1. Introduction

This document will outline the scope, theory of operation and functional steps required for use of the portable x55 Performance Verification Application (x55 PVA).

1.1. Scope

This tool can be used to assess the wavelength accuracy, repeatability, channel power characteristics, and and operational state for all instruments within the x55 product family, including si155, si255 and si255 EV models.

1.2. Theory of operation and test artifacts

The x55 Performance Verification Application assesses a key subset of instrument performance relative to a set of standardized optical components, identical to those used in the factory calibration and characterization process. The application executes identical data collection, processing, and analysis steps as are conducted during a factory application and applies the results to appropriate field distributed pass/fail criteria. The PVA application requires that a specific assembly of optical characterization components are used. To make use of the x55 PVA, please contact Micron Optics to obtain an appropriate calibration artifact.

Three key areas of x55 performance are assessed using the the PVA. For a more complete description details regarding detailed specifications and test methodology, please see Section 8.3 of the Hyperion User Guide.

1.2.1. Wavelength Accuracy

Defined as “accuracy of measurement”, per NIST Technical Note 1297, 1994 Edition, Section D.1.1.1, the “closeness of the agreement between the result of a measurement and the value of the measurand.”

Accuracy is here reported as the standard uncertainty of the distribution of measurements made over the course several minutes, relative to the NIST Standard Reference Material 2519, as described in NIST Special Publication 260-137. Of the HCN lines characterized by NIST, those used in the qualification of MOI spectral interrogators are the 21 lines certified by NIST (or a subset thereof) with an expanded uncertainty (coverage factor k=2) of +/-0.0006nm.

To be consistent with the sensing and telecom industries’ expectation of low distribution and low systematic error of wavelength measurements, MOI enhances its definition of wavelength accuracy to a more stringent definition that includes a component of “systematic error”, defined in NIST Technical Note 1297, Section D.1.1.6. Here, “systematic error” is defined as the “mean that would result from an infinite number of the same measurand carried out under repeatability conditions minus the value of the measurand.” Here, again the measurand is NIST SRM 2519.

In total, the wavelength accuracy reported for MOI spectral interrogators is the absolute value of the “systematic error” plus the standard uncertainty of the “accuracy of measurement,” or $|\mu| + \sigma$ of the series of wavelength measurements made on the atomic absorption NIST Standard Reference Material 2517. In order to eliminate stability effects of peak detection which might influence the accuracy measurement, averaging of the spectrum prior to peak detection is performed.

For evaluation of wavelength accuracy, the x55 PVA Test artifact includes a sample of NIST SRM 2519, the port for which is labeled “GAS CELL”.

1.2.2. Repeatability

Defined as “Repeatability (of results of measurements)”, per NIST Technical Note 1297, Section D.1.1.2, the “closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement,” called “repeatability conditions.”

“Repeatability conditions” include using the same measurement procedure, the same observer, the same measuring instrument used under the same conditions (constant temperature), the same location, and repetition over a short period of time.

In the interest of making such measurements most applicable to the users of MOI products, the test artifact selected for the repeatability test is representative of a typical sensor which might be used, of bandwidth ~0.250 nm, high reflectivity.

Repeated measurements are made on the artifact by the EUT over the course of minutes, and the standard uncertainty (1 σ distribution) of the resulting measurements is reported as the Repeatability.

For evaluation of wavelength repeatability, the x55 PVA Test artifact includes a 16 FBG array, spanning a ~160nm range, the port for which is labeled “FBG ARRAY”.

1.2.3. Power uniformity

At the factory, the x55 interrogator goes through an extensive power calibration and uniformity verification procedure, which itself references traceable optical power meters. For field verification, the aforementioned reference FBG array is used to assess the received levels and relative consistency of optical power across all measurement channels.

1.2.4. Test artifacts

NOTE: the gas cell characteristics, FBG characteristics, and optical fiber path lengths for the x55 PVA test artifacts are managed to rigorous tolerances in order to ensure a consistent base of measurands from which verification measurements can reliably be made. Please do not attempt to execute the x55 PVA with any artifacts other than those supplied direction by Micron Optics for this purpose.

