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15R Specular Reflectometer Frequently Asked Questions

Q: We are comparing second surface mirrors from different companies. For one of the mirrors the maximum reflectance reading is obtained with the source image significantly off center in the aperture as compared to the others.

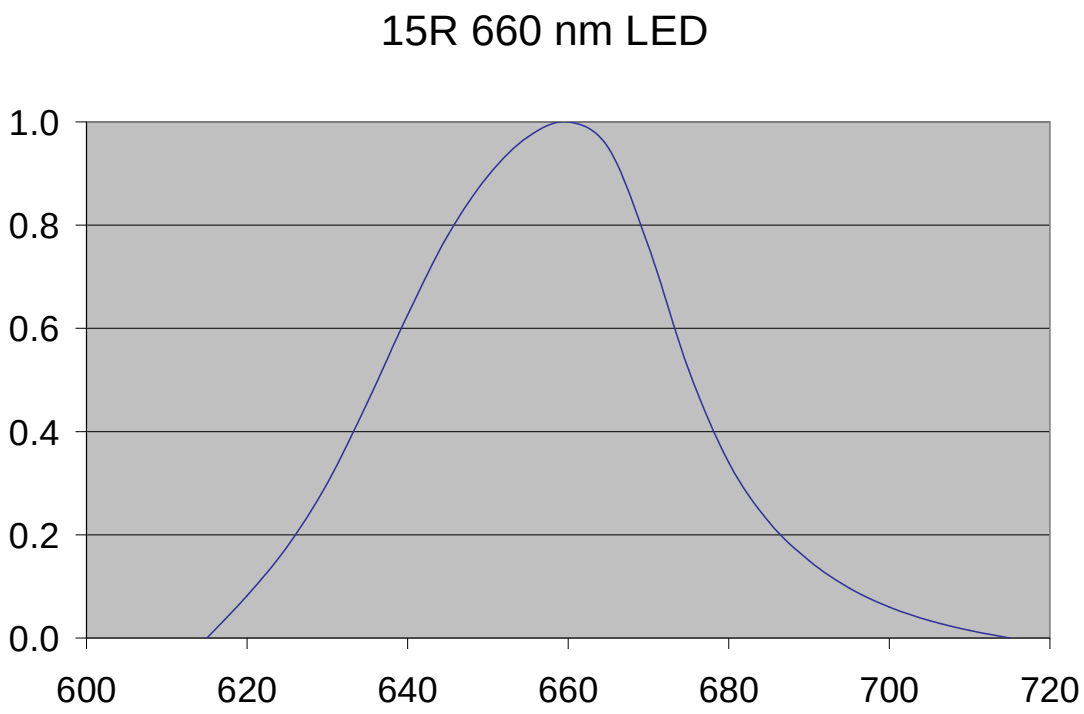
A: It could be that the front and back surfaces of the specific glass mirror are not perfectly parallel. That causes the secondary reflections from the mirror to emerge at a slightly different angle and create a ghost image at the aperture. Depending on the position of things and the aperture selection, the ghost image could be partially out of the aperture until the primary image is adjusted further toward the edge.

Q: After calibrating the 15R on the 15 mrad aperture we rotate the aperture wheel to the 7 mrad position and the reading drops dramatically. Is this a problem?

A: The calibration standard provided with the instrument was never intended to be used directly with the 7 mrad aperture. The instrument and the standard housing are not expected to be accurate enough to keep the reflected image of the source cleanly within the 7 mrad aperture. The best practice is to use an external reference mirror known to be highly specular and calibrate the reflectance of that mirror against the D&S supplied standard at say 25 mrad. It is then assumed that the external highly specular mirror should have the same reflectance at 7 mrad.

Q: What is the wavelength distribution for the red LED source?

A: The approximate wavelength distribution for the red LED is shown below. LEDs are selected for wavelength distribution to minimize differences from one instrument to the next.



