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INS250 INTEGRATING SPHERE

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1.0 INTRODUCTION

You have purchased an integrating sphere which has been designed to be very versatile as to its applications. The sphere size and port hole sizes where chosen to be large enough to accept most miniature lamps, up to and including most automotive bulbs. Three ports are made available to allow for a readout detector, the built in transfer standard lamp, and one for the users lamp or beam input port. The transfer device is included, since the calibration changes for every different port plug and even due to the absorption of the lamp envelope itself. This built in lamp permits an absolute calibration to be accomplished even with these variations.

You will notice there are rubber feet on three sides of the system. This is to facilitate the orientation of any of the input/output ports in a horizontal plane.

With the use of International Lights equipment is its ability to be programmed for direct reading. This is especially useful with an integrating sphere since it can offer the direct reading option for any of the applicable absolute calibrations. For example, the system can be calibrated to read out the mean spherical candle power of miniature lamps and/or light emitting diodes (LED) directly. This permits rapid quality control inspection. The two series of instruments specifically designed for this type of programming are the IL1700 and IL1400A series Radiometer/Photometers.

As you will notice they are located orthogonal (90 degrees) to each other to minimize interaction between a source and detector and also between a first “light bounce” and the detector. This concept is expanded upon in section 4.4.

2. PHYSICAL CONFIGURATION

2.1 Size and Weight - The cabinet forms a cube which is 36.5cm (14.4 inches) along each dimension which houses the sphere having an inside diameter of 25.4cm (10 inches) . The weight of the housing and sphere, including port adapters is approximately 4.8 kg (168 ounces)

2.2 Port Orientation - The system is supplied with three (3) standard input/output ports, located in one hemisphere. These ports are carefully positioned orthogonal to each other to minimize the possibility of light traveling directly from one port to the detector.

2.3 Inter port relationship - One might assume you could locate the three ports very close together to eliminate the possibility of direct exposure, but there is another condition to be met for proper optical measurements. In the case where a beam of light is being measured, the first bounce of the beam should not provide a direct input to the detector. In the case of lamp measurements which are located in the sphere, this is not a problem since the sphere is uniformly illuminated. Any "hot" spots, however, should not be in direct view of the detector. To meet these conditions, the ideal position is 90 degrees from each other which is the design condition of the IN5250. We have also designed the detector input cone to restrict the field of view to plus or minus 45 degrees, so as to prevent a direct view of the source. In addition to this there are two baffles placed between the detector and each of the other two ports (user and standard lamp). This requirement is especially needed for the total flux measurement from a lamp

2.4 Port Adapters - In order to complete the symmetry of the system, we have designed the adapters for each port to be the same. The lamp holder and detectors are also designed to have the same diameter (42 mm). This arrangement permits a fair sized hole for the user to use for large lamps or large beam diameters up to 37.6 millimeters. This generally will accommodate any application except for the case of a very large lamp or the situation where a "perfect" cosine acceptance angle was required. To enhance a port for "perfect" cosine acceptance, we can eliminate one port adapter and cover the port with a window as a custom modification. This would remove the cosine restrictions created by the sides of the port adapter .

2.5 Baffles - As mentioned before in paragraph 2.2, we provide a standard baffle mounted securely in the center position between the three ports. If your application requires a change of baffle, to prevent damage to the delicate white reflectance surface of the sphere, please contact international Light to have a custom baffle installed.. The purpose of the baffle is to prevent direct pickup of light from the lamp or from a wide angle source coming through the input port. The standard baffle has been designed with the assumption that the lamp will be a miniature type so that it will not project very far into the sphere. If this is not the case, a custom baffle can be constructed to block this direct path. It is necessary to know the exact nature (size) of the lamp to be measured since the geometry is quite complex for the design of a new baffle.

3. ELECTRICAL CONSIDERATIONS

3.1 Input Power - The standard wiring configuration is set up to accept 115 volts, 50—60 Hz input power. If we know in advance, the power supply inside can also be connected for 230 VAC, simply by changing two jumpers on the power transformer.