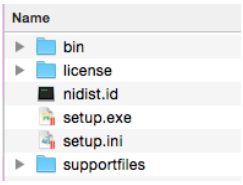
NOTE: it is imperitave that the connection made from the x55 unit under test (UUT) and the x55 PVA test artifact be made with a 1 meter long optical jumper. Any additional fiber length will add uncertainty to the absolute wavelength measurement and render the test non-functional.

Micron Optics can supply a certified test artifact containg both the SRM 2519 gas cell and the custom 16 FBG array. Please contact Micron optics for details.

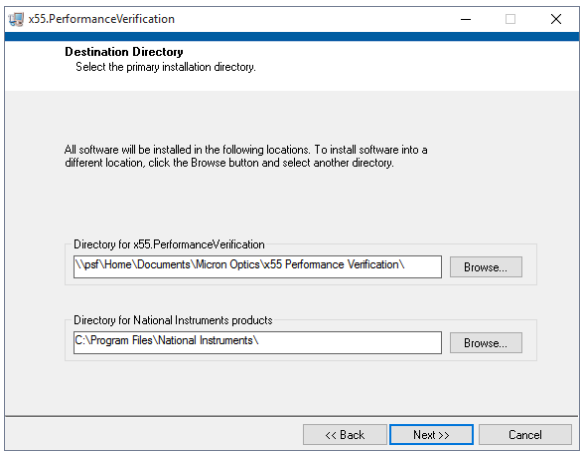
2. Software

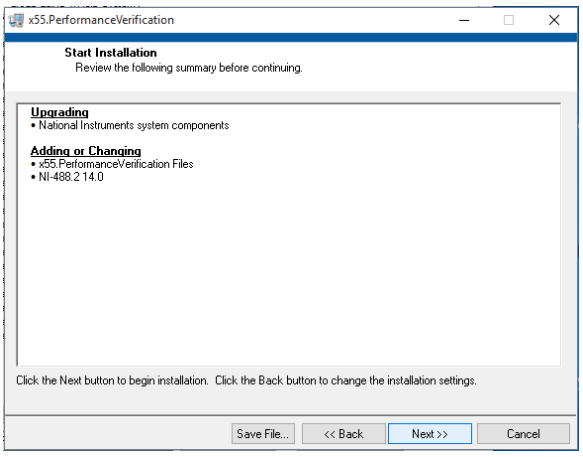
2.1. Installation

Installation of the x55 PVA begins by running the **setup.exe** file on your Windows computer.

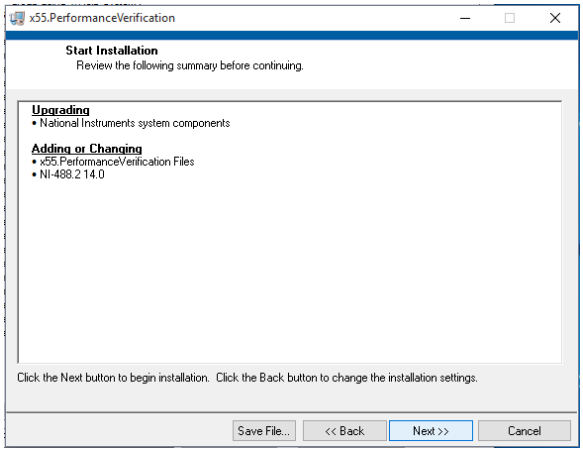


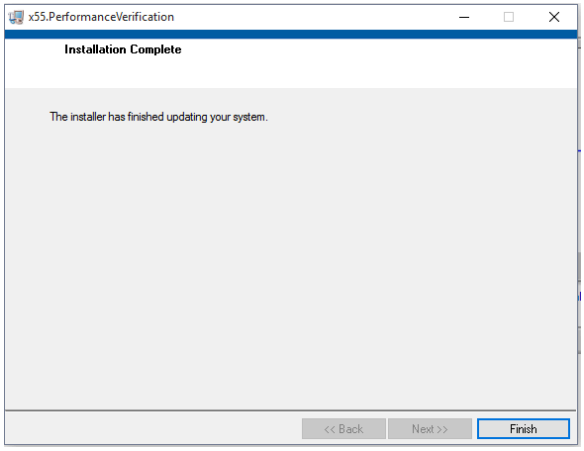
The installation process will prompt the user to choose a Destination Directory and give consent for installation.