Q: Am I right, that the incident angle of the LED source is 15°? The acceptance angle is the angle of the radiation reaching the Si cell detector (2.64, 1.43 or 0.84°)?

A: Yes, the incidence angle of the source is 15 degrees. And of course the reflection angle is also 15 degrees. The instrument accepts reflected energy in a small solid angle (cone) centered on the 15 degree reflectance angle. It is common practice to specify the acceptance angle as a plane angle (radians) rather than a solid angle (steradians). The standard 15R acceptance angles are 15, 25 and 46 mradians (full angle). So for the 25 mradian aperture the instrument will collect (approximately) any reflected energy that is within 12.5 mradians of the nominal 15 degree angle of reflectance.

Q: As I understand – the receiver aperture is selectable. By choosing the aperture number I change the aperture diameter. Looking at the original D&S schematic [operating instructions], the selectable apertures are located exactly on the intersection point. Is it correct to locate them a little bit higher?

A: The schematic shows a perfect point source but in fact the source is a small circular spot of light, 0.010 inches in diameter. The proper position of the receiving aperture is at the focal length of the lens where an image of the source is sharply focused. Ideally the source is very small compared to the size of the aperture so that any deviation of a light ray that just hits the edge of the aperture is divergent by exactly the specified half acceptance angle. Because the source is not infinitely small, the aperture edge clips light in a small range of divergence angles around the specified half angle.

Q: What is the minimum radius of curvature for a mirror that can be measured with the instrument?

A: The curvature of a mirror compared to the size of the source beam creates divergence of the reflected beam for the 15R reflectance measurement. If the divergence due to curvature is significantly less than the receiving aperture size then the measurement is mostly unchanged by the curvature of the mirror. So, the

amount of curvature allowed depends on the selection of the aperture, 15, 25 or 46 mrad (full angle).The radius of curvature of the mirror should be significantly larger (maybe 2x) than the numbers given below:

Aperture	Divergence half angle for->	radius of curvature
15 mrad	7.5 mrad	133.3 cm
25 mrad	12.5 mrad	80.0 cm
46 mrad	23 mrad	43.5 cm

Note that if it is required to measure a mirror with a smaller radius of curvature, an aperture can be installed in the source side optical path to reduce the beam diameter from 10 mm to 3 mm or even less. The divergence caused by mirror curvature scales directly with the diameter of the source beam.

Q: It seems that the adjustment of the central support leg for the thickness of a second surface mirror has almost no effect on the reflectance reading. Should this be the case?

A: On the central support screw that is adjusted for the thickness of a second surface mirror, it is correct that it should normally make little if any difference in the measurement. The reason for adjusting the central support screw is to ensure that the reflected light from the second surface follows the same optical path back through the optics as does the reflected beam from the reference standard mirror. For example, suppose that there was a speck of dust on the receiving lens or the port window and the reflected beam from the standard just misses the spec. Then when a second surface mirror is in position without adjusting the central support leg, the reflected beam is shifted slightly. If the slight shift causes the beam to hit the speck of dust then there is a small error in the calibration. In practice this seldom appears as a significant error.

Q: We understand that the standard mirror provided with the instrument should be as clean as possible. Is there a recommended procedure for cleaning the mirror?

A: The reference mirror should be cleaned when necessary, with a lens tissue and reagent grade isopropyl alcohol. The source and receiver lenses or the port window may need to be cleaned when the difference in readings for the reference standard between apertures 1 (15 mrad) and 3 (46 mrad) is greater than 1.2 percent. If the unit has a port window it is unlikely that the lenses need to be cleaned. Clean the outside surface of the port window by first removing as much dust as possible with dry air. Then dampen one end of a cotton swap or a lens tissue with reagent grade isopropyl alcohol and clean the window. If necessary, remove the outer shell to access the lenses. Use the same process to clean the lenses if required.

Q: Do you sell a spare reflectance standard so that proper calibration of the instrument can be verified?

