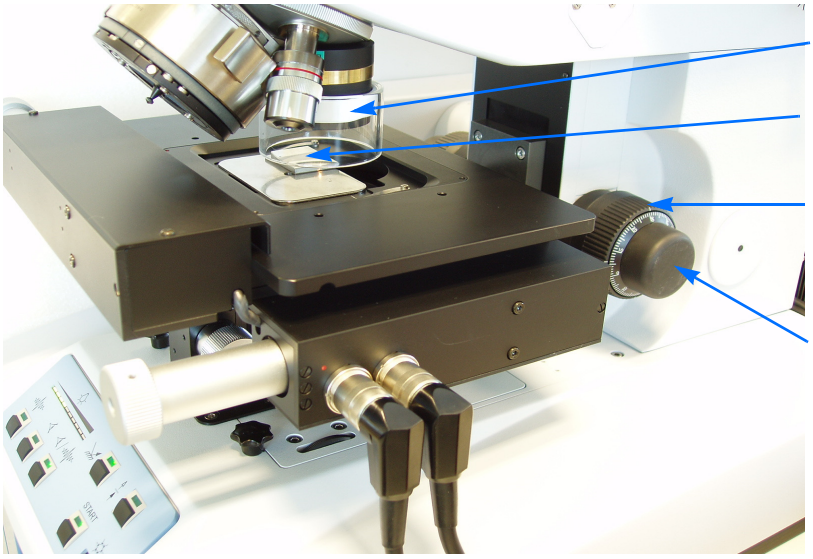


Figure 23: Preparing the Microscope for an OVP Test in Reflectance

The next step - defining a measurement area of 100 x 100 microns - depends on whether you work with a validated or a non-validated microscope or whether your microscope is equipped with an automatic knife-edge aperture.

- In case of a **non-validated system**, define a measurement area of 100 x 100 micron using the manual knife-edge aperture. To do this, proceed as follows: Make sure that the knife edge aperture lever (figure 24) is in the rear position. While looking through the binocular, rotate one of the two thumb wheels (figure 24) to change the gap between the left and right knife edges.

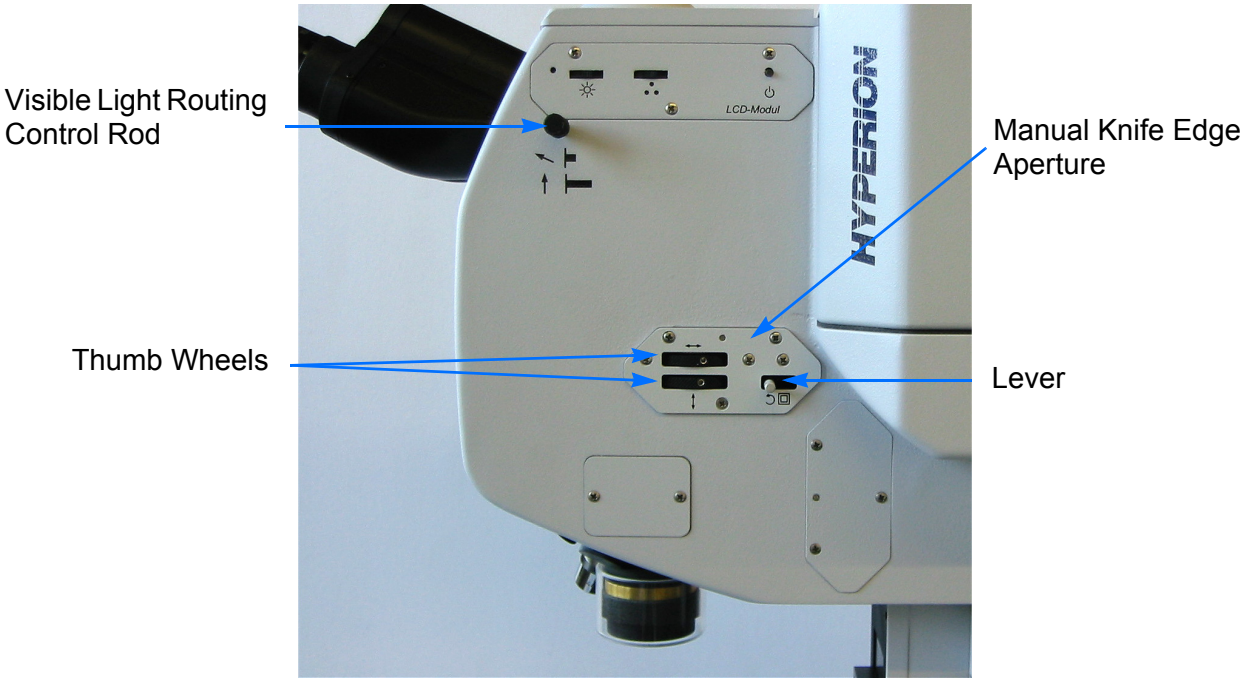


Figure 24: Non-validated Microscope

Note: 100 microns correspond to 5 scale lines of the cross-hairs.

- Then rotate the other thumb wheel to change the gap between the upper and the lower knife edges until there is a quadratic measurement area of about 100 x 100 microns. (See figure 25.)

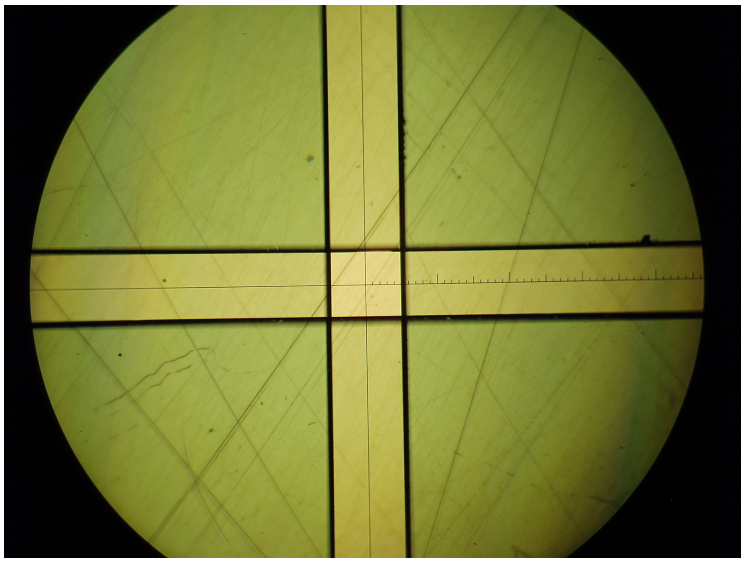


Figure 25: Image of the Mirror Surface with correctly adjusted Knife Edge Aperture

- In case of a **validated system**, adjust the exact measurement area of 100 x 100 microns by swinging the reflection alignment aperture (figure 26) in the beam path. The resulting image is shown in figure 27.

Figure 26: Validated Microscope

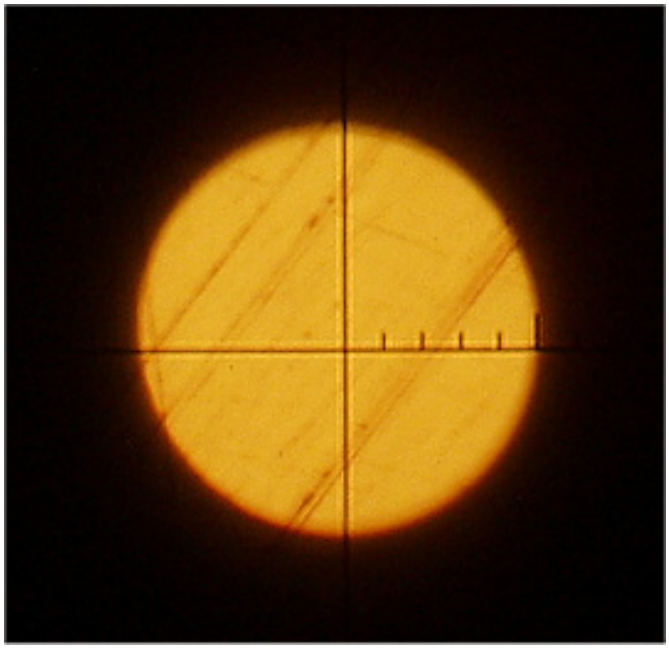


Figure 27: Image of the Mirror Surface with Reflection Alignment Aperture

- If your microscope is equipped with the optional **automatic knife edge aperture** define a measurement area of 100 x 100 microns by using the OPUS/VIDEO software. (For detailed information about it refer to the OPUS/VIDEO manual.)

After having prepared the microscope for the PQ test, it is highly recommended to check the signal using OPUS before starting the test. To do this, proceed as follows:

- Switch the microscope to the IR mode by pressing the corresponding button on the microscope control panel.
- Start OPUS and select in the *Measure* menu the *Advanced Measurement* function.
- Load an existing standard experiment file (*.xmp) for reflectance measurements with the microscope. Then click on the *Check Signal* tab. See figure 28. (For detailed information about this dialog window refer to the OPUS Reference Manual.)
- To find out whether the displayed signal is sufficient, compare the displayed amplitude value (see figure 28) with the one written down in the form *Hyperion MIR Acceptance Measurements*. (You will find this form in the blue ring binder containing the final test results delivered with the microscope.) Both values should be more or less the same.

Note: An amplitude value above 32000 counts indicates a detector oversaturation.

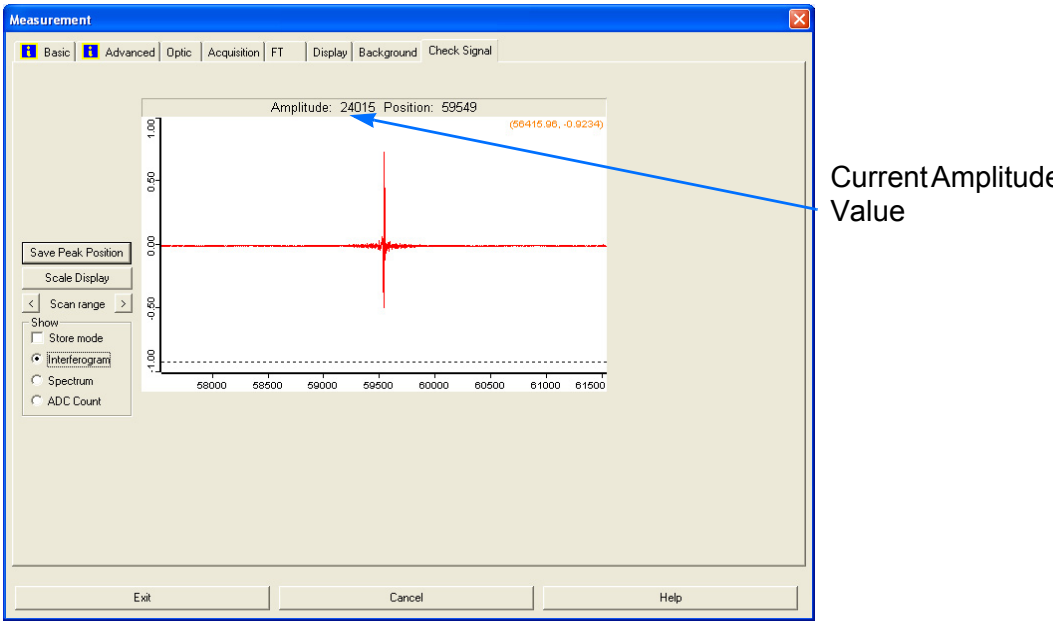


Figure 28: Checking the Signal

- If the signal is OK proceed as described in the following sections.

Note: If you perform the PQ test for the test channel in question for the first time, proceed with the following section *Setting up OVP Test Channel for the PQ Test* in this chapter. In case you have already performed a PQ test for the test channel in question, proceed with section *Running the PQ Test* in this chapter.

Setting up OVP Test Channel

- Select in the OPUS *Validation* menu the *Setup OVP* function. The follow dialog window opens:

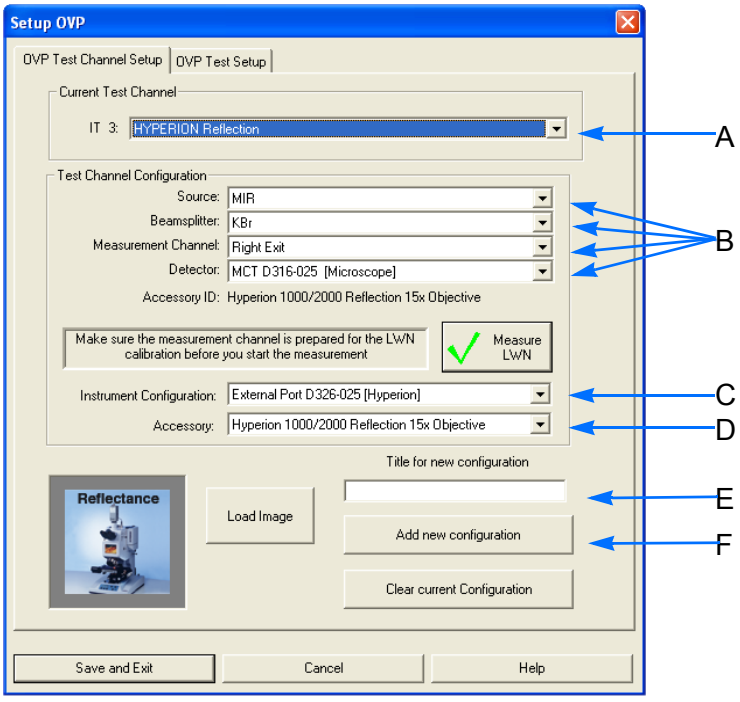


Figure 29: Setup OVP

In case you set up OVP for the first time, enter a descriptive title for the current configuration (e.g. HYPERION reflection) into the entry field *Title for new configuration* (E in figure 29) and click on the *Add new configuration* button (F in figure 29). Moreover, you have to specify the installed source, beamsplitter installed in the spectrometer, the measurement channel (i.e. whether the microscope is coupled to the left or right exit port of the spectrometer) and the detector installed in the microscope (B in figure 29). Then, select the correct option for the instrument configuration (C in figure 29) and the accessory in question (D in figure 29).

Note: Select only an instrument configuration which is designed for the HYPERION microscope. Such a configuration option includes *[Hyperion]* in its name.

