

Gas Reference Cells Overview

Optical Systems

Free Space Isolators

E-O Devices

Spherical Singlets

Multi-Element Lenses

Cylindrical Lenses

Aspheric Lenses

Mirrors

Diffusers & Lens Arrays

Windows

Prisms

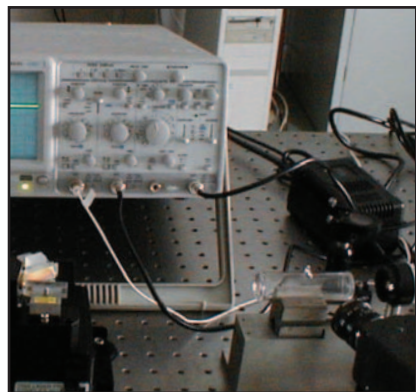
Gratings

Polarization Optics

Beamsplitters

Filters & Attenuators

Gas Cells



Applications:

- Tunable Laser Calibration
- Stabilized Frequency Source
- OSA Calibration
- Gas Analyzer Calibration
- Calibration of Wavelength Meter
- Frequency Standards

Gas reference cells, hereafter referred to as reference cells, are often used in applications where the wavelength of light needs to be accurately determined. Although spectrometers and optical spectrum analyzers are built specifically for this purpose, both need to be accurately calibrated in order to yield accurate absolute wavelength measurements. A reference cell consists of a cylindrical container (cell) containing a high purity molecular compound or atomic element. During the manufacturing of the reference cell, the temperature and pressure inside the cell are precisely regulated since these factors affect the reference cell performance.

A reference cell can serve as an absolute wavelength calibration source because the reference cell will only absorb light at wavelengths that correspond to the allowed transitions between energy levels of the material inside the reference cell. For the materials offered in the reference

cells sold by Thorlabs, the absorption lines (wavelengths of light that are absorbed) are well known. The absolute wavelength of the absorption lines can be found in peer reviewed journals and in some cases online at www.nist.gov. In order to reproduce the absorption lines reported by these sources, the temperature and contents of the reference cell need to be identical to the cell used in the reported measurement since changes in temperature, pressure, and material can cause shifts and/or broadening of the absorption lines.

Reference Cell Contents

The alkali atoms are located in the first column of the periodic table. Thorlabs offers alkali reference cells that contain sodium, potassium, rubidium, and cesium. In alkali atom reference cells, the bulk of the material in the cell will be coalesced in a solid or liquid form on the cell walls. However, since the cell was sealed with vacuum conditions inside the cell, alkali vapor will be present. The atomic vapor will absorb light with wavelengths corresponding to the allowed transitions between the energy levels of the atoms. When the reference cell is at room temperature, the light absorbed will be principally due to transitions between the ground state and excited electronic states of the atom. A reference cell that contains an alkali atom source is sometimes referred to as a vapor reference cell.

Additional vapor reference cells offered by Thorlabs include cells with water or iodine as the source material. The iodine vapor forms the diatomic molecule I_2 . Water and iodine absorb light corresponding to transitions between rotational and/or vibrational energy levels in the molecule.

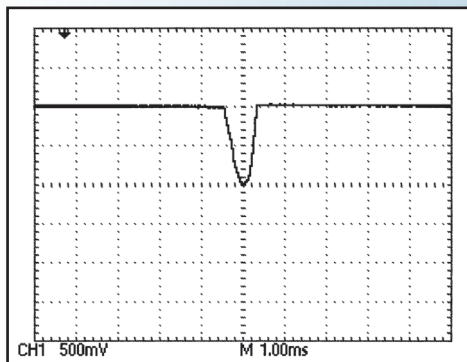
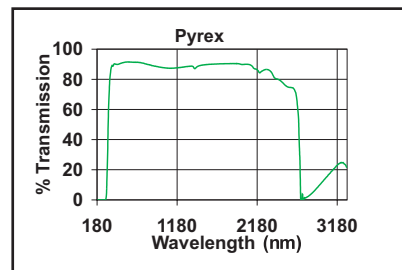
In addition to vapor reference cells, cells that contain molecules that exist in the gaseous state at room temperature are