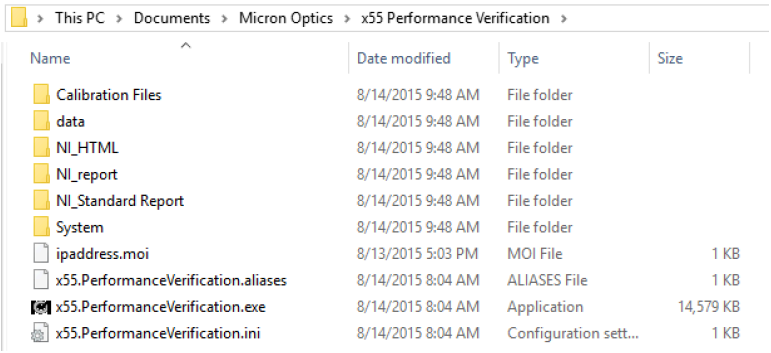
Once selected, installation will progress until complete.





After installation is complete, a shortcut is placed on the user's desktop for easy access.

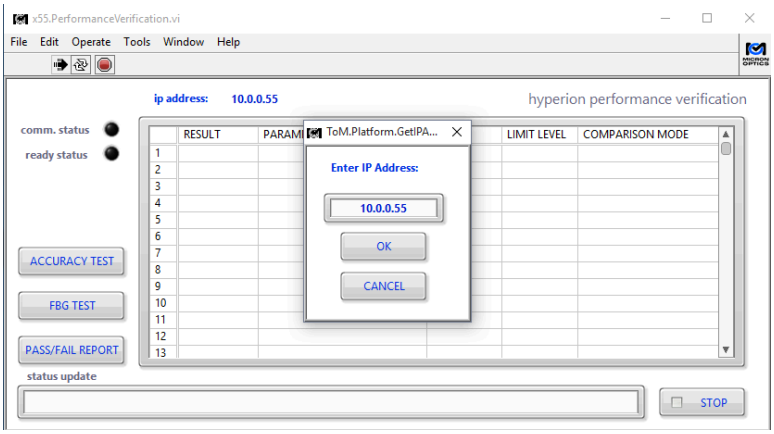
The x55 PVA application **x55.PerformanceVerification.exe** is installed in the following directory (Win7/Win10):



2.2. Execution

2.2.1. Connection

Upon launch, the PVA application will poll the user for the IP address of the target x55 UUT.

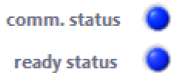


The user keys in the specific IP address of the target x55 UUT, as seen on the front panel mounted LCD screen.

As read on the UUT.

As entered into the PVA.

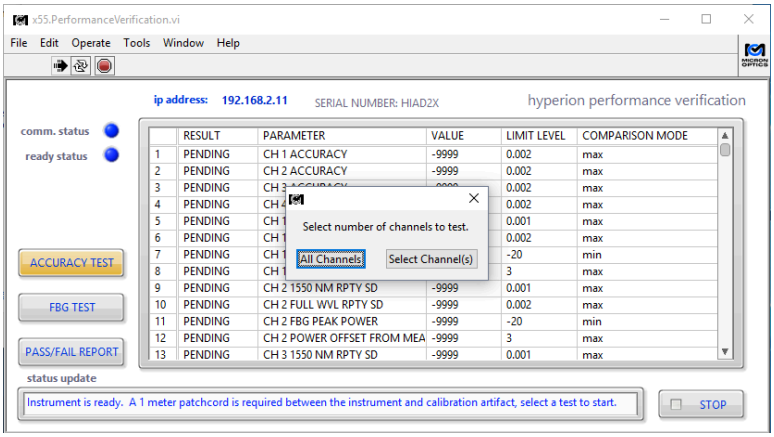
Once connected and ready, the PVA will indicate as such via the two blue status indicators on the top left of the UI.



2.2.2. Accuracy test

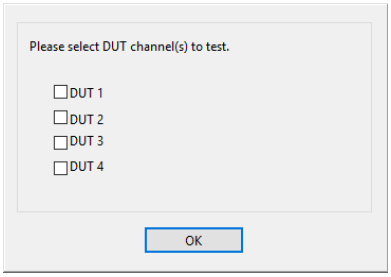
Testing executed in batches of desired test channels and grouped according to the required test element. The first test is accuracy, which will require use of the supplied NIST traceable HCN gas cell. The accuracy test makes comparisons between NIST published values for wavelength references lines of the gas cell reference and the measurements made on that same component by the UUT. The test results in a **CH X ACCURACY** measure for each tested channel.