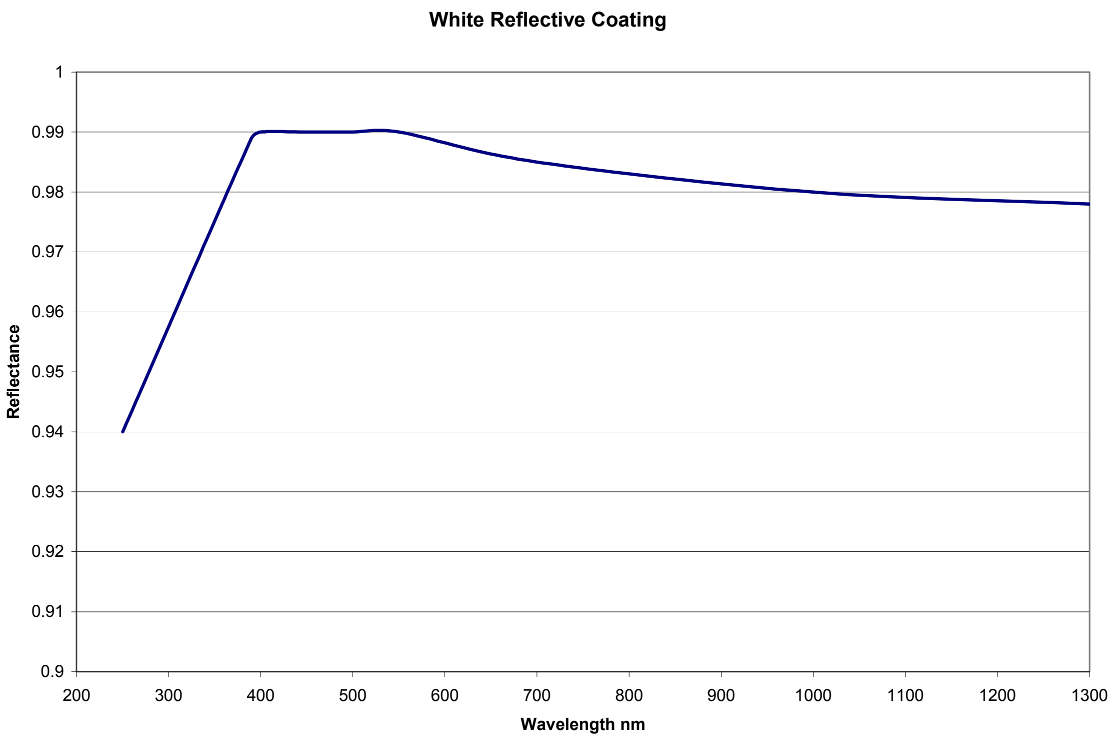
The source input power requirement is less than 10 watts, and if the internal power supply in not used to drive an extra load, the requirement drops to less than 3 watts.

3.2 Standard Source Power - Inside the integrating sphere cabinet is a 5 volt D.C. power supply which supplies 60 milliamps of current to the 300 milliwatt transfer standard lamp.

3.3 Available User Power - If the user has use for this available source of 5 volts, the power supply is capable of a total of 1.5 amps and must only deliver .06 amps to the internal lamp. This leaves more than one (1) amp available for a lamp to be tested. If LED's are to be tested, an appropriate current limiting resistor can be used to supply the proper bias current for this test lamp. Also if a brighter transfer lamp is desired, the 300 mw transfer lamp can be replaced with a higher power lamp up to 7 watts.

4. OPTICAL PROPERTIES

4.1 Sphere Coating- The sphere coating has been chosen for its optical reflectance over a broad spectral range, at the sacrifice of its adhesion quality. For this reason it should be handled with extreme care or not touched at all. Its reflectance through the visible is 98 percent and remains above 90 percent from 225 to 1300 nanometers (see spectral response curve)



Extreme care should be exercised to keep dirt out of the sphere, since a one percent change of reflectance can produce a five (5) percent change in throughput. This coating is the most expensive part of this product and has the most effect on stability and prolonged life of the system. For this reason every effort should be exercised to keep any foreign particles from falling inside. If the system gets a lot of use, it is recommended that the calibration be checked once a year or sooner (especially if the output of the internal transfer standard begins to show a different reading)

4.2 Standard Transfer, Lamp - This lamp is not meant to be a standard in its own right, but it has been selected to have a long life and can provide a good indication of the condition of the sphere. Its primary use is to transfer the sphere calibration, which usually has been performed with a blank plug in the user port, to the condition with either a different plug or holding adapter for a test lamp. When the test lamp is off but inserted into the sphere, it can change the original calibration of the sphere because of the introduction of the foreign body into the calibrated environment. By reading the transfer lamp before and after the conditions have been changed, a new calibration can be established (see section 6. for details)

4.3 Detector Input Cone - The INS250 does not come with a detector, but most applications will require one as well as an appropriate instrument to measure the signal from same. The IL1700 and IL1400A series instruments are especially well suited for this purpose since they can be programmed for direct readout of the final answer. In other words the sphere is calibrated together with the instrument, usually with a blank plug in the user port. The transfer standard lamp output is read under these same conditions so that the user port can be modified and still make it possible to get an absolute calibration (see section 6.)