available. When these reference cells are loaded with the molecular gas and sealed, the pressure and temperature are precisely controlled so that it is possible to reproduce the conditions, and as a result, the location of the absorption lines reported in literature. The molecular gas reference cells sold by Thorlabs include acetylene, hydrogen cyanide, carbon monoxide, carbon dioxide, nitrogen dioxide, methane, ethane, and ethylene. Each gas has a unique set of absorption lines corresponding to allowed transitions between rotational and vibrational energy levels.

Due to the number of absorption lines in the NIR region of the electromagnetic spectrum, molecular gas reference cells make excellent calibration sources for light sources and test equipment used in the Telecom industry. The National Institute of Standards and Technology (NIST) have created wavelength reference standards for the Telecom industry based on Standard Reference Materials (SRM): 2515 (carbon monoxide), 2517a (acetylene), and 2519 (hydrogen cyanide).

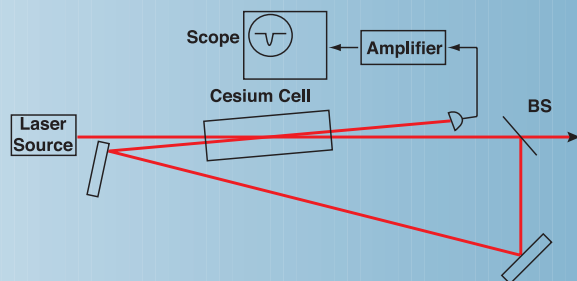
Reference Cell Containers

Thorlabs' reference cells are made from either Pyrex or quartz. Pyrex is an inexpensive material with good optical transmission characteristics. Between 350 and 2400nm, the transmission of Pyrex is over 92% as can be seen on the plot below. Pyrex is also durable in that it is less susceptible to breaking or chipping than quartz. Due to its chemical stability,



Cesium Absorption Lines at 852nm

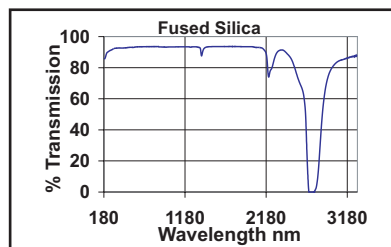
Typical saturated absorption experiment using a cesium reference cell that yields a plot of the Doppler-free Cs absorption line at 852nm.



Gas Reference Cells Overview... (cont)

Pyrex is suitable for holding K, Na, Cs, and Rb. The standard sized Pyrex cell is 25mm in diameter and 75mm in length. Quartz is a more expensive material with excellent optical characteristics. The cell is composed of a cylindrical quartz tube with UV fused silica (synthetic fused quartz) windows on each end. The optical transmission plot for the UV fused silica can be seen to the right. Notice that the transmission range extends much farther into the UV than it does for Pyrex. In addition, the UV grade fused silica windows have an optical flatness of $\lambda/4$ for minimal wavefront distortion of the light passing through the cell. Quartz has

a low coefficient of thermal expansion that makes it resilient to thermal shock. The thermal properties as well as the welded



construction of the quartz cell make it suitable for high-temperature applications (up to 850°C). The quartz cells are

constructed with windows that have a 2° wedge. In addition, the window is also mounted at an angle with respect to the length of the cell to minimize saturation and interference effects due to surface reflections. The angled surfaces prevent the surface reflection from retracing the same optical path as the incident light. Except for potassium and sodium, all other materials are available in a quartz reference cell.