To run the accuracy test, the user clicks on the **ACCURACY TEST** button, as seen below. The PVA will then prompt the user to choose which channels to test, either **All Channels**, which will cycle the test over the complete number of detected UUT channels, or **Select Channel(s)** which will offer the user a user a list of available channels from which to choose.



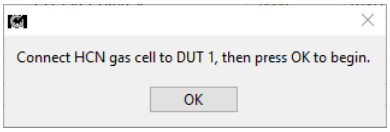
	RESULT	PARAMETER	VALUE	LIMIT LEVEL	COMPARISON MODE
1	PENDING	CH 1 ACCURACY	-9999	0.002	max
2	PENDING	CH 2 ACCURACY	-9999	0.002	max
3	PENDING	CH 3 ACCURACY	-9999	0.002	max
4	PENDING	CH 4 ACCURACY	-9999	0.002	max
5	PENDING	CH 1 1550 NM RPTY SD	-9999	0.001	max
6	PENDING	CH 1 FULL WVL RPTY SD	-9999	0.002	max
7	PENDING	CH 1 FBG PEAK POWER	-9999	-20	min
8	PENDING	CH 1 POWER OFFSET FROM MEA	-9999	3	max
9	PENDING	CH 2 1550 NM RPTY SD	-9999	0.001	max
10	PENDING	CH 2 FULL WVL RPTY SD	-9999	0.002	max
11	PENDING	CH 2 FBG PEAK POWER	-9999	-20	min
12	PENDING	CH 2 POWER OFFSET FROM MEA	-9999	3	max
13	PENDING	CH 3 1550 NM RPTY SD	-9999	0.001	max

ACCURACY TEST selected.



Select Channel(s) selection panel.

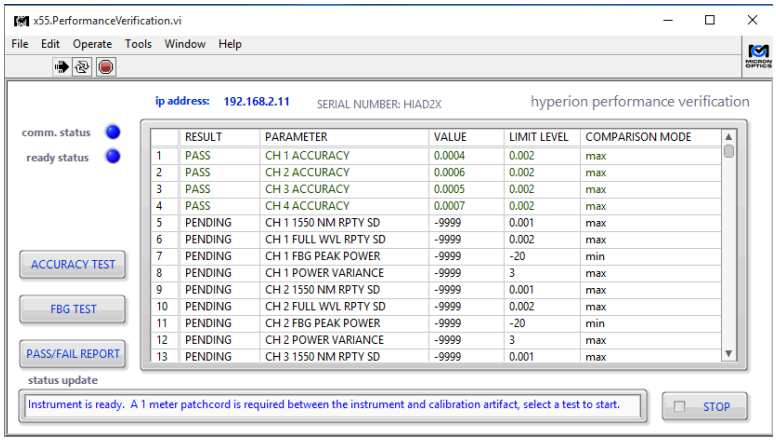
Once the desired channels are selected, the UI will instruct the user to connect the UUT to the GAS CELL channel and press OK to begin.



NOTE: Remember to always connect between the UUT and the PVA test artifact using a 1 meter jumper to maintain calibration accuracy.

Once connections are made and the user clicks OK, the PVA will begin measurements of the gas cell. Measurements are made sequentially on each of the selected channels, with the PVA requesting the user to switch fiber connections as appropriate. Gas cell measurements on each channel should take approximately 30 – 40 seconds.

Once the measurements for all selected tests are completed, the Results Summary panel will be update to reflect the results of the complete tests, the resulting value of the measurements, the limit level to which it was compared, and the applied mode of comparison.