In case you have already performed an OVP test and therefore already setup the test channel configuration, you can select the test channel in question from the *Current Test Channel* drop-down list (A in figure 29). In this case, the correct options for *Source*, *Beamsplitter* etc. (B in figure 29) are selected automatically and you need not repeat the measurement of the LWN and the reference spectra.

Measuring the Laser Wavenumber

In case you perform an OVP test for the first time or you have replaced the laser or another optical component you need to measure the laser wavenumber (LWN) by clicking in the *Measure LWN* button. See figure 29. Otherwise, you can leave out this step and proceed with the following section *Setting up the PQ Test Protocol*.

Before starting the laser wavenumber measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope in Reflectance for the PQ test*.

The result of the laser wavenumber measurement is displayed as follows:

Figure 30: LWN Measurement Result

If the newly computed LWN is inside a certain tolerance range no changes are required. In this case, proceed by clicking on the *OK* button.

If the newly computed LWN is outside a certain tolerance range, the window shown in figure 31 appears. This window allows you to set the newly computed LWN by clicking on the *Yes* button.

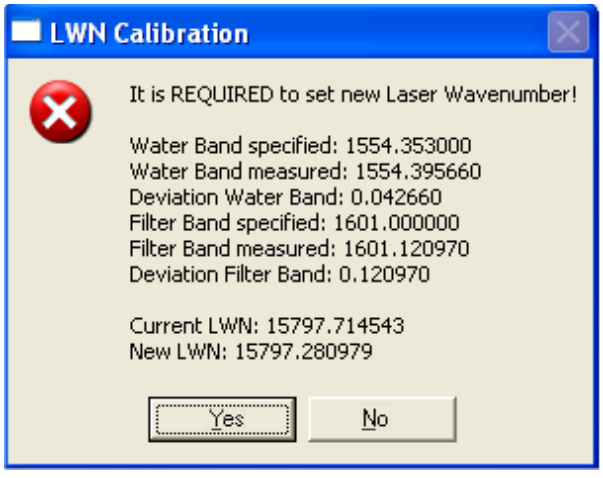


Figure 31: Setting the new LWN

Warning: If the measured filter band value is 0.000000 (see figure 32) DO NOT click on the *Yes* button because with a LWN based on such a value the OVP tests will fail! In this case, if you click inadvertently on the *Yes* button, the current LWN will get lost irretrievably and with the new LWN no OVP test will be passed!

A measured filter band value of 0.000000 indicates a microscope problem. In this case refer to chapter *Troubleshooting*, section *Problem with the LWN Measurement*.

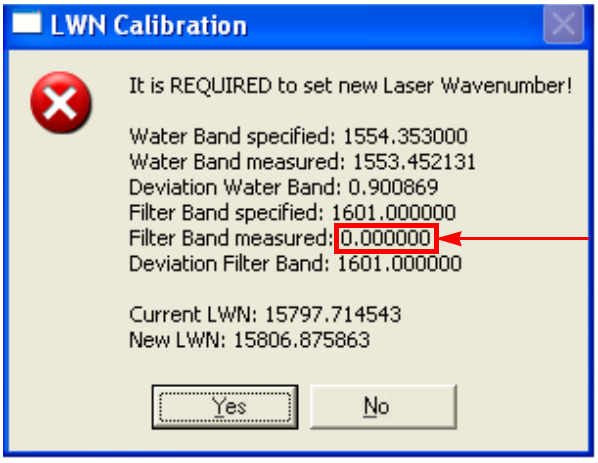


Figure 32: Unacceptable new LWN

If OPUS displays a warning message or an error message during the LWN measurement refer to chapter *Troubleshooting*, section *Problems with the LWN Measurement*.

Note: For each test channel configuration (transmittance, reflectance and ATR objective), the laser wavenumber needs to be remeasured in order to ensure the wavenumber accuracy of the spectral data.

For detailed information about the laser wavenumber measurement refer to the OPUS Reference Manual.

Setting up PQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run PQ Test every* check box and specify the validity period for the PQ test (i.e. when the specified validity period is over the PQ test needs to be repeated). See figure 33.

For a validated system, the recommended time interval for repeating the PQ test is 24 hours. In case of a non-validated system, you can specify a longer time interval (e.g. every 7 days).

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has expired or failed.

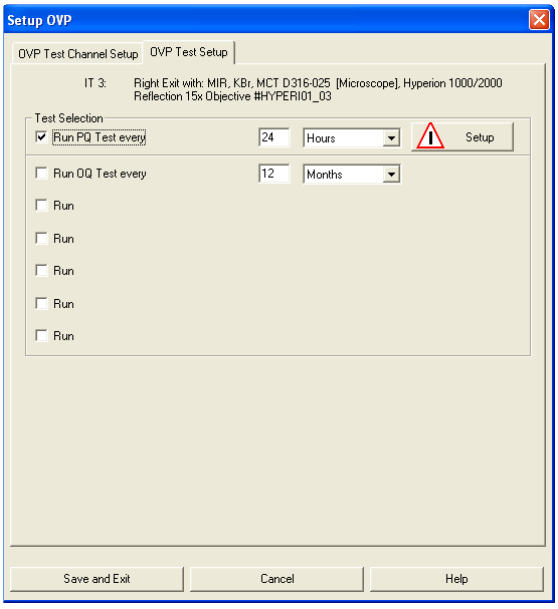


Figure 33: Specifying the Validity Period for the PQ Test

- Then, click in the *Setup* button. (The warning symbol on this button indicates that the PQ test protocol is not yet set up and/or that the reference spectra, required for the PQ test, are not yet measured.) The following dialog window appears:

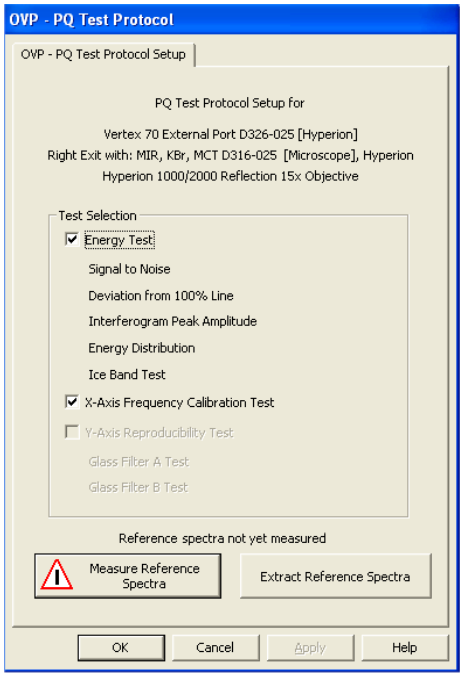


Figure 34: Setting up the PQ Test Protocol

Note: All tests available for this particular test channel are automatically selected. It is recommended to use this default setting. Only in exceptional cases, you should deactivate one or more tests of the PQ test protocol.

A warning symbol on the *Measure Reference Spectra* button indicates that the reference spectra need to be measured. See figure 34. The cases, in which new reference spectra need to be measured, are listed in the following section.

- If a reference spectra measurement is not required click on the *OK* button and proceed with the PQ test as described in the section *Running a PQ Test*. Otherwise, you need to measure the reference spectra first. See the following section.

Measuring Reference Spectra

The measurement of the reference spectra is only required in the following cases:

- after the installation of the instrument,
- after a major repair,
- after the replacement of an optical component (e.g. HeNe laser, source, beamsplitter, detector) or
- after the evacuation of the MCT detector.

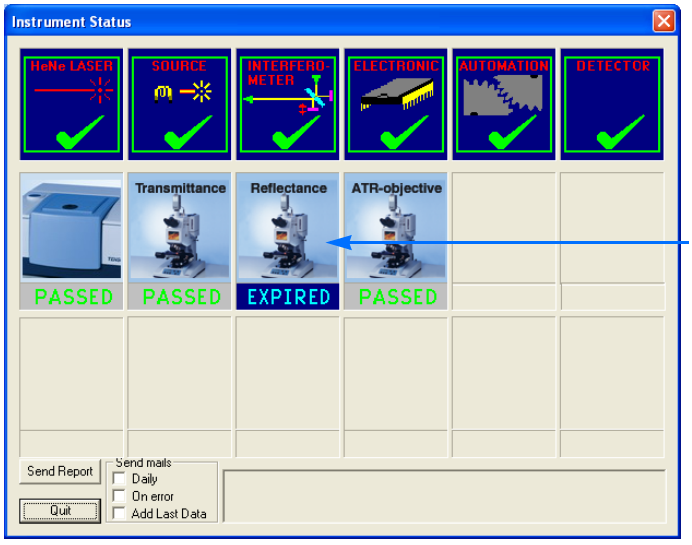
The necessity for a reference spectra measurement is indicated by a warning symbol on the *Measure Reference Spectra* button. (See figure 34.) Otherwise, you can leave out this step, click in the *Setup OVP* window on the *Save and Exit* button (see figure 29) and proceed with the section *Running the PQ Test*.

For the reference spectra measurement, proceed as follows:

- Before starting the reference spectra measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope in Reflectance for the PQ Test*. Check whether the microscope is set to the reflection mode. Additionally, you need to press the IR button on the microscope control panel.
- Click on the *Measure Reference Spectra* button.
- After the measurement is finished, click on the *OK* button.
- Then, click in the *Setup OVP* window (figure 29) on the *Save and Exit* button.

Running the PQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the measurement channel *HYPERION in Reflectance Mode*. See figure 35.



Icon for the test channel *HYPERION in Reflectance mode*; (For this channel, the validity period of an OVP has expired.)

Figure 35: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 36.

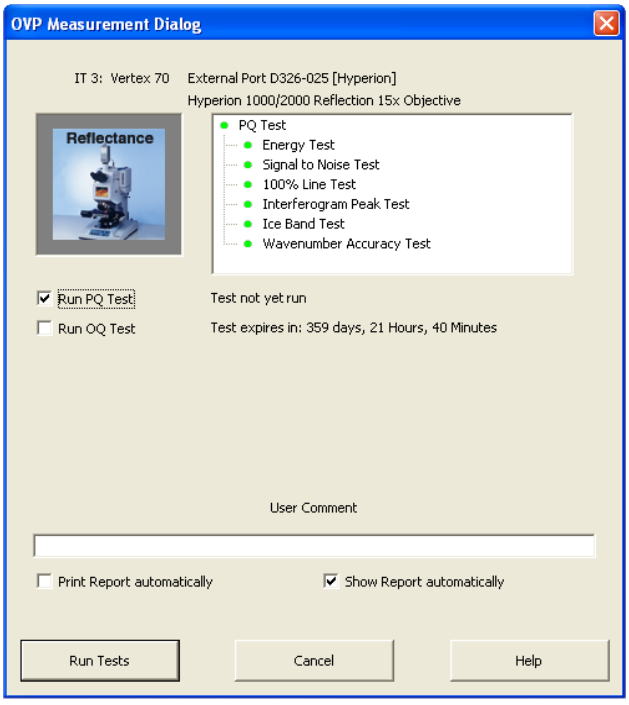


Figure 36: Starting the PQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not to select it.

- Activate the *Run PQ Test* check box.
- Decide whether you want the PQ test report either been printed automatically after or shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 37 appears reminding you to check whether the microscope is prepared as described in the above section *Preparing the Microscope in Reflectance for the PQ Test*.

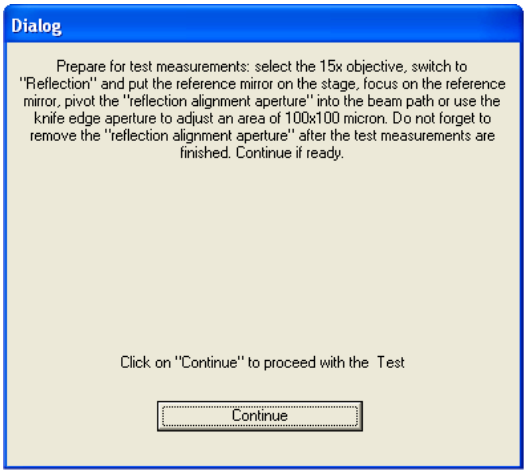


Figure 37: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the PQ test.
- If the warning message shown in figure 38 appears, it is highly recommended to check whether the current water vapor spectrum (with spectrum file name, for example: *PQ_Tensor_37_Exteranl_Port_D316-025_Hyperion_Fequency.1*) is OK. You will find this spectrum in the following directory: *OPUS path\VALIDATION\Data\YYYYMMDD*[1]*\HHMMSS*[2]. (For detailed information about the file name of the test spectra refer to the OPUS Reference Manual.)

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and s = second.

Figure 38: Warning Message regarding the Water Vapor Concentration

Note: After the PQ test is completed, do not forget to swing the reflection alignment aperture out of the beam path again.

PQ Test Results

The PQ test protocol is stored as pdf file in the directory *OPUS Path/VALIDATION/REPORTS*.

Note: For the display of the report make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 36), the test report is displayed and/or printed automatically immediately after the PQ test.