Pyrex Reference Cells



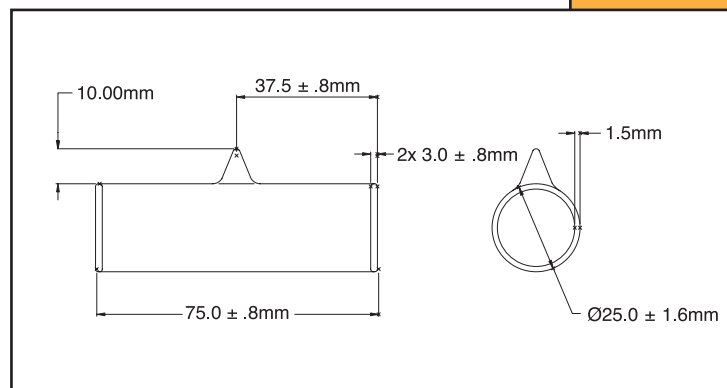
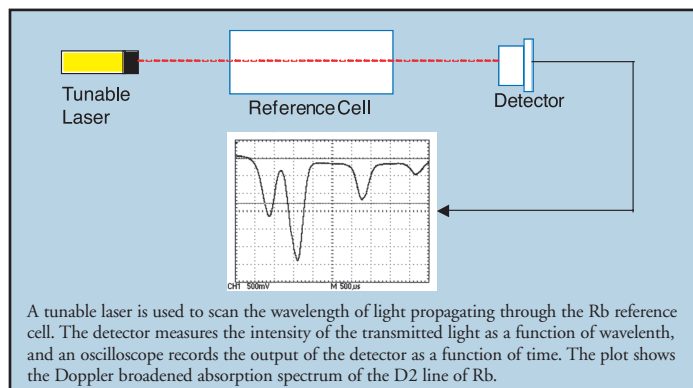
The quality Pyrex reference cells offered by Thorlabs have optical quality Schott Borofloat windows and are tested to ensure that the transmission of off resonant light through the reference cell exceeds 84%. The transmission loss is primarily due to surface reflections from the windows. The content of the reference cell is also tested by measuring the absorption spectra of a well known transition using a tunable diode laser. The following transitions are used for each reference cell: 764nm for potassium, 589nm for sodium, 780nm for rubidium, and 852nm for cesium.

The standard reference cells are evacuated before the fill material is added and the cell is sealed so that the fill material is the only material inside the cell. However, the reference cells can be ordered with the fill material and a buffer gas at a specified pressure. The noble gases as well as nitrogen are commonly used as buffer gases. The presence of a buffer gas will cause the central wavelength of the absorption lines to shift and the width of the absorption lines to broaden.

Specifications

- **Window Material:** Schott Borofloat Glass
- **Cell Diameter:** 25mm
- **Fill Stem:** <10mm
- **Window Angle:** 0°
- **Window Type:** Flat
- **Window Thickness:** 3mm

Email tech support at techsupport@thorlabs.com for custom reference cells.



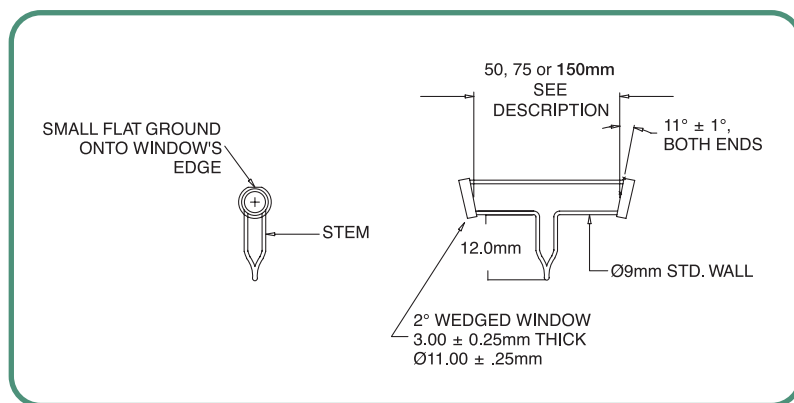
ITEM #	\$	£	€	RMB	PRESSURE	DESCRIPTION
CP25075-RB	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	>1x10 ⁻⁷ Torr	Ref. Cell, Pyrex Ø25 x 75mm, Rubidium (Rb)
CP25075-CS	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	>1x10 ⁻⁷ Torr	Ref. Cell, Pyrex Ø25 x 75mm, Cesium (Cs)
CP25075-K	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	>1x10 ⁻⁷ Torr	Ref. Cell, Pyrex Ø25 x 75mm, Potassium (K)
CP25075-NA	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	>1x10 ⁻⁷ Torr	Ref. Cell, Pyrex Ø25 x 75mm, Sodium (Na)