To make the detector have the correct acceptance angle, we have a detector "CONE PLUG" which is mounted on the front of the detector to restrict the field of view to plus or minus 45 degrees, and .yet it improves the gain over the typical cosine diffuser that comes with most of the detectors. This field restriction is especially necessary when a beam measurement is being made. The beam from a source such as a laser will impinge on the opposite side of the sphere, which will make a "hot spot" at an angle about 45 degrees off axis. It is not desirable to let the detector see this first bounce. In most cases the laser can even be angled to further reduce this effect or the baffle could be repositioned to block the reflection path rather than the input port path.

4.4 Standard Lamp Location- The standard lamp is located on one of the port plugs, which again puts it off axis from the detectors field of view. The baffle is located so that the direct rays from the lamp will not be seen by the detector. This port plug can be removed to inspect the lamp as necessary.

4.5 Standard Lamp Output - This transfer lamp is chosen to have a low output in a range similar to that of small miniature lamps, and to be closer to the low level of irradiance typical from other sources of beam power. This proximity to the unknown magnitude reduces any chances of nonlinearities from creating unwanted errors. This is not to say that our detectors are non linear, in fact they are more linear than most methods of measurement, but it is a technical precaution to stay in the same "ball park". The lamp puts out all of its 300 milliwatts of input power in one form or another but only a little more than 10 milliwatts makes it into the visible spectrum. The visible magnitude is provided with the INS2SO, however a detector based measurement is considered a more stable reference to use for this calibration. The transfer standard lamps output is recorded as comparison reference to keep tabs on the changes in the performance of the entire system as elements are changed within the system.

4.6 User lamp-location— Other miniature lamps may be mounted in a similar fashion to that of the transfer standard lamp. The standard baffle provides proper blocking of direct radiation from getting to the detector, as long as the lamp is located close to the port plug. If it were a large lamp which projects considerably into the sphere, the direct path to the detector may not be properly blocked. In this case it would be necessary to redesign the baffle, or make a new one specifically for that application. An alternate design could be to make a holder to put the lamp in the center of the sphere, which is the best place from an optical standpoint since it does not create any “hot spots” along the wall of the sphere. In this case a baffle would have to be made to project up to the middle in order to block the direct path to the detector. We did not design the system that way because the extensive structure needed in the sphere offsets the advantage of being in the center. This long holder creates more of an absorbing surface which must be compensated for.

5. TYPICAL APPLICATIONS

5.1 Mean Spherical Intensity— To properly measure the total flux from a source, one must “catch” all the radiation regardless of the-emission direction. A sphere is the ideal choice for this application. Two of the standard intensity measurements would be the candela and the watts/steradian for photometric and radiometric applications. Also the flux measurements of lumens and watts are another variation. This is the best indication of total efficiency of a lamp, since it indicates its total ability to convert electrical power to optical flux.

To differentiate between beam intensity and isotropic intensity, the measurements have often been classified as beam candle power and mean spherical candela. If the output of the source may be used in all directions, then the MSC (using the INS250) measurement is a better indication of performance. On the other hand, if the output from the source is used in one direction, then beam intensity measurements would be more appropriate. These could be expressed in lumens per steradian (or watts/steradian) or beam candela in a given orientation.

5.2 Flux Measurements

5.2.1 Laser Measurements— Total flux measurements (as mentioned in 5.1) can be performed with the source located outside the sphere (directional sources) or inside (omni—directional sources). If your requirements are to determine the flux output from a source which is in the form of a beam, such as a laser or output from an optical system, the integration sphere makes a very nice receiving system since the large input port forms a uniformly sensitive detector- with a large receiving - diameter (37.6mm). - In the case of laser applications the final absolute answers are in optical power (watts/square centimeter)