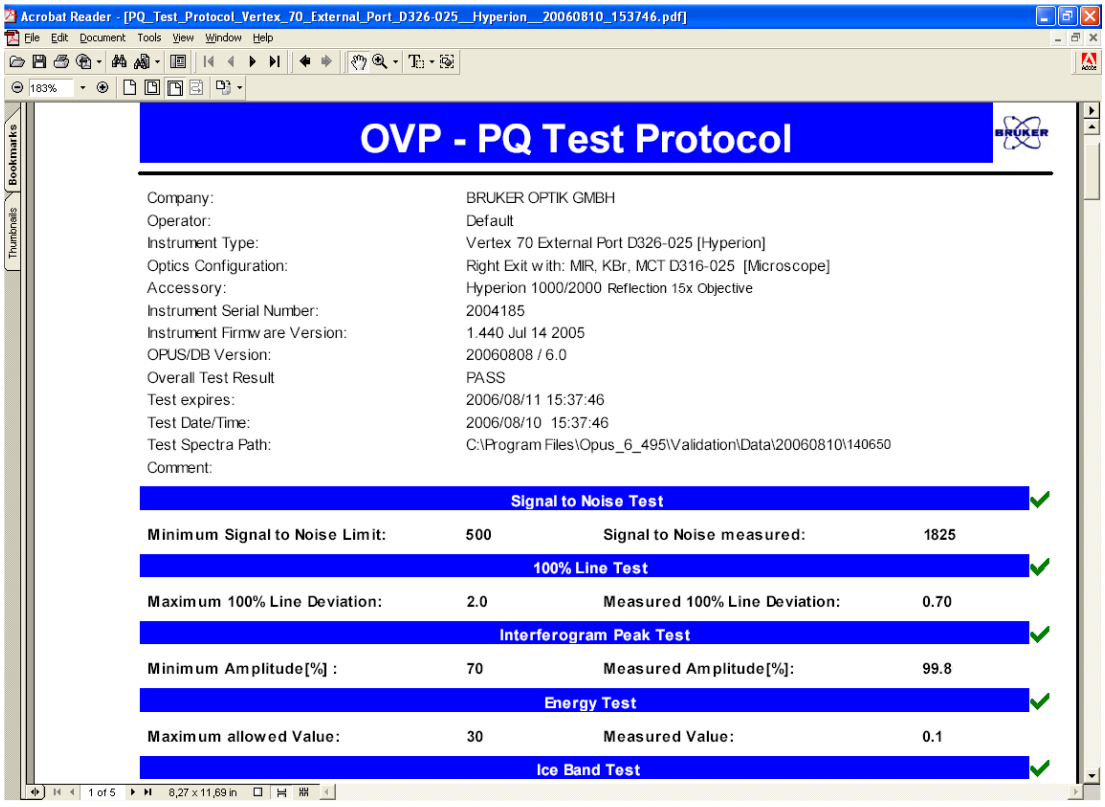


Figure 39: PQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the PQ test protocol failed, refer to chapter *Troubleshooting*.

OQ TEST PROCEDURE

Preparing the Microscope in Reflectance for the OQ test

Prepare the microscope as described in the above section *PQ Test Procedure*, subsection *Preparing the Microscope in Reflectance for the PQ Test*. The preparation procedure is identical for both OVP tests.

Setting up OVP Test Channel for the OQ Test

Set up the OVP test channel as described in the above section *PQ Test Procedure*, subsection *Setting up OVP Test Channel for the PQ Test.* The procedure for setting up the OVP test channel is identical for both OVP tests.

Measuring the Laser Wavenumber

In case you perform the OQ test for the first time or you have replaced the laser or another optical component, you need to measure the laser wavenumber (LWN). See section *PQ Test Procedure*, subsection *Measuring the Laser Wavenumber*. Otherwise, you can leave out this step and proceed with the following subsection *Setting up the OQ Test Protocol*.

Setting up the OQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run OQ Test every* check box.

In case you work with a validated system, specify the validity period for the OQ test (i.e. when the specified validity period is over the OQ test needs to be repeated). See figure 40. It is recommended to use the default setting (12 month).

In case of a non-validated instrument, the OQ test needs to be repeated only after the reinstallation of the instrument or the replacement of an optical component (e.g. laser) that may influence the instrument performance.

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has expired or failed.

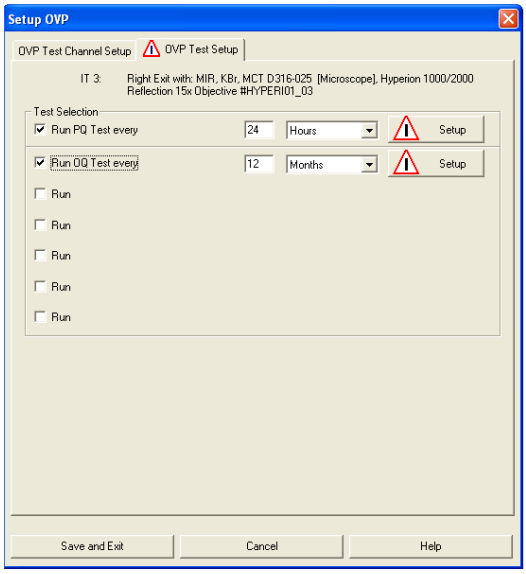


Figure 40: Specifying the Validity Period for the OQ Test

- Then, click in the *Setup* button. (The warning symbol on this button indicates that the OQ test protocol is not yet set up.) The following dialog window appears:

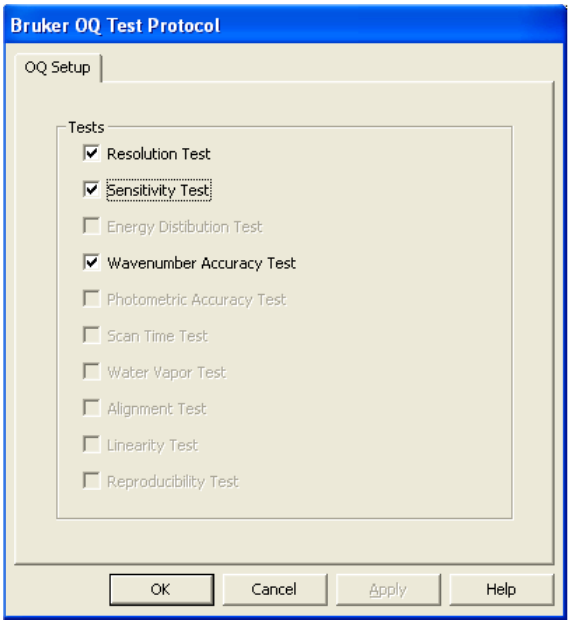


Figure 41: Setting up the OQ Test Protocol

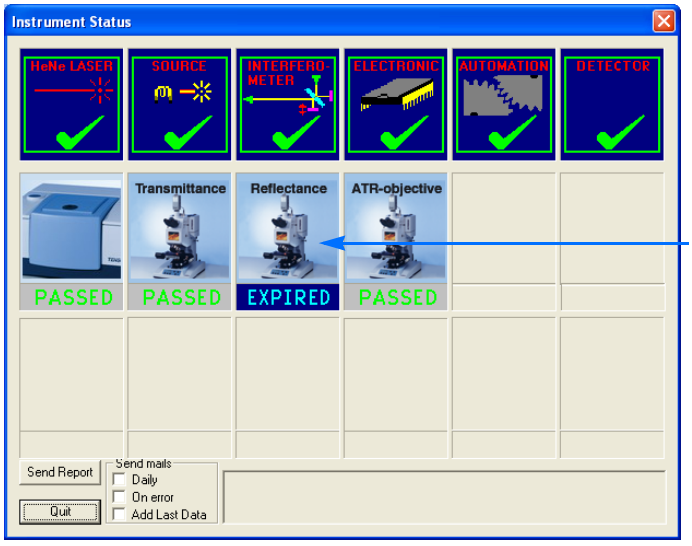
All tests available for this particular test channel are automatically selected.

Note: For the OQ test, the HYPERION microscope needs to be purged with dry air or nitrogen gas (flow rate: 100 to 200 l/hour). If your microscope is not equipped with this feature, deactivate the Wavenumber Accuracy Test of the OQ test protocol. See figure 41.

- Click on the *OK* button.
- Then, click on the *Save and Exit* button.

Running the OQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the measurement channel *HYPERION in Reflectance Mode*. See figure 42.



Icon for the test channel *HYPERION in Reflectance mode*; (For this channel, the validity period of an OVP has expired.)

Figure 42: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 42.

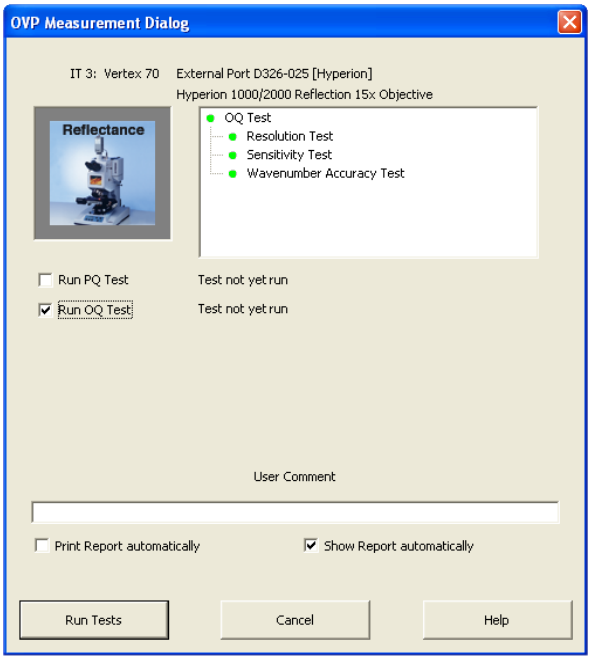


Figure 43: Starting the OQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not to select it.

- Activate the *Run OQ Test* check box.
- Decide whether you want the OQ test report either been printed automatically after the measurement or only shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 44 appears reminding you to check whether the microscope is prepared as described in section *PQ Test Procedure*, subsection *Preparing the Microscope in Reflectance for the PQ Test*.

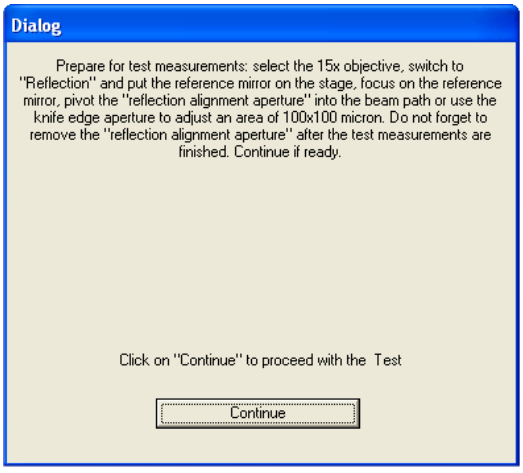


Figure 44: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the OQ test.
- If the warning message shown in figure 45 appears, it is highly recommended to check whether the current water vapor spectrum (with the following file name, for example: *PQ_Tensor_37_External_Port_D316-025_Hyperion_WnAccuracy.x*) is OK. You will find the spectrum in the following directory: *OPUS path**VALIDATION**Data* *YYYYMMDD*[1]*HHMMSS*[2]. (For information about the file name of the test spectra refer to the OPUS Reference Manual.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and S = second.

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

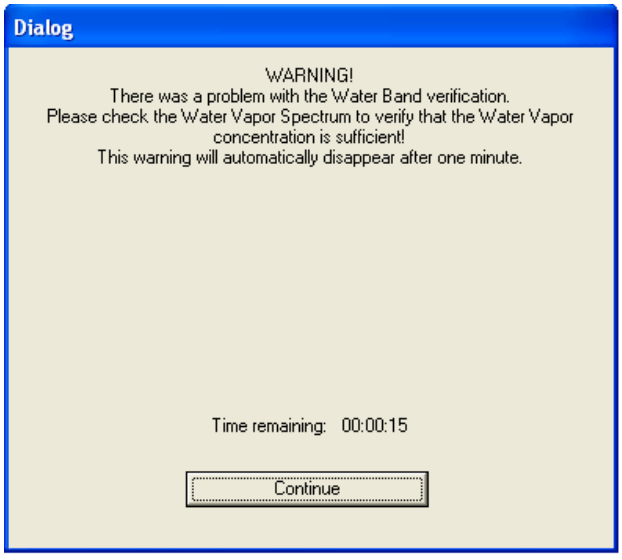


Figure 45: Warning Message regarding the Water Vapor Concentration

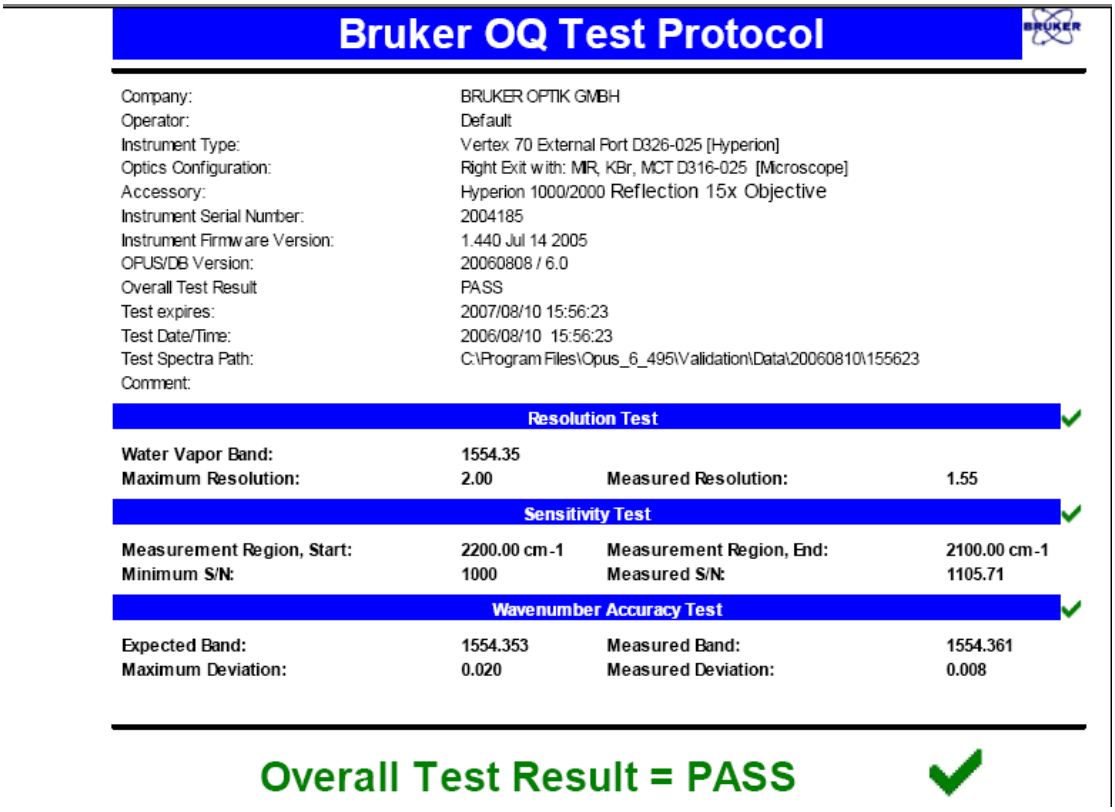
Note: After the OQ test is completed, do not forget to swing the reflection alignment aperture out of the beam path again.

OQ Test Results

The OQ test protocol with the test results is stored as pdf file in the directory *OPUS Path/VALIDATION/REPORTS*.

Note: For the display of the report, make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 36), the test report is displayed and/or printed automatically immediately after the OQ test is finished.