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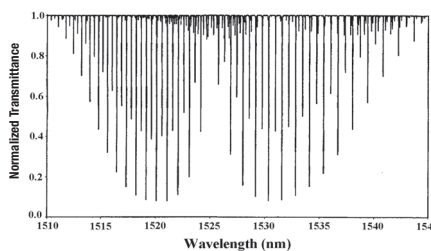
Molecular Gas Cells

The complex absorption line spectrum of the molecular gases offered by Thorlabs make them excellent fill materials for reference cells used to calibrate the absolute wavelength of light over a range of wavelengths from 0.5-10 μ m. The multitude of absorption lines is a result of the large number of allowed transition between the various rotational and vibrational energy levels.

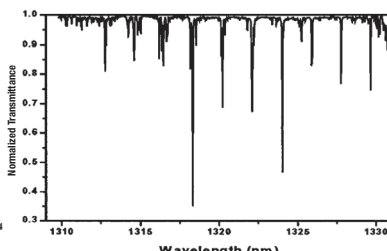
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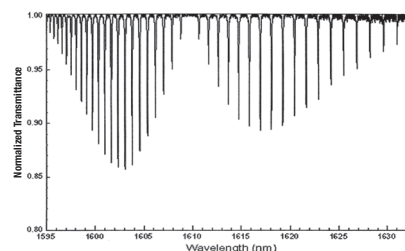
Custom molecular gas reference cells are available by request. For example, reference cells can be created with a mixture of gases at different pressures to create a calibration source with absorption lines in more than one spectral region. A plot is shown below of the absorption spectrum of a cell that contains a mixture of acetylene and methane gas. This cell has absorption lines from 1510-1545nm due to acetylene as well as absorption lines from 1630-1670nm due to methane. Other common gas mixtures used include HCN and carbon monoxide (¹²C¹⁶O), or HCN and carbon monoxide (¹³C¹⁶O).



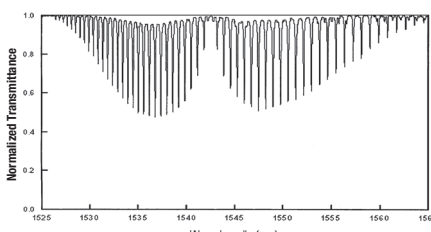
Acetylene Isotope 13 Absorption



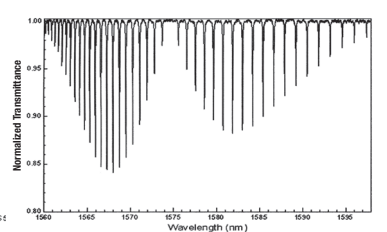
Spectrum Methane Absorption Spectrum



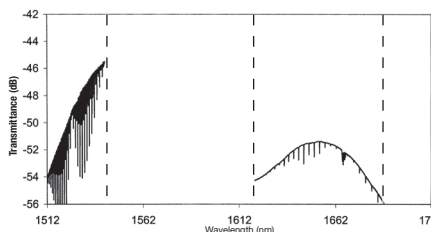
Carbon Monoxide Isotope 13 Absorption Spectrum



HCN Absorption Spectrum



Carbon Monoxide Isotope 12 Absorption Spectrum



Methane-Acetylene Mixture Absorption Spectrum

ITEM #	\$	£	€	RMB	PRESSURE	DESCRIPTION
CQ09050-CH12	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	50Torr	Ref. Cell, Quartz Ø9 x 50mm, Acetylene (¹² C ₂ H ₂