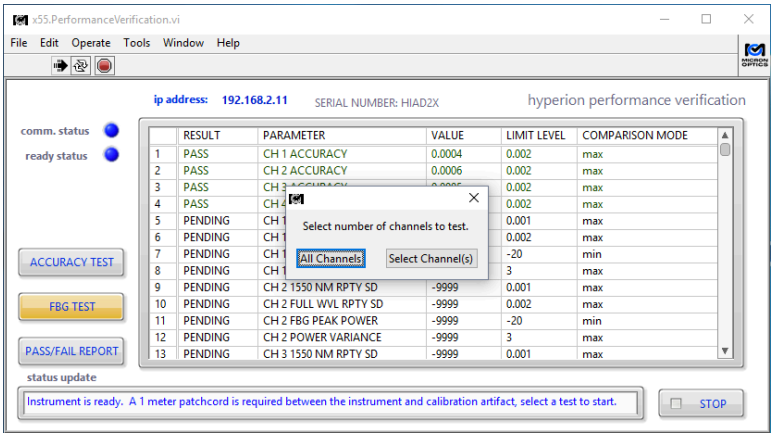
	RESULT	PARAMETER	VALUE	LIMIT LEVEL	COMPARISON MODE
1	PASS	CH 1 ACCURACY	0.0004	0.002	max
2	PASS	CH 2 ACCURACY	0.0006	0.002	max
3	PASS	CH 3 ACCURACY	0.0005	0.002	max
4	PASS	CH 4 ACCURACY	0.0007	0.002	max
5	PENDING	CH 1 1550 NM RPTY SD	-9999	0.001	max
6	PENDING	CH 1 FULL WVL RPTY SD	-9999	0.002	max
7	PENDING	CH 1 FBG PEAK POWER	-9999	-20	min
8	PENDING	CH 1 POWER VARIANCE	-9999	3	max
9	PENDING	CH 2 1550 NM RPTY SD	-9999	0.001	max
10	PENDING	CH 2 FULL WVL RPTY SD	-9999	0.002	max
11	PENDING	CH 2 FBG PEAK POWER	-9999	-20	min
12	PENDING	CH 2 POWER VARIANCE	-9999	3	max
13	PENDING	CH 3 1550 NM RPTY SD	-9999	0.001	max

An image of the PVA having generated Pass values for accuracy tests on channels 1 – 4.

2.2.3. FBG Test

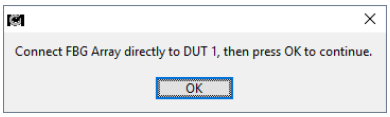
The second set of tests require use of the supplied 16 FBG array. The FBG Test suite evaluates the UUT on several key parameters. The first evaluation is the wavelength repeatability of the UUT on a single test FBG at ~1550nm. This test results in a **CH X 1550 NM RPTY SD** measure for each tested channel. The second evaluation is of the wavelength repeatability of the UUT across all of the measurable FBGs on the test array. This test results in a **CH X 1550 NM RPTY SD** measure for each tested channel. The third evaluation is of the maximum received peak power across all of the measurable FBGs on the test array. This test results in a **CH X FBG PEAK POWER** measure for each tested channel. The final assessment calculates the average peak power seen by all channels of UUT as attached to the 16 FBG array and assesses the **CH X POWER OFFSET FROM MEAN** for each tested channel.

The FBG test is executed in a manner nearly identical to that of the Accuracy test. The user will select the **FBG TEST** button, will be asked to choose among desired test channels,



	RESULT	PARAMETER	VALUE	LIMIT LEVEL	COMPARISON MODE
1	PASS	CH 1 ACCURACY	0.0004	0.002	max
2	PASS	CH 2 ACCURACY	0.0006	0.002	max
3	PASS	CH 3 ACCURACY		0.002	max
4	PASS	CH 4 ACCURACY		0.002	max
5	PENDING	CH 1 1550 NM RPTY SD		0.001	max
6	PENDING	CH 1 FULL WVL RPTY SD		0.002	max
7	PENDING	CH 1 FBG PEAK POWER		-20	min
8	PENDING	CH 1 POWER VARIANCE		3	max
9	PENDING	CH 2 1550 NM RPTY SD	-9999	0.001	max
10	PENDING	CH 2 FULL WVL RPTY SD	-9999	0.002	max
11	PENDING	CH 2 FBG PEAK POWER	-9999	-20	min
12	PENDING	CH 2 POWER VARIANCE	-9999	3	max
13	PENDING	CH 3 1550 NM RPTY SD	-9999	0.001	max