Bruker OQ Test Protocol

Company:	BRUKER OPTIK GMBH
Operator:	Default
Instrument Type:	Vertex 70 External Port D326-025 [Hyperion]
Optics Configuration:	Right Exit with: MIR, KBr, MCT D316-025 [Microscope]
Accessory:	Hyperion 1000/2000 Reflection 15x Objective
Instrument Serial Number:	2004185
Instrument Firmware Version:	1.440 Jul 14 2005
OPUS/DB Version:	20060808 / 6.0
Overall Test Result	PASS
Test expires:	2007/08/10 15:56:23
Test Date/Time:	2006/08/10 15:56:23
Test Spectra Path:	C:\Program Files\Opus_6_495\Validation\Data\20060810\155623
Comment:	

Resolution Test

Water Vapor Band:	**1554.35**		
Maximum Resolution:	**2.00**	**Measured Resolution:**	**1.55**

Sensitivity Test

Measurement Region, Start:	**2200.00 cm-1**	**Measurement Region, End:**	**2100.00 cm-1**
Minimum S/N:	**1000**	**Measured S/N:**	**1105.71**

Wavenumber Accuracy Test

Expected Band:	**1554.353**	**Measured Band:**	**1554.361**
Maximum Deviation:	**0.020**	**Measured Deviation:**	**0.008**

Overall Test Result = PASS

Figure 46: OQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the OQ test protocol failed, refer to chapter *Troubleshooting*.

OVP Test for ATR Objective

4

PQ Test Procedure

Preparing the Microscope with ATR Objective for the PQ Test

- Place the ATR objective in the beam path.
- Make sure that the beam path is not obstructed, for example, by a polarizer, a sample or the knife edge aperture (i.e. the knife edge aperture has to be open).
- Set the microscope to the reflection mode and the viewing (VIS) mode by pressing the corresponding buttons on the microscope control panel. (See HYPERION Manual.)
- Move the sample stage downwards as far as it will go using the coarse and focus knob (figure 23).
- Pull down the crystal holder of the ATR objective into the first pressure mode. See figure 47.

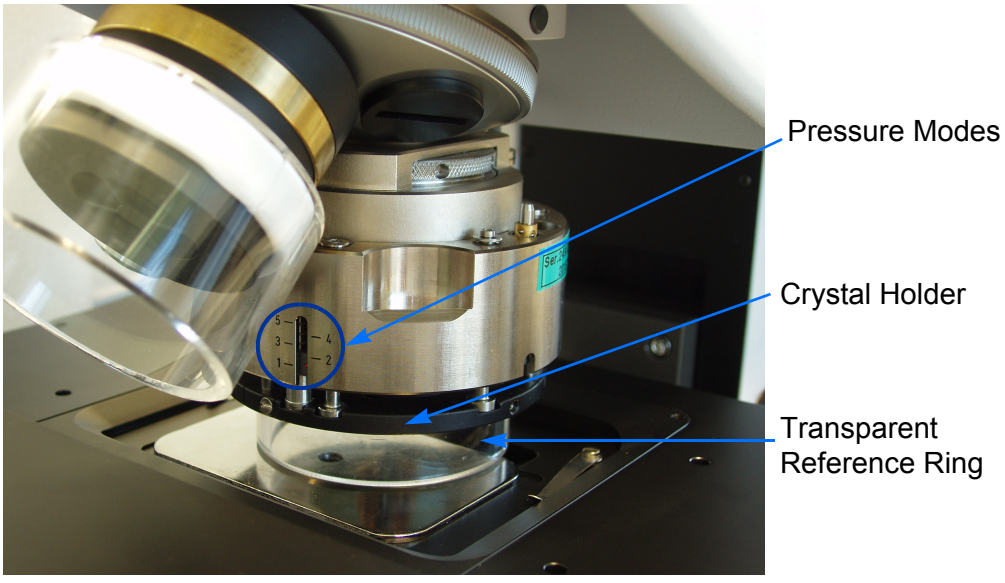


Figure 47: ATR Objective

- Put the transparent reference ring (which is included in the delivery scope of the ATR objective) on the sample stage. Position the ring concentrically below the ATR objective. Make sure the transparent reference ring does not contact the ATR objective.

- Move the sample stage upwards using the coarse and fine focus knobs (figure 23) until the ATR crystal is pressed in the focus position by the transparent reference ring. The ATR crystal focus position is indicated by a beep and the in-focus LED switches from red to green for a short moment. Then, it goes out.

After having prepared the microscope for the PQ test, it is highly recommended to check the signal using OPUS before starting the test. To do this, proceed as follows: Switch the microscope to the IR mode by pressing the corresponding button on the microscope panel.

- Start OPUS and select in the *Measure* menu the *Advanced Measurement* function.
- Load an existing standard experiment file (*.xmp) for ATR measurements with the microscope. Then click on the *Check Signal* tab. See figure 48. (For detailed information about this dialog window refer to the OPUS Reference Manual.)
- If the signal is too high (indicated by an amplitude value above 32000 counts) reduce the signal intensity by closing the knife edge aperture.
- If the signal is too low the ATR crystal is either damaged, dirty or out of alignment. To find out whether the displayed signal is sufficient, compare the displayed amplitude value (see figure 48) with the one written down in the form *ATR (Ge) Objective Hyperion Acceptance Measurements*. (You will find this form in the blue ring binder containing the final test results delivered with the microscope.) Both values should be more or less the same.

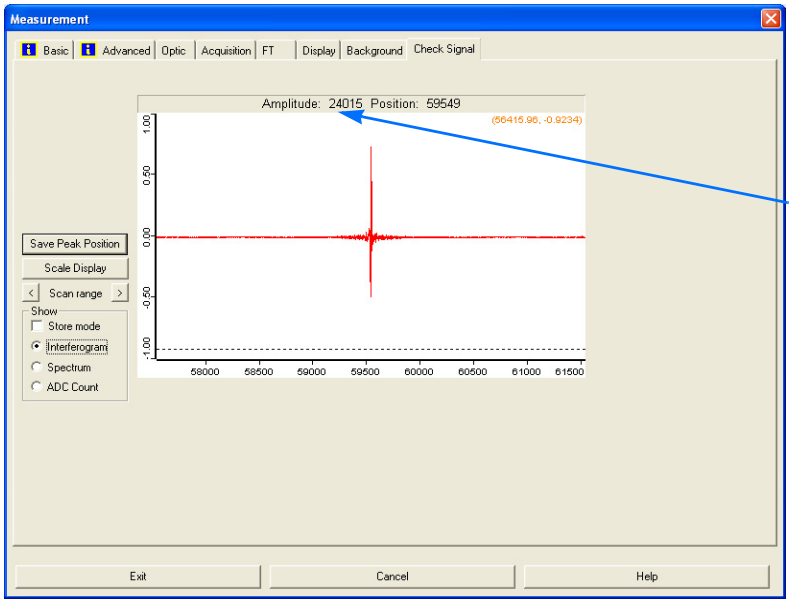


Figure 48: Checking the Signal

Setting up OVP Test Channel for the PQ Test

- Select in the OPUS *Validation* menu the *Setup OVP* function. The follow dialog window opens:

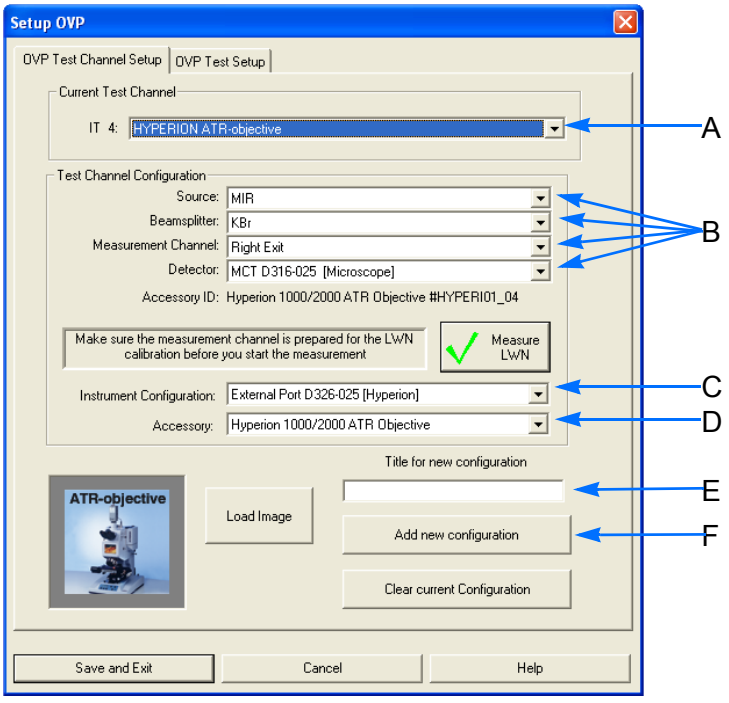


Figure 49: Setup OVP

In case you set up OVP for the first time, enter a descriptive title for the current configuration (e.g. HYPERION ATR-objective) into the entry field *Title for new configuration* (E in figure 49) and click on the *Add new configuration* button (F in figure 49). Moreover, you have to specify the installed source, beamsplitter installed in the spectrometer, the measurement channel (i.e. whether the microscope is coupled to the left or right exit port of the spectrometer) and the detector installed in the microscope (B in figure 49). Then, select the correct option for the instrument configuration (C in figure 49) and the accessory in question (D in figure 49).

Note: Select only an instrument configuration which is designed for the HYPERION microscope. Such a configuration option includes *[Hyperion]* in its name.

In case you have already set up one or more test channel configurations, you can select the test channel in question from the *Current Test Channel* drop-down list (A in figure 49). In this case, the correct options for *Source*, *Beamsplitter* etc. (B in figure 49) are selected automatically and you need not repeat the measurement of the LWN and the reference spectra.

Measuring the Laser Wavenumber

In case you perform an OVP test for the first time or you have replaced the laser or another optical component you need to measure the laser wavenumber (LWN) by clicking in the *Measure LWN* button. See figure 49. Otherwise, you can leave out this step and proceed with section *Setting up the PQ Test Protocol*.

Before starting the laser wavenumber measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope with ATR Objective for the PQ Test*.

The result of the laser wavenumber measurement is displayed as follows:

Figure 50: LWN Measurement Result

If the newly computed LWN is inside a certain tolerance range no changes are required. In this case, proceed by clicking on the *OK* button.

If the newly computed LWN is outside a certain tolerance range, the window shown in figure 51 appears. This window allows you to set the newly computed LWN by clicking on the *Yes* button.

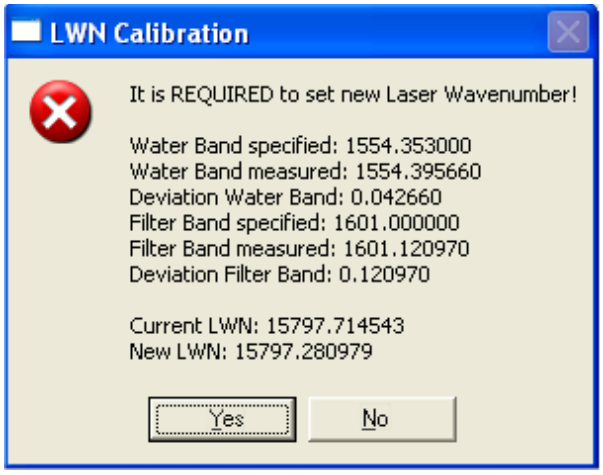


Figure 51: Setting the new LWN

Warning: If the measured filter band value is 0.000000 (see figure 52) DO NOT click on the *Yes* button because with a LWN based on such a value the OVP tests will fail! In this case, if you click inadvertently on the *Yes* button, the current LWN will get lost irretrievably and with the new LWN no OVP test will be passed!

A measured filter band value of 0.000000 indicates a microscope problem. In this case refer to chapter *Troubleshooting*, section *Problem with the LWN Measurement*.

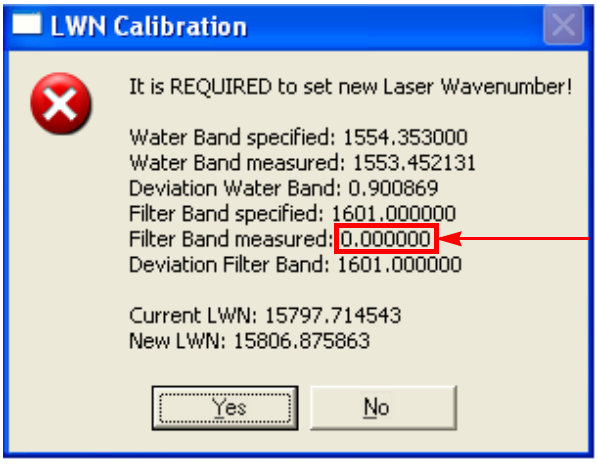


Figure 52: Unacceptable new LWN

If OPUS displays a warning message or an error message during the LWN measurement refer to chapter *Troubleshooting*, section *Problems with the LWN Measurement*.

Note: For each test channel configuration (transmittance, reflectance and ATR objective), the laser wavenumber needs to be remeasured in order to ensure the wavenumber accuracy of the spectral data.

For detailed information about the laser wavenumber measurement refer to the OPUS Reference Manual.

Setting up PQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run PQ Test every* check box and specify the validity period for the PQ test (i.e. when the specified validity period is over the PQ test needs to be repeated). See figure 53.

For a validated system, the recommended time interval for repeating the PQ test is 24 hours. In case of a non-validated system, you can specify a longer time interval (e.g. every 7 days).

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has expired or failed.