A: Since the reflectance standard is custom aligned for a particular instrument we would have to have the instrument in hand to provide an extra reflectance standard. We have not supplied second reflectance standards for any instruments. It is recommended that the customer maintain a highly specular external mirror to track and verify the reflectance value of the supplied reference mirror. For example, the reflectance of an external reference mirror can be measured and recorded over time for the different apertures. This will provide a check on the stability of the supplied reference mirror as well as the alignment. In addition, the external reference mirror can be used as a backup reference in the event that the supplied reference mirror is lost or damaged.

Q: Should we follow any other maintenance procedures in order to maintain accuracy?

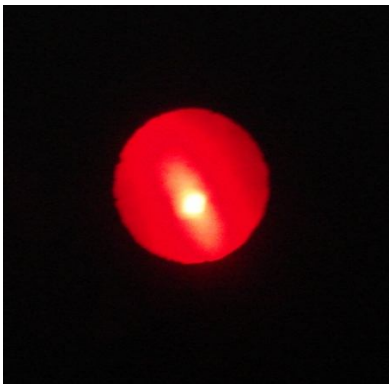
A: In addition to the reflectance standard remaining stable and clean, accuracy of the instrument depends on the alignment of the standard and the uniformity of response across the receiving aperture. Also the instrument optics (lenses and window if present) must be reasonably clean. You can check alignment of the reflectance standard, uniformity of the detector response and dust on the optics as outlined below.

Checking Alignment of the Reflectance Standard

To make a reflectance measurement it is necessary to adjust the alignment of the instrument so that the focused image of the source and the near specular scattered light passes completely (or most completely) through the receiving aperture. The reflectance standard for the instrument attaches to the base and is factory adjusted to a fixed orientation so that the reflected image should appear near the center of the aperture. For proper calibration of the instrument the alignment of the reflectance standard must remain accurate. There is a simple method of checking the alignment.

With the eyepiece that is available on the 15R reflectometer it is easy to verify that the reflected image from the standard mirror is passing cleanly through the aperture. The use the eyepiece, rotate the detector thumbwheel from the DET position to the OPTICS position. Just by viewing the image it is possible to see that the circular dot of light is not being clipped by the edge of the aperture. However, it is often not possible to see the circular aperture to ensure that the image is roughly centered. The LED source is bright enough so that all that can be seen is a bright dot on a black background. There is not enough scattering from the reflectance standard mirror to illuminate the area around the source dot so that the edge of the aperture is delineated.

In order to see the aperture edge, some scattering can be introduced by laying a small piece of lens tissue over the mirror.

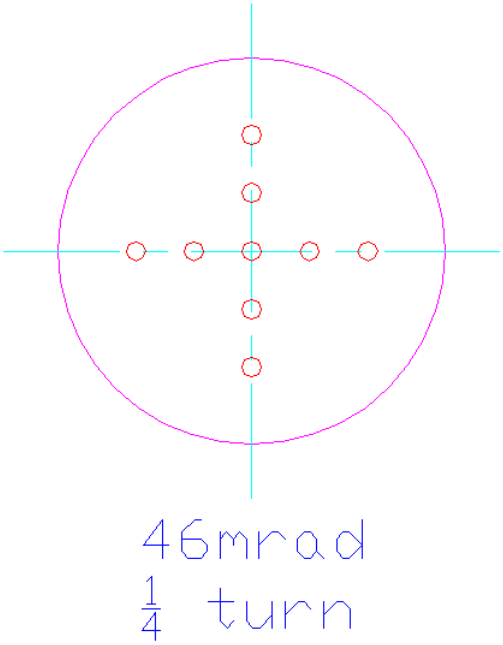


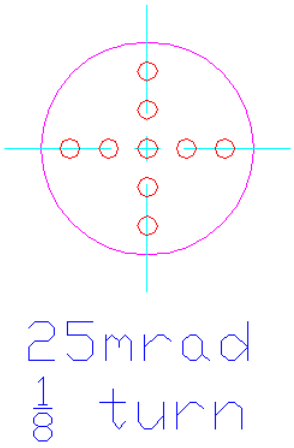
The tissue scatters light to provide illumination of the aperture edge and reduces the intensity of the source image. Note that the image of the source pinhole need not be perfectly centered in each aperture. Due to mechanical limitations the image will possibly be off center in each aperture and not off in the same direction.