5.2.2 Wide Beam Flux Measurements— Wide beam sources are also very accurately measured simply by catching all the light in the input port. For diverging beams, it is necessary to be close enough to insure that the outer edges of the beam diameter are still smaller than the input port diameter. The uniform sensitivity of the port properly measures the total flux entering the hole. In addition the sphere acts as an attenuator and provides a uniform signal to the detector. Large solid angles can be accommodated. In fact one steradian of flux can be measured by establishing the source at 34.7 millimeters distance away from the user port. This makes it very easy to make beam candela (lumen/steradian) measurements, since you would be measuring with a solid angle of one steradian. The receiving cone for other solid angles can also be measured with a great deal of accuracy, since the distances are large and uncertainties are minimized. If the distance-to the input port is large with respect to the port diameter (37.6mm), then the calculation reduces approximately to the area of the input port (11.10 sq. cm.), divided by the distance squared. In other words if you were 10 centimeters away from the rim of the port, you would divide 11.10 by 10 squared and get the solid angle to be .111 steradians.

If the sphere is calibrated to read optical watts, it is easy to measure irradiance since the input port is 11.10 square centimeters; therefore by dividing the number of watts measures by the input area gives the irradiance in watts per square centimeter. If it is calibrated in lumens, then by dividing by the input area in square feet (11.95e—3), we will get the number of lumens per square foot which is equal to foot candles.

5.3 Diffuse Source (Radiance/Luminance) — In order to calibrate a luminance (brightness) meter, it is necessary to have a uniform diffuse source of luminance. Such a source is difficult to generate while maintaining both the properties of uniformity across the surface and still have a diffuse Lambertian spatial emission pattern. An integrating sphere is ideal for solving both requirements. The internal transfer standard lamp will produce a low level luminance source; however a brighter source could be used if this was to be one of the primary applications. We can provide a luminance calibration and special lamp installation if this is a requirement.

5.4 Cosine Receiver—Not only does the input port of an integrating sphere have a uniform sensitivity across the face of the hole, it also provides a very good spatial sensitivity to match the Lambertain response (cosine). In the design of the INS250 we had to include the input port adapters which obstruct the light at wide angles, thus altering, the cosine response to oblique angles. If this is an important application, we can manufacture the system without a port adapter, and can install a window for environmental protection. Contact the factory for these custom modifications.

5.5 Flat Response Attenuator— The special White Reflectance coating has a very flat spectral response, which makes it perform as an excellent attenuator from the UV through to the infrared part of the spectrum (see Fig 1). Ultraviolet light is especially difficult to measure and still maintain detection, having a cosine response. This is one of the strong features of the INS250.

6. USING THE TRANSFER STANDARD LAMP

The 300 mill watt transfer standard lamp has been included in the INS250 to eliminate some of the small errors produced by variations in the configuration of the sphere as it is used to perform different jobs. For example when the sphere is calibrated, the user port will have a plug which is painted to match the inside of the sphere. When it is used to measure a laser beam, the plug will be removed which changes the calibration of the sphere. The transfer lamp allows the user to transfer the calibration with the plug inserted, to one without the plug. This is done by making a measurement of the transfer lamp with the plug in position. Next, this number is dialed into the IL1700 or IL1400A series instrument (as the sensitivity factor). The readout should now read the factory calibrated sensitivity factor that was originally dialed in. The plug is removed and the lamp is again read. This new readout is the corrected sensitivity factor for the sphere without the plug. This is then entered (programmed) in as the new calibration factor and the system is now ready to read the incoming flux accurately in the new configuration. In some applications, it might be necessary to make a special holding fixture for lamp measurements. These fixtures will often absorb radiation and change the sphere calibration. By using this same method, it is possible to transfer the calibration for each and every new fixture, and still maintain accurate measurements. People often forget that the lamp under test can change the sphere calibration. The lamp base itself may absorb a great deal of light since it is a different configuration from that which was present in the original calibration. In this case the transfer compensates not only for the new lamp holder, but also for the lamp itself. The transfer is done with the new test lamp off but installed in position ready for the measurement. As indicated above, a transfer is performed to get a new calibration sensitivity factor, which is used when the new test lamp is now turned on.

7. MAINTENANCE

The most vulnerable part of the INS250 is the White Reflectance Paint. Any foreign vapors or particles can change its reflection quality and thereby change the calibration of the system. For this reason, it is extremely important to keep the unused ports closed with a port plug, detector, or some type of tape to prevent dust from getting inside. Since there are no moving parts, and since the white paint cannot be cleaned, there really aren't any maintainable parts. The sphere paint would need to be recoated by returning it to the factory.