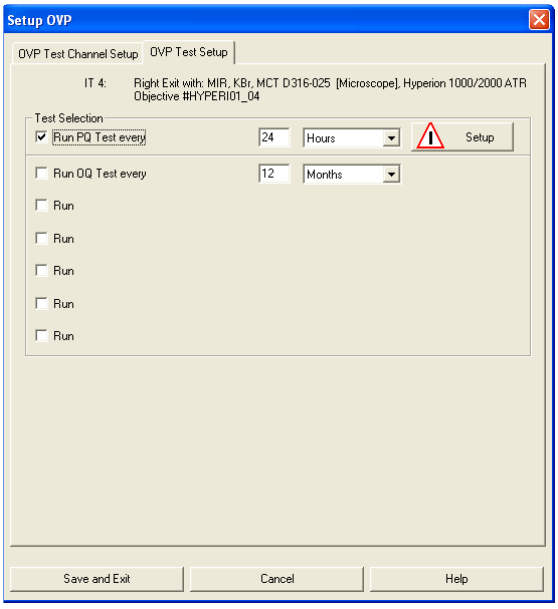


Figure 53: Specifying the Validity Period for the PQ Test

- Then, click in the *Setup* button. (The warning symbol on this button indicates that the PQ test protocol needs to be set up and/or that the reference spectra, required for the PQ test, need to be measured.) The following dialog window appears:

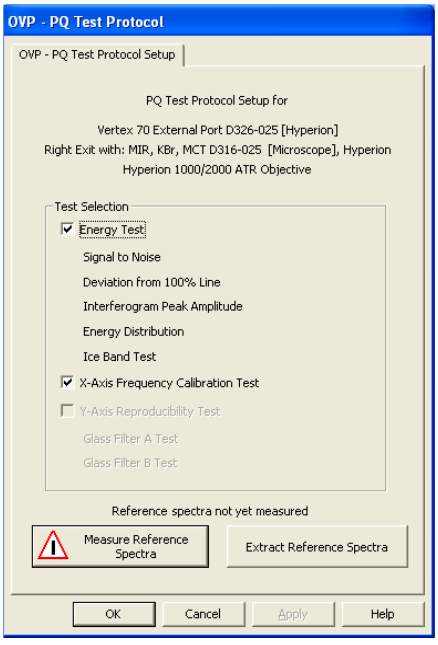


Figure 54: Setting up the PQ Test Protocol

Note: All tests available for this particular test channel are automatically selected. It is recommended to use this default setting. Only in exceptional cases, you should deactivate one or more tests of the PQ test protocol.

A warning symbol on the *Measure Reference Spectra* button indicates that reference spectra need to be measured. (See figure 54.) The cases, in which new reference spectra need to be measured, are listed in the following section.

- If a reference spectra measurement is not required click on the *OK* button and proceed with the PQ test as described in the section *Running the PQ Test*. Otherwise, you need to measure the reference spectra first. See the following section.

Measuring Reference Spectra

The measurement of the reference spectra is only required in the following cases:

- after the installation of the instrument,
- after a major repair,
- after the replacement of an optical component (e.g. HeNe laser, source, beamsplitter, detector) or
- after the evacuation of the MCT detector.

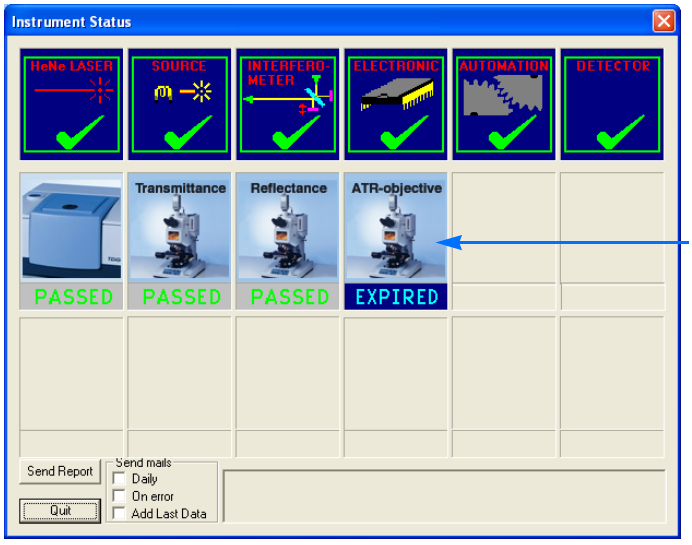
The necessity for a reference spectra measurement is indicated by a warning symbol on the *Measure Reference Spectra* button. (See figure 54.) Otherwise, you can leave out this step, click in the *Setup OVP* window on the *Save and Exit* button (see figure 49) and proceed with the section *Running the PQ Test*.

For the reference spectra measurement, proceed as follows:

- Before starting the reference spectra measurement, make sure that the microscope is prepared as described in the above section *Preparing the Microscope with ATR Objective for the PQ Test*. Check whether the microscope is set to the reflection mode. Additionally, you need to press the IR button on the microscope control panel.
- Click on the *Measure Reference Spectra* button.
- After the measurement is finished, click on the *OK* button.
- Then, click in the *Setup OVP* window (figure 49) on the *Save and Exit* button.

Running the PQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the test channel *HYPERION with ATR-objective*. See figure 55.



Icon for the test channel *HYPERION with ATR-objective*; (For this channel, the validity period of an OVP has expired.)

Figure 55: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 56.

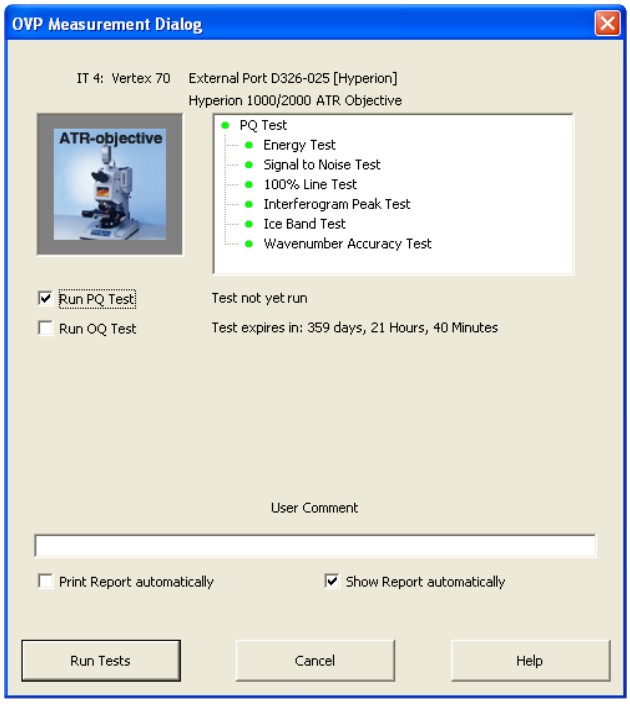


Figure 56: Starting the PQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not to select it.

- Activate the *Run PQ Test* check box.
- Decide whether you want the PQ test report either been printed automatically after or shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 57 appears reminding you to check whether the microscope is prepared as described in the above section *Preparing the Microscope with ATR Objective for the PQ Test*.

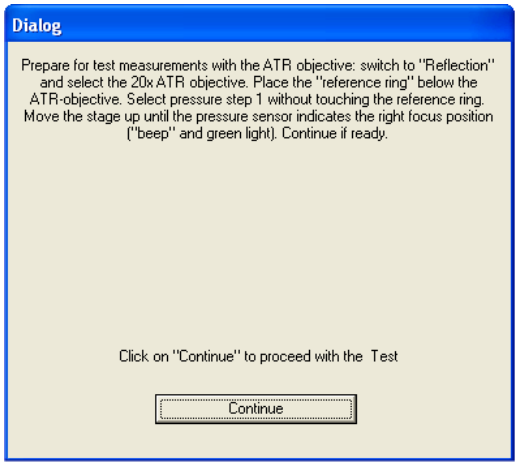


Figure 57: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the PQ test.
- If the warning message shown in figure 58 appears, it is highly recommended to check whether the current water vapor spectrum ((with spectrum file name, for example: *PQ_Tensor_37_External_Port_D316-025_Hyperion_Frequency.1*) is OK. You will find the spectrum in the following directory: *OPUS path\VALIDATION \Data \YYYYMMDD*[1]*\HHMMSS*[2]. (For information about the file name of the test spectra refer to the OPUS Reference Manual.)

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and S = second.

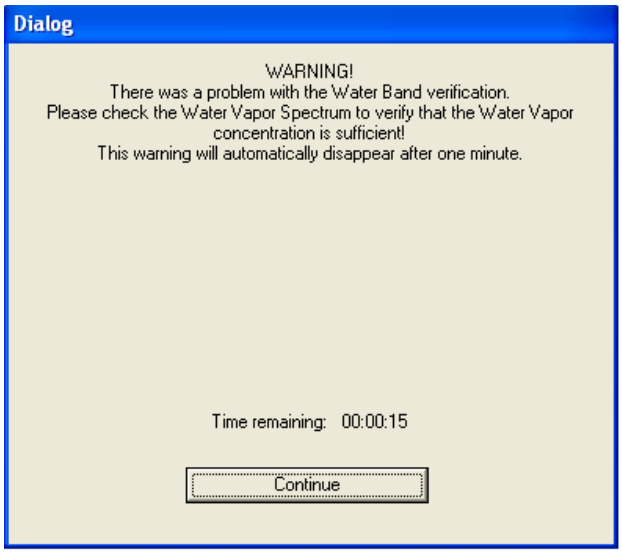


Figure 58: Warning Message regarding the Water Vapor Concentration

Note: After the PQ test is completed, do not forget to remove the reference ring.

PQ Test Results

The PQ test protocol is stored as pdf file in the directory *OPUS path/VALIDATION/REPORTS*.

Note: For the display of the report make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 56), the test report is displayed and/or printed automatically immediately after the PQ test.

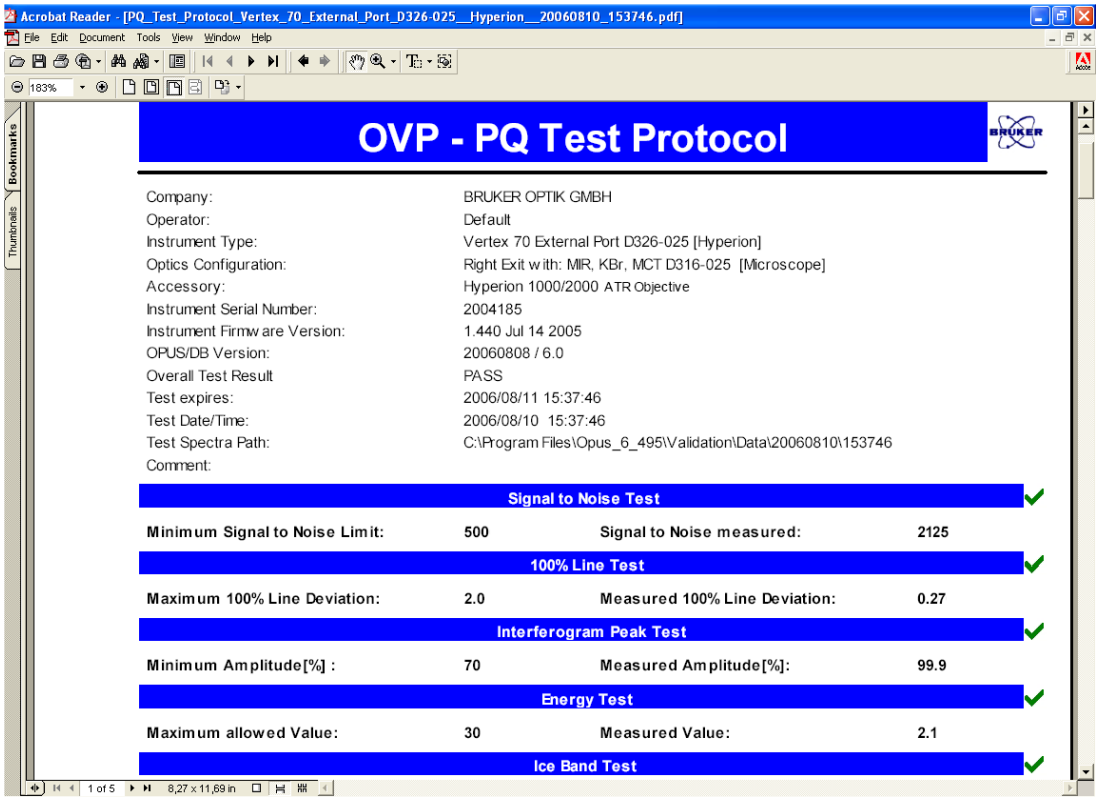


Figure 59: PQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the PQ test protocol failed, refer to chapter *Troubleshooting*.

OQ TEST PROCEDURE

Preparing the Microscope with ATR Objective for the OQ Test

- Prepare the microscope as described in the above section *PQ Test Procedure*, subsection *Preparing the Microscope with ATR Objective for the PQ Test*.
- Proceed with the OQ test as described in the following subsection *Setting up the OVP Test Channel for the OQ Test*.

Later in the course of the OQ test, the transparent reference ring needs to be substituted for the Nylon sample[1]. OPUS prompts you to do so by the following message dialog:

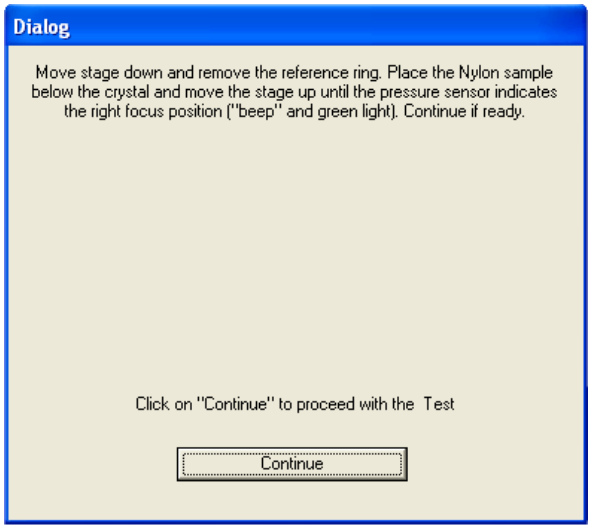


Figure 60: OPUS Prompt Message

- Keep the Nylon sample ready. When this message dialog appears, move the sample stage a few millimeters downwards, remove the transparent reference ring and put the Nylon sample on the stage. Place it below the ATR crystal.
- Move the sample stage upwards until the ATR crystal contacts the Nylon sample. (See figure 61.) As soon as the ATR crystal is in the focus position, it beeps and the in-focus LED switches from red to green for a short moment. Then, it goes out.
- Then, click on the *Continue* button and proceed with the OQ test.

The exact OQ test sequence is described in detail in the section *Running the OQ Test* in this chapter.

Note: The Nylon spectrum is required for the photometric accuracy test.