Checking uniformity of detector response

For a highly specular mirror, the reflectance reading should be almost the same regardless of the position of the source image within the receiving aperture. The following test verifies the uniformity of the detector response. The reflectance value should vary by only a few counts with position.

First select the smallest aperture on the instrument which is typically 7 or 15 mrad. Adjust the instrument to read maximum reflectance on a sample of a highly specular mirror. Then select the largest aperture on the instrument which is usually 25 or 46 mrad. The reflected image should be close to the center of the receiving aperture. Record the “centered” reflectance value. Adjust one of the outer support legs as shown below and record the reflectance readings at two locations on either side of the “center” position. Return the first screw to the center position and repeat the procedure with the other outer support leg. The readings should all be within a few counts.





Checking for dust on the optics

The source and receiver lenses or the port window may need to be cleaned when the difference in readings for the reference standard (clean and free of dust) between apertures 1 (15 mrad) and 3 (46 mrad) is greater than 1.2 percent. Or, if the maximum aperture size on the instrument is 25 mrad, the agreement between the 15 mrad and 25 mrad aperture should be no greater than 0.5 percent. The comparison is made by calibrating on the larger aperture and then rotating the aperture wheel to the 15 mrad position without changing the gain. If the unit has a port window it is unlikely that the lenses need to be cleaned. Clean the outside surface of the port window by first removing as much dust as possible with dry air. Only if it is absolutely required to sufficiently clean the window, dampen one end of a cotton swap or a lens tissue with reagent grade isopropyl alcohol and clean the window. If necessary, remove the outer shell to access the lenses. Use the same process to clean the lenses if required.

Q: Is the instrument capable of working in a dusty environment?

A: The window at the measurement port of the instrument protects the interior from excessive dust accumulation. There will be some scattering of light in the optical path of the instrument caused by dust

including dust on the port window. A little dust however does not cause an error because the calibration accounts for the loss. If there is some light lost due to scattering it only requires that the gain be increased to compensate for the loss. That is, the calibration of the instrument to the correct reflectance value for the standard corrects for the loss due to scattering by dust in the optical path. Obviously it does not correct for dust on the reference mirror.

Q: How can I check that the little mirror is what it is supposed to be in reflectivity? Hypothetically I could scratch the mirror.

A: You should maintain one or more of your own external mirrors to verify that the reference mirror is reading correctly. Also you can periodically check alignment of the standard as described above.

Q: Also referring to the window where the reference standard goes. Should I clean it regularly?

A: As mentioned above, a small amount of dust on the window will not cause a problem. Try to clear the dust with dry air if needed. Avoid touching the window.

Q: The instrument has three apertures but the instructions say to calibrate to the same reflectance value. What is the application for the different apertures?

A: The choice of aperture depends on the application of the mirror being measured. For example a parabolic mirror might be measured with a larger aperture than a flat mirror for a central receiving tower application. For a central tower application the flat mirror must reflect light into a tighter acceptance angle for the light to be collected.

For the reference mirror, it is specular enough that the reflectance is very nearly the same for the 15, 25 and 46 mrad apertures. This has been confirmed by comparison against a highly specular first surface mirror. That is why the calibration value is the same for all three apertures. You will find that some mirrors (metallized films for example) have enough scattering that the reflectance values are not the same for all three apertures.

Q: It is written in the manual to use the second aperture for curved mirrors. So that is the aperture that I am using. I wonder what is the maximum degree of curvature that I can measure without moving the screw legs.