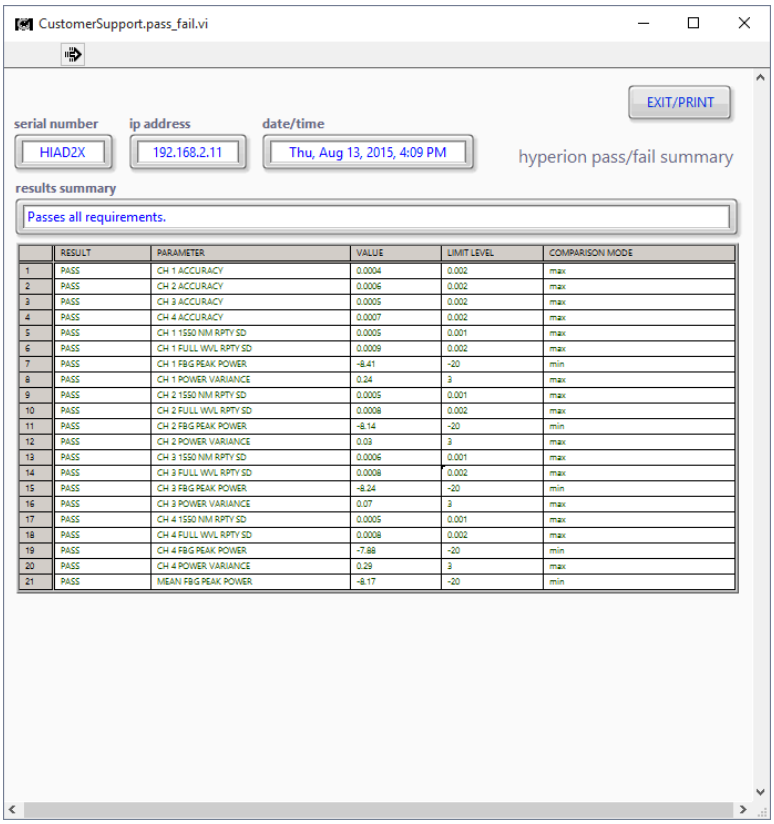
and will be prompted to make the proper connections to execute the test.



As with the gas cell Accuracy test, FBG measurements are made sequentially on each of the selected channels, with the PVA requesting the user to switch fiber connections as appropriate. All four FBG measurements taken on each channel should take approximately 30 – 40 seconds total per channel.

2.2.4. Viewing and printing summary report

Once all required tests are complete, the user can view and optionally print a complete summary report. This feature is accessed by pressing the **PASS/FAIL REPORT** button, on the left, towards the bottom of the UI. Doing so will present a formatted summary page like the following:



	RESULT	PARAMETER	VALUE	LIMIT LEVEL	COMPARISON MODE
1	PASS	CH 1 ACCURACY	0.0004	0.002	max
2	PASS	CH 2 ACCURACY	0.0006	0.002	max
3	PASS	CH 3 ACCURACY	0.0005	0.002	max
4	PASS	CH 4 ACCURACY	0.0007	0.002	max
5	PASS	CH 1 1550 NM RPTY SD	0.0005	0.001	max
6	PASS	CH 1 FULL WVL RPTY SD	0.0009	0.002	max
7	PASS	CH 1 FBG PEAK POWER	-8.41	-20	min
8	PASS	CH 1 POWER VARIANCE	0.24	3	max
9	PASS	CH 2 1550 NM RPTY SD	0.0005	0.001	max
10	PASS	CH 2 FULL WVL RPTY SD	0.0008	0.002	max
11	PASS	CH 2 FBG PEAK POWER	-8.14	-20	min
12	PASS	CH 2 POWER VARIANCE	0.03	3	max
13	PASS	CH 3 1550 NM RPTY SD	0.0006	0.001	max
14	PASS	CH 3 FULL WVL RPTY SD	0.0008	0.002	max
15	PASS	CH 3 FBG PEAK POWER	-8.24	-20	min
16	PASS	CH 3 POWER VARIANCE	0.07	3	max
17	PASS	CH 4 1550 NM RPTY SD	0.0005	0.001	max
18	PASS	CH 4 FULL WVL RPTY SD	0.0008	0.002	max
19	PASS	CH 4 FBG PEAK POWER	-7.88	-20	min
20	PASS	CH 4 POWER VARIANCE	0.29	3	max
21	PASS	MEAN FBG PEAK POWER	-8.17	-20	min

The number of reported results will scale with the number of channels on the UUT. After viewing the results, the user can exit by pressing the **EXIT/PRINT** button and will be offered the opportunity to print a hard copy before closing.