1. The Nylon sample is delivered with the ATR objective.

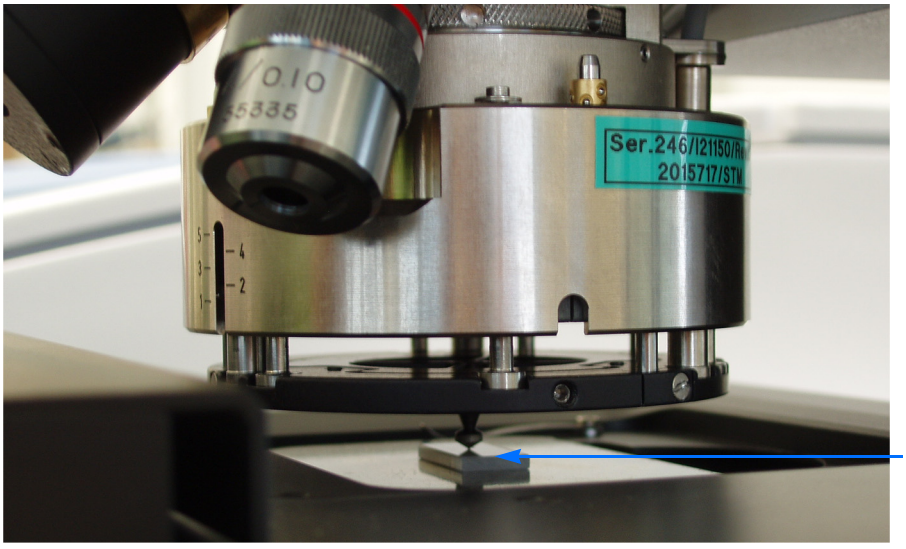


Figure 61: Preparing the Microscope for the Photometric Accuracy Test

Setting up the OVP Test Channel for the OQ Test

Set up the OVP test channel as described in the above section *PQ Test Procedure*, subsection *Setting up OVP Test Channel for the PQ Test*. The procedure for setting up the OVP test channel is identical for both OVP tests.

Measuring the Laser Wavenumber

In case you perform the OQ test for the first time or you have replaced the laser or another optical component, you need to measure the laser wavenumber (LWN). See section *PQ Test Procedure*, subsection *Measuring the Laser Wavenumber*. Otherwise, you can leave out this step and proceed with the following subsection *Setting up the OQ Test Protocol*.

Setting up the OQ Test Protocol

- Click in the *Setup OVP* dialog window on the *OVP Test Setup* tab.
- Activate the *Run OQ Test every* check box.

In case you work with a validated system, specify the validity period for the OQ test (i.e. when the specified validity period is over the OQ test needs to be repeated). See figure 62. It is recommended to use the default setting (12 month).

In case of a non-validated system, the OQ test needs to be repeated only after a reinstallation of the instrument or after the replacement of an optical component (e.g. laser) that may influence the instrument performance.

Note: An expired or failed OVP test is indicated by a yellow or red instrument status lamp in the lower right corner of the OPUS user interface. Click on this lamp to find out for which test channel an OVP test has been expired or failed.

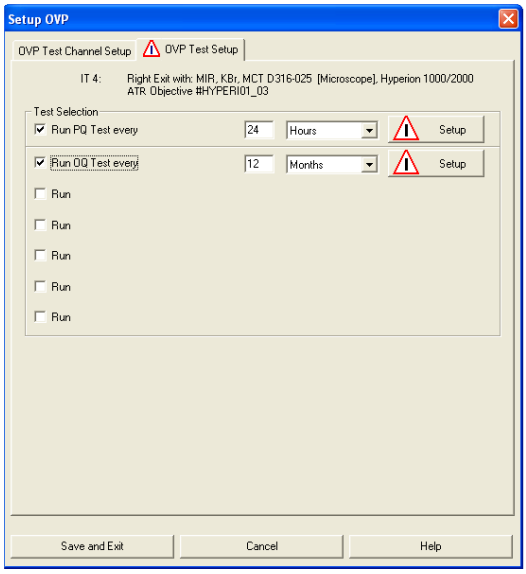


Figure 62: Specifying the Validity Period for the OQ Test

- Then, click in the *Setup* button. (The warning symbol on this button indicates that the OQ test protocol needs to be set up.) The following dialog window appears:

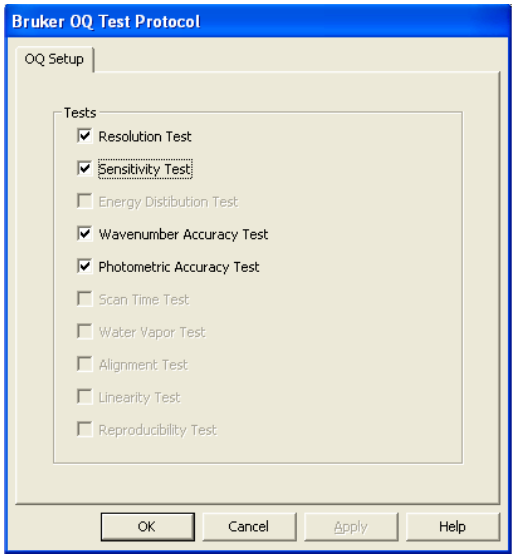


Figure 63: Setting up the OQ Test Protocol

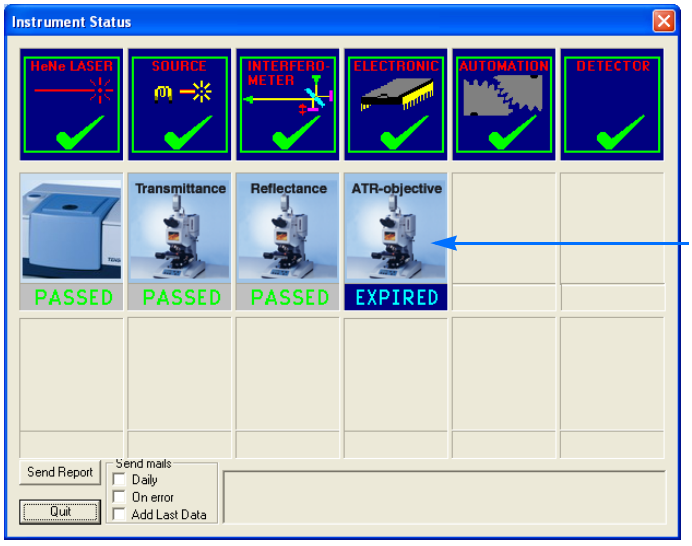
All tests available for this particular test channel are automatically selected.

Note: For the OQ test, the HYPERION microscope needs to be purged with dry air or nitrogen gas (flow rate: 100 to 200 l/hour). If your microscope is not equipped with this feature, deactivate the *Wavenumber Accuracy Test* of the OQ test protocol. See figure 63.

- Click on the *OK* button.
- Then, click on the *Save and Exit* button.

Running the OQ Test

- Either select in the OPUS *Validation* menu the *Run OVP Tests* function **OR** click on the instrument status lamp in the lower right corner of the OPUS user interface. In the latter case, the *Instrument Status* dialog window opens. Click on the icon of the test channel *HYPERION with ATR-Objective*. See figure 64.



Icon for the test channel *HYPERION with ATR-Objective*; (For this channel, the validity period of an OVP has expired.)

Figure 64: Instrument Status Dialog

- As a result, the *OVP Measurement Dialog* opens. See figure 65.

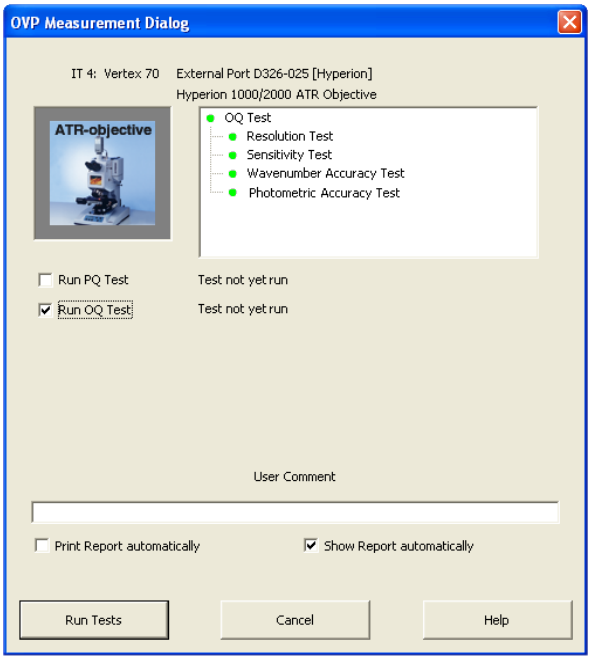


Figure 65: Starting the OQ Test

Note: Depending on the way you have opened this dialog, it looks slightly different. If you have opened this dialog via the OPUS *Validation* menu you have to select the test channel in question in the drop-down list *IT n* (with *n* being the number of the corresponding test channel you have set up). Whereas, if you have opened the *OVP Measurement* dialog by clicking on the corresponding icon in the *Instrument Status* dialog, the correct test channel is displayed automatically so that you need not to select it.

- Activate the *Run OQ Test* check box.
- Decide whether you want the OQ test report either been printed automatically after the measurement or only shown automatically or both by activating the corresponding check box(es).
- Click on the *Run Tests* button.
- Thereupon, the message window shown in figure 66 appears reminding you to check whether the microscope is prepared as described in section *PQ Test Procedure*, subsection *Preparing the Microscope with ATR Objective for the PQ Test*.

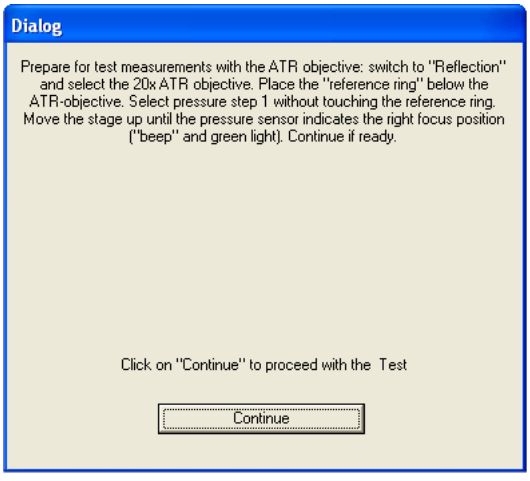


Figure 66: OPUS Reminder Message

- When the microscope is ready for the test, click on the *Continue* button to proceed with the OQ test.
- If the warning message shown in figure 67 appears, it is highly recommended to check whether the current water vapor spectrum (with the following file name, for example: *PQ_Tensor_37_External_Port_D316-025_Hyperion_WnAccuracy.x*) is OK. You will find the spectrum in the following directory: *OPUS path**VALIDATION**Data* *YYYYMMDD*[1]*HHMMSS*[2]. (For information about the file name of the test spectra refer to the OPUS Reference Manual.)

1. The name of this subdirectory is the current date with Y = year, M = month and D = day.
2. The name of this subdirectory is the current time with H = hour, M = minute and S = second.

If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 (appendix A) you have to take appropriate steps (e.g. purging) in order to decrease the water vapor concentration in the instrument. (An example of a water vapor spectrum indicating the need for purging is shown in figure 74, appendix A.) If your water vapor spectrum is OK you can ignore this warning message. (Note: This message will disappear automatically after one minute.)

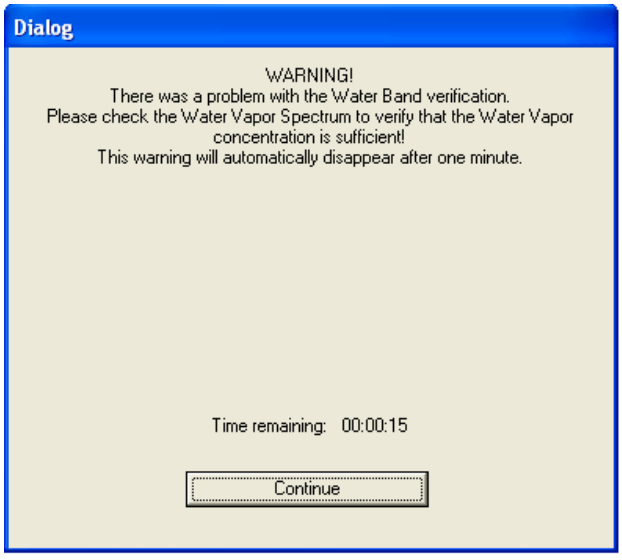


Figure 67: Warning Message regarding the Water Vapor Concentration

Later on, the following message box appears:

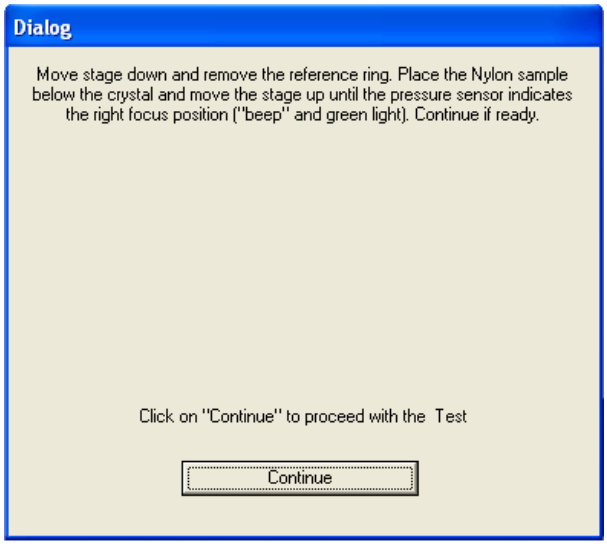


Figure 68: OPUS Prompt Message

- Substitute the reference ring for the nylon sample as described in the above section *Preparing the Microscope with ATR Objective for the OQ Test*. Then, click on the *Continue* button.

Later in the course of the OQ test, the OPUS reminder message (shown in figure 66) appears again.

- Substitute the nylon sample for the reference ring as described in the above section *Preparing the Microscope with ATR Objective for the OQ Test*. Then, click on the *Continue* button.