A: The curvature of a mirror compared to the size of the source beam creates divergence of the reflected beam for the 15R reflectance measurement. The amount of curvature that can be accommodated has been discussed above.

In reference to the comment “without moving the screw legs”, the recommended measurement procedure is to maximize the reading by adjusting the outer support legs. Therefore you would in theory always at least confirm that the maximum reading is obtained at each measurement point even when moving the instrument to a new location on a flat mirror. You would at least adjust both outer screws a little in either direction to make sure that the source image is not being clipped by the aperture. In practice we have had customers “lock” the support legs and make measurements without adjusting the legs. We have not received feedback on how well this approach works but we do now provide the locking hardware so that it

can be done easily. Using this approach the user could actually tilt the instrument slightly by hand to verify that the source image is not being clipped.

Q: What is the eyepiece for?

A: In the original design the eyepiece was included as a way to visually observe the effect of surface imperfections and curvature as well as to possible help find the source image if it is not initially partially within the aperture. As it turns out however the eyepiece is usually of no use finding the source image because there is not enough scattered light to see the aperture edges. Now the eyepiece is used primarily to align and check the alignment of the reflectance standard. The eyepiece is not used for routine reflectance measurements.

Q: How do I maximize the reading to get a reflectance value?

A:

1. Select the aperture.
2. Calibrate the instrument.
3. On the test surface, adjust the outer legs to first locate the reflected image within the aperture by watching the display.
4. Maximize the reading by adjusting the outer legs. This is the reflectance reading.
5. Moving the instrument to another spot or another test surface the outer legs should already be close and require very little adjustment.
6. Even if the reading on the new sport or test surface seems OK, adjust the outer legs to be sure the reading is maximized.
7. Recalibrate the instrument periodically.

Q: When do I use the battery disconnect switch?

A: The instrument draws a small amount of power from the batteries to retain any data that is stored. If this feature is not used, the disconnect switch can be turned off to save power. The switch should be turned off if the instrument will not be used for an extended period.

Q: How often do I need to replace the batteries?

A: The life of the NiCad batteries is affected by the charge and discharge cycle. For the longest life, it is best to fully charge the batteries each time and discharge them to 50 percent or less before recharging. Fully charged batteries should operate the instrument for 10 to 12 hours of continuous use.

NOTE: If the batteries are run down for some time after the low battery indication appears, the 15R-USB will automatically switch to the ‘off’ mode in order to retain stored data. In this state the unit may not come back on when the power switch is in the ‘on’ position until the battery is recharged. If it does not come back on after charging the batteries, try rebooting the electronics by disconnecting and then reconnecting the battery using the battery disconnect switch on the bottom of the instrument.

Q: Can I buy the NiCad batteries locally?

A: We special order the NiCad batteries for the 15R. The batteries are two separate stacks that are connected in series. The description of the NiCad battery stack is 3.6V/.750AH size 1/2C Cell. The

battery pack assembly instructions would need to be provided by D&S. This should only be attempted by a skilled technician.

Q: What is the accuracy of the 15R?

A: We do not specify accuracy of the 15R. We do specify repeatability to be +/-0.2 percent reflectance. That is, an identical measurement should be able to be repeated to within +/- 0.2 on the display.

Q: How often should I send my unit to the factory for recalibration?

A: We do not specify a recalibration frequency for the instrument and leave this to the customer to decide. Calibration frequency can be extended by maintaining one or more external mirrors to check against the supplied reference standard.

Q: When do I need to send my unit in for service other than when it has an obvious mechanical or operational issue?

A: Service is required when there is indication that the accuracy of the instrument is in question and the issue cannot be corrected. Refer to the answer above to the question concerning maintenance procedures to maintain accuracy. Service is required if:

1. The reference standard is clean and dust free but the reflectance no longer agrees with the customer supplied external mirror(s) used to track calibration.
2. The reference standard is out of alignment. Factory alignment is recommended.
3. The detector response varies by more than a few counts across the area of the largest aperture and the optics are reasonably dust free.