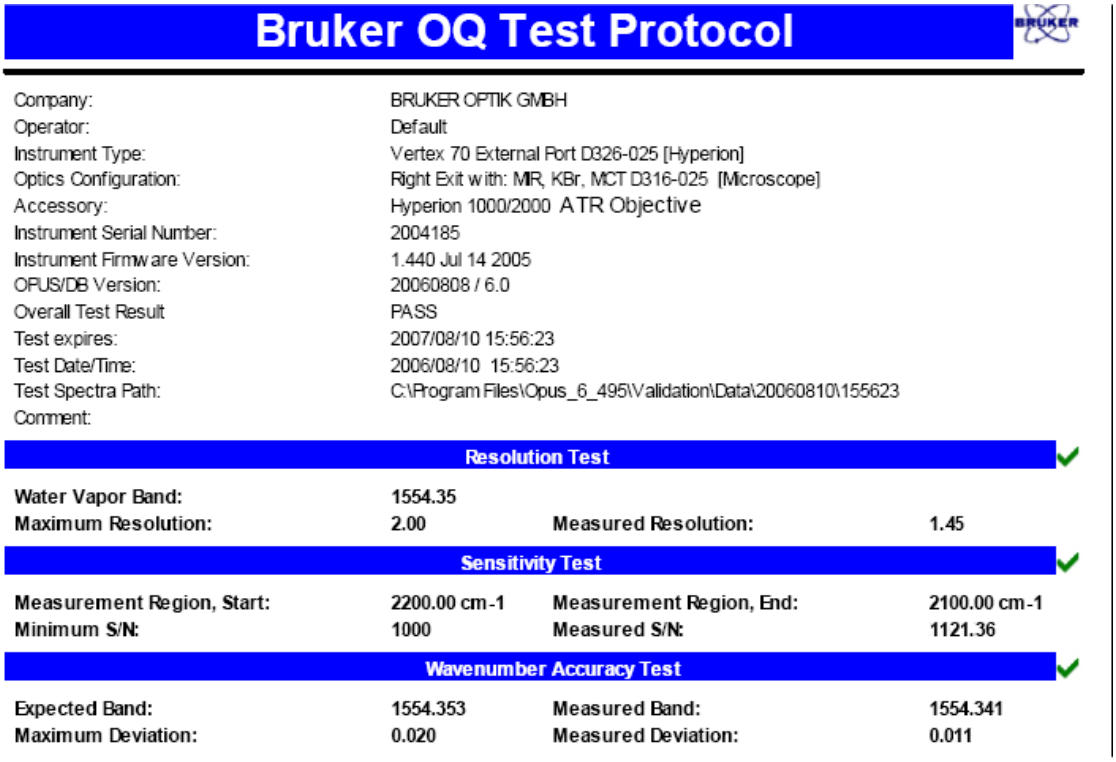
Note: After the OQ test is completed, do not forget to remove the reference ring.

OQ Test Results

The OQ test protocol is stored as pdf file in the directory *OPUS Path/VALIDATION/REPORTS*.

Note: For the display of the report, make sure that the Adobe Acrobat Reader is installed on your computer. This program is available on the OPUS installation CD.

Depending on your settings in the *OVP Measurement Dialog* window (figure 56), the test report is displayed and/or printed automatically immediately after the OQ test is finished.



Bruker OQ Test Protocol

Company:	BRUKER OPTIK GMBH
Operator:	Default
Instrument Type:	Vertex 70 External Port D326-025 [Hyperion]
Optics Configuration:	Right Exit with: MIR, KBr, MCT D316-025 [Microscope]
Accessory:	Hyperion 1000/2000 ATR Objective
Instrument Serial Number:	2004185
Instrument Firmware Version:	1.440 Jul 14 2005
OPUS/DB Version:	20060808 / 6.0
Overall Test Result	PASS
Test expires:	2007/08/10 15:56:23
Test Date/Time:	2006/08/10 15:56:23
Test Spectra Path:	C:\Program Files\Opus_6_495\Validation\Data\20060810\155623
Comment:	

Resolution Test

Water Vapor Band:	1554.35		
Maximum Resolution:	2.00	Measured Resolution:	1.45

Sensitivity Test

Measurement Region, Start:	2200.00 cm-1	Measurement Region, End:	2100.00 cm-1
Minimum S/N:	1000	Measured S/N:	1121.36

Wavenumber Accuracy Test

Expected Band:	1554.353	Measured Band:	1554.341
Maximum Deviation:	0.020	Measured Deviation:	0.011

Figure 69: OQ Test Protocol

A passed test is indicated by a green check mark and a failed test by a red cross.

If one or more tests of the OQ test protocol failed, refer to chapter *Troubleshooting*.

TROUBLESHOOTING

5

GENERAL INFORMATION

In case one or more OVP test(s) have failed, the following general information can help you to narrow down the cause of the problem, regardless which test of the PQ or OQ test protocol failed. For a more detailed troubleshooting refer to the following sections. If the solutions provided in this chapter do not solve a certain problem contact the Bruker service. For service addresses and telephone numbers refer to appendix B.

- To exclude the spectrometer being the cause of a failed OVP test, perform the OQ and/or PQ test for the spectrometer alone (test channel: sample compartment of the spectrometer in question). A passed spectrometer OQ and/or PQ test is an important precondition for the subsequent OQ and/or PQ test performed for the HYPERION test channel(s).
- It is of crucial importance that the microscope is prepared exactly as described in this Procedure Guide for the channel(s) (transmittance, reflectance, ATR-objective) you intend to test. Otherwise, the tests will fail.
- Check whether the MCT detector is cooled down to its operating temperature. After having filled liquid nitrogen in the detector dewar, wait about 20 minutes to allow the detector to stabilize before you start an OVP test.
- After having replaced the laser, do not forget to measure the laser wavenumber. Otherwise, some tests will fail.
- After having replaced an optical component (source, detector, beamsplitter and laser) or after having evacuated the detector dewar do not forget to measure new reference spectra for the PQ test. Otherwise, some tests will fail.
- For some OVP tests, the water vapor content inside the microscope needs to be low. To fulfill this condition, purge the microscope. In case your microscope cannot be purged and the tests are not passed, deactivate these tests (PQ: x-axis frequency calibration test, OQ: resolution test and wavenumber accuracy test) as there is no real chance to pass them, especially, if the air humidity level is high at your site.
- Make sure that the beam path is not blocked (e.g. by a filter, polarizer, aperture or sample) by checking the signal using the OPUS program. (For information about how to check the signal refer to the corresponding microscope preparation sections in this manual.)
- During a running OVP test, make sure that the spectrometer and the microscope is not exposed to vibrations caused by other instruments and/or devices (e.g. stirrer, mixer, fan) which are on the same table or close to the spectrometer and the microscope.

PROBLEMS WITH THE LWN MEASUREMENT

These problems are indicated by an number of error or warning messages.

Error Message: Specified Peak not found

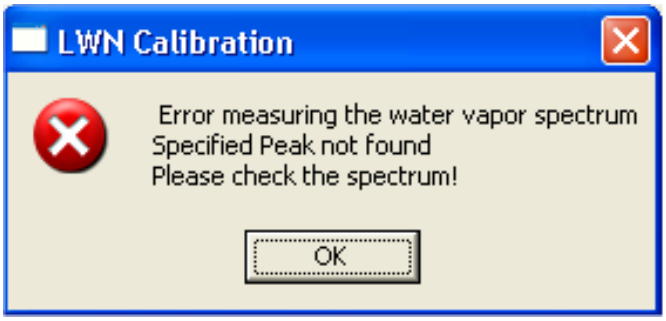


Figure 70: OPUS Error Message

The error message shown in figure 70 means that no signal has been detected.

Possible Causes	Solutions
MCT detector is not cooled down to its operating temperature.	Cool the detector with liquid nitrogen. After having filled in liquid nitrogen in the detector dewar, wait about 20 minutes to allow the detector to stabilize.
Detector cable connection has not been realized properly.	Check the detector cable connections.
Beam path is blocked.	Check the beam path for obstructions (e.g. filter polarizer, sample) and remove it. Check whether a signal is detected. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.)

Warning Message: Problem with the Water Band Verification

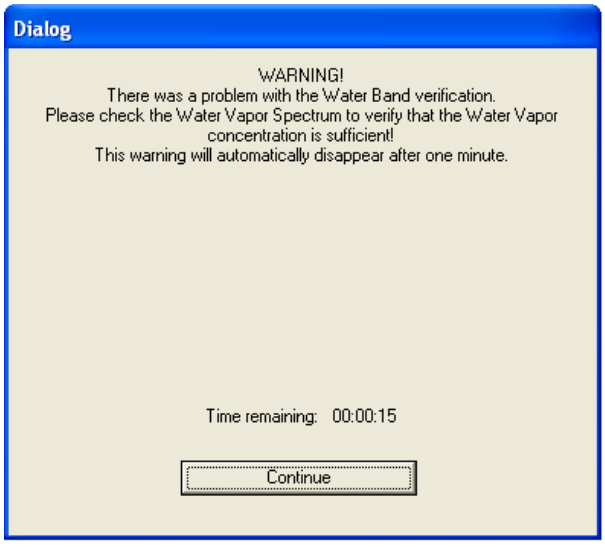


Figure 71: OPUS Warning Message

Note: This message disappears automatically after one minute.

Possible Causes	Solutions
Water band could not be detected properly because the water vapor concentration inside your instrument system is too high.	Check the water vapor spectrum *LWN_Water.x* (with *x* being the consecutive number of the measured water vapor spectra) stored under *OPUS path/VALIDATION/TEMP*. If the band at 1554cm^{-1} of your water vapor spectrum differs from the one shown in figure 73 of appendix A you have to take appropriate steps in order to decrease the water vapor content inside the instrument system (e.g. by purging the spectrometer and the microscope and/or replacing the desiccant cartridge in the spectrometer by a new or regenerated one). Repeat the LWN measurement until the result is OK. If your water vapor spectrum is OK you can ignore this warning message. (This message disappears automatically after one minute.)

Note: In case you cannot measure the LWN because your microscope cannot be purged and the air humidity level at your site is too high for the LWN measurement to be successful, OVP uses the last LWN settings.

Measured Filter Band Value is Zero

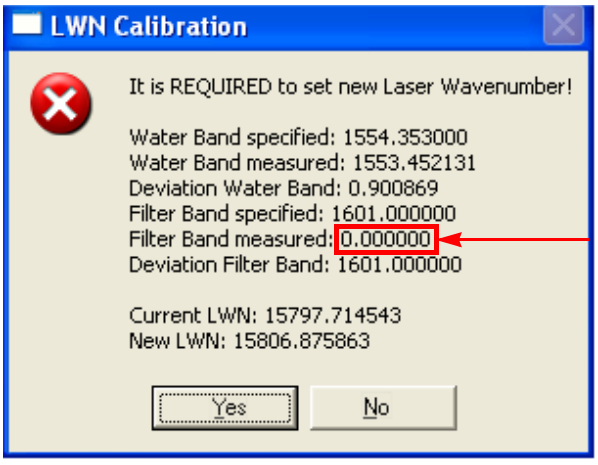


Figure 72: Unacceptable new LWN

Possible Causes	Solutions
Microscope is not prepared properly for the test channel (transmittance, reflectance, ATR objective) you intend to validate.	**Click on the *No* button!** Then, prepare the microscope for the test channel in question exactly as described in this manual. Repeat the LWN measurement until the measured filter band value is OK.

Warning: If the measured filter band value is 0.000000 (see figure 72) DO NOT click on the *Yes* button because with a LWN based on such a value the OVP tests will fail! In this case, if you click inadvertently on the *Yes* button, the current LWN will get lost irretrievably and with the new LWN no OVP test will be passed!

A FAILED PQ TEST

The PQ test protocol consists of a number of several tests. See chapter 1. For detailed information about these tests refer to the OPUS Reference Manual.

Signal-to-Noise Test failed

Possible Causes	Solutions
Microscope is not prepared properly for the test channel in question (transmittance, reflectance, ATR-objective).	Prepare the microscope for the test channel in question as described in the respective chapter of this Procedure Guide.
Source performance has decreased or source is defective.	Replace the source as described in the spectrometer user manual. (The source is installed inside the spectrometer. To find out whether the source is the cause of the failed sensitivity test, perform the OQ test for the test channel of the spectrometer alone.)
MCT detector needs to be evacuated. (Note: In this case, the ice band test failed as well.)	Evacuate the detector as described in the HYPERION User Manual.
Vibrations	Ensure that there are no vibrating instruments near to the microscope and the spectrometer.
Beam path is blocked.	Check the beam path for obstructions (e.g. filter polarizer, sample) and remove it. Check whether a signal is detected. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.)
For the test channel with the ATR objective, the ATR crystal is damaged or dirty or misaligned.	To find out whether the ATR crystal is the cause of the problem, perform a photometric accuracy test (which is included in the OQ test). A failed photometric accuracy test is an indication that the ATR crystal is the cause of the problem. Damaged ATR crystal: Order a new ATR crystal and replace the damage one. Dirty ATR crystal: Clean it using ethanol, for example. Do not use solvents! Solvents will make the adhesive-bonded crystal to come off! Misaligned ATR crystal: Align the ATR objective as described in the HYPERION User Manual.

Possible Causes	Solutions
For the test channel with the ATR objective, the signal intensity is too high (i.e. the amplitude value exceeds 32000 counts). This may be the case after an ATR crystal replacement due to the properties of the new crystal.	Check the signal. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.) If the amplitude value is above 32000 counts close the knife edge aperture to reduce the signal intensity.

100% Line Deviation Test failed

Possible Causes	Solutions
After you have filled liquid nitrogen in the detector dewar, the MCT detector has not yet stabilized.	After having filled in liquid nitrogen, wait about 20 minutes before you start the PQ test.
Vibrations	Ensure that there are no vibrating instruments near to the microscope and the spectrometer.
Purge gas flow rate is too high.	Reduce the purge gas flow rate and wait to allow the water vapor content to increase again. Then, repeat this test. Recommended flow rate: 100 to 200 l/h.

Interferogram Peak Amplitude Test failed

Possible Causes	Solutions
Source performance has decreased or source is defective.	Replace the source as described in the spectrometer user manual. (The source is installed inside the spectrometer. To find out whether the source is the cause of the failed sensitivity test, perform the OQ test for the test channel of the spectrometer alone.)
Microscope is not prepared properly for the test channel in question (transmittance, reflectance, ATR-objective).	Prepare the microscope for the test channel in question as described in the respective chapter of this Procedure Guide.

Possible Causes	Solutions
Beam path is blocked.	Check the beam path for obstructions (e.g. filter polarizer, sample) and remove it. Check whether a signal is detected. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.)

Energy Distribution Test failed

Possible Causes	Solutions
Source performance has decreased or source is defective.	Replace the source as described in the spectrometer user manual. (The source is installed inside the spectrometer. To find out whether the source is the cause of the failed sensitivity test, perform the OQ test for the test channel of the spectrometer alone.)
Microscope is not prepared properly for the test channel in question (transmittance, reflectance, ATR-objective).	Prepare the microscope for the test channel in question as described in the respective chapter of this Procedure Guide.
Beam path is blocked.	Check the beam path for obstructions (e.g. filter polarizer, sample) and remove it. Check whether a signal is detected. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.)

Ice Band Test failed

Possible Causes	Solutions
Ice formation in the MCT detector dewar.	Evacuate the MCT detector. See HYPERION User Manual, chapter *Operation*, section *Evacuating the Detector.*
After the evacuation of the detector dewar, you did not wait long enough for the detector to stabilize.	After the evacuation, wait about 20 minutes to allow the detector to stabilize. Then, repeat the test.

X-Axis Frequency Calibration Test failed

Possible Causes	Solutions
Water vapor content inside the microscope is too high.	Purge the microscope. If your microscope cannot be purged, deactivate this test of the OQ test protocol.
After having replaced the laser, you have forgotten to calibrate the laser wavenumber.	Measure the laser wavenumber and repeat the test. Note: In case you can not purge your microscope to reduce the water vapor concentration and, consequently, not perform a successful LWN calibration, deactivate this test.
Laser performance has decreased or laser is defective.	(The laser is installed inside the spectrometer. To find out whether the laser is the cause of the failed X-axis frequency calibration test, perform the OQ/PQ test for the test channel of the spectrometer alone.) If the laser is the cause of the problem order a new one and replace it as described in the spectrometer user manual.
After having replaced an optical component (beamsplitter, source, detector, laser), you have forgotten to measure new reference spectra.	Measure new reference spectra as described in this Procedure Guide.

A FAILED OQ TEST

The OQ test protocol consists of a number of several tests. See chapter 1. For detailed information about these tests refer to the OPUS Reference Manual.

Resolution test failed

Possible Causes	Solutions
Water vapor content inside the microscope is too high or too low.	Water vapor content is too high: Purge the microscope and repeat the test. If your microscope cannot be purged, deactivate this particular OQ test. Water vapor content is too low: Reduce the purge gas flow rate and wait a while. Then, repeat the test.

Sensitivity test failed

Possible Causes	Solutions
Microscope is not prepared properly for the test channel in question (transmittance, reflectance, ATR-objective).	Prepare the microscope for the test channel in question as described in the respective chapter of this Procedure Guide.
Source performance has decreased or source is defective.	Replace the source as described in the spectrometer user manual. (The source is installed inside the spectrometer. To find out whether the source is the cause of the failed sensitivity test, perform the OQ test for the test channel of the spectrometer alone.)
MCT detector needs to be evacuated. (Note: In this case, the ice band test failed as well.)	Evacuate the detector as described in the HYPERION User Manual.
Vibrations	Ensure that there are no vibrating instruments near to the microscope and the spectrometer.
Beam path is blocked.	Check the beam path for obstructions (e.g. filter polarizer, sample) and remove it. Check whether a signal is detected. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.)

Possible Causes	Solutions
For the test channel with the ATR objective, the ATR crystal is damaged or dirty or misaligned.	To find out whether the ATR crystal is the cause of the problem, perform a photometric accuracy test (which is included in the OQ test). A failed photometric accuracy test is an indication that the ATR crystal is the cause of the problem. Damaged ATR crystal: Order a new ATR crystal and replace the damaged one. Dirty ATR crystal: Clean it using ethanol. Do not use other solvents that will make the adhesive-bonded crystal to come off! Misaligned ATR crystal: Align the ATR objective as described in the HYPERION User Manual.
For the test channel with the ATR objective, the signal intensity is too high (i.e. the amplitude value exceeds 32000 counts). This may be the case after an ATR crystal replacement due to the properties of the new crystal.	Check the signal. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.) If the amplitude value is above 32000 counts close the knife edge aperture to reduce the signal intensity.

Wavenumber accuracy test failed

Possible Causes	Solutions
Water vapor content inside the microscope is too high.	Purge the microscope. If your microscope cannot be purged, deactivate this test of the OQ test protocol.
After having replaced the laser, you have forgotten to calibrate the laser wavenumber.	Measure the laser wavenumber and repeat the test. Note: In case you can not purge your microscope to reduce the water vapor concentration and, consequently, not perform a successful LWN calibration, deactivate this test.
Laser performance has decreased or laser is defective.	(The laser is installed inside the spectrometer. To find out whether the laser is the cause of the failed X-axis frequency calibration test, perform the OQ/PQ test for the test channel of the spectrometer alone.) If the laser is the cause of the problem order a new one and replace it as described in the spectrometer user manual.

Possible Causes	Solutions
After having replaced an optical component (beamsplitter, source, detector, laser), you have forgotten to measure new reference spectra.	Measure new reference spectra as described in this Procedure Guide.

Photometric accuracy test[1] failed (only for HYPERION with ATR objective)

Possible Causes	Solutions
ATR crystal is damaged or dirty or misaligned.	Damaged ATR crystal: Order a new ATR crystal and replace the damaged one. Dirty ATR crystal: Clean it using ethanol. Do not use other solvents that will make the adhesive-bonded crystal to come off! Misaligned ATR crystal: Align the ATR objective as described in the HYPERION User Manual.
Signal intensity is too high (i.e. the amplitude value exceeds 32000 counts). This may be the case after an ATR crystal replacement due to the properties of the new crystal.	Check the signal. (For information about the signal check refer to the corresponding microscope preparation sections in this manual.) If the amplitude value is above 32000 counts close the knife edge aperture to reduce the signal intensity.
Nylon sample is dirty.	Clean it or, if required, order a new one.

1. This test verifies the absorbance accuracy.

WATER VAPOR SPECTRA

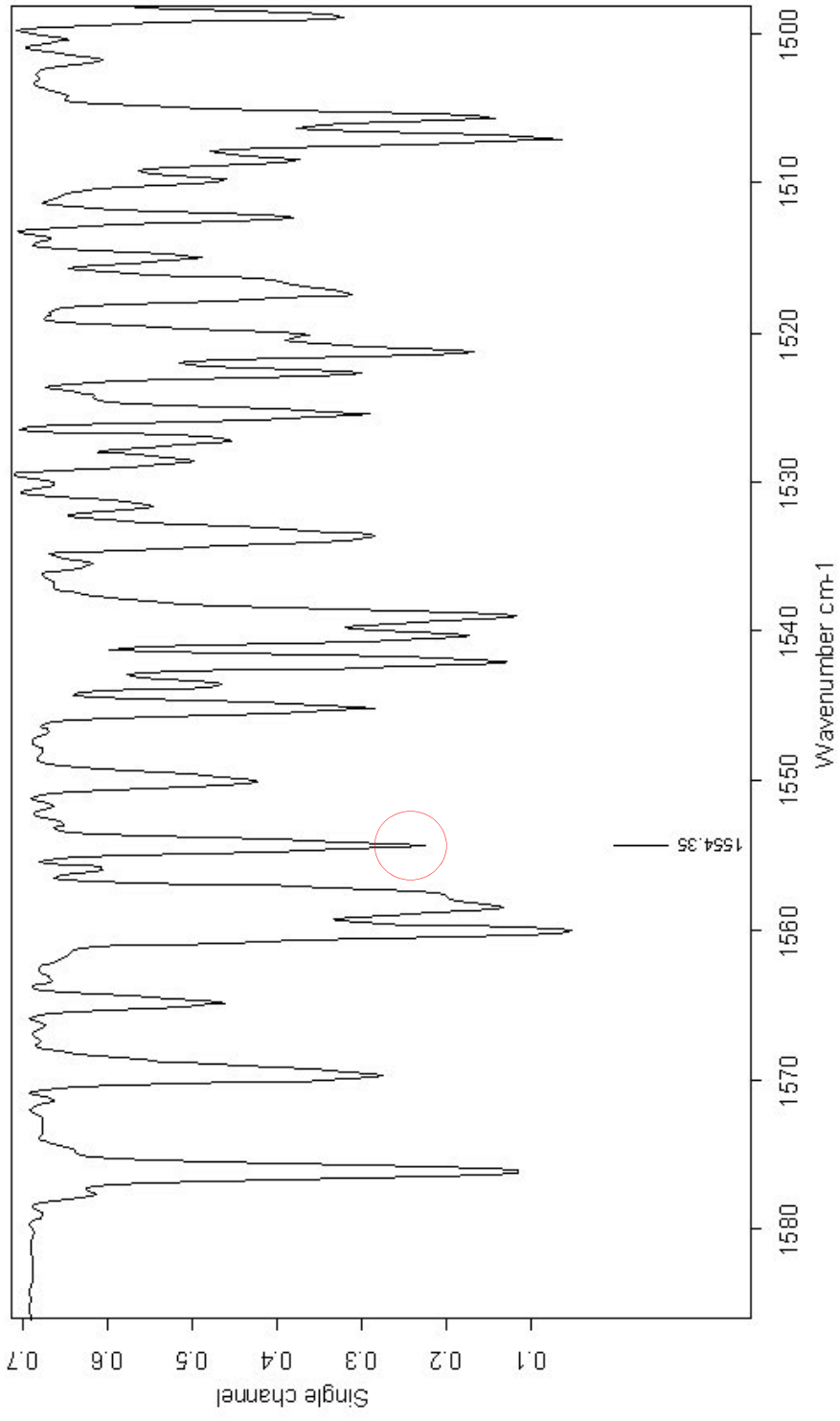


Figure 73: Water Vapor Spectrum is OK

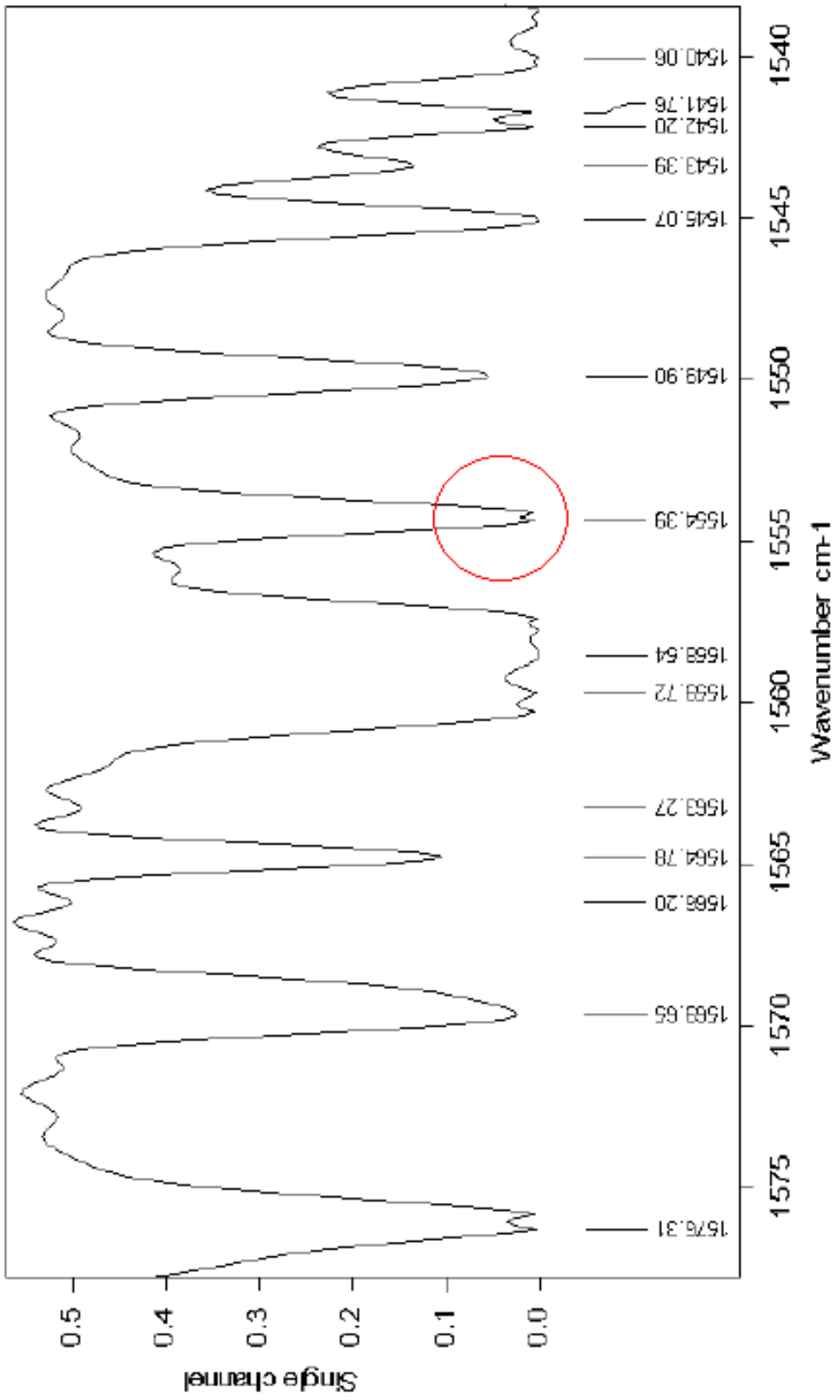


Figure 74: Water Vapor Spectrum is not OK

SERVICE ADDRESSES

B

Bruker Optik has an international network of branch offices and representations to ensure worldwide a competent customer service. Below the addresses of the Bruker headquarters are listed.

For a complete list with the addresses and telephone numbers of the Bruker branch offices and representations worldwide refer to the internet: **http://www. brukeroptics.com/contacts/worldwide.html**

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Bruker Optics Inc
19 Fortune Drive
Billerica, MA 01821
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Phone: +1-978-439-9899 (ext. 5227)
Fax: +1-978-663 9177
www.brukeroptics.com
info@brukeroptics.com

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Bruker Optik GmbH
Rudolf-Plank-Str. 27
76275 Ettlingen
Germany

Phone: +49 7243/504-619 / -600
Fax: +49 7243/504-698
www.brukeroptics.de
ir_service@brukeroptics.de

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Enterprise Square
No. 9, Sheung Yuet Road
Hong Kong

Phone: +852 2796 6100
Fax: +852 2796 6109
asiapacific@brukeroptics.com.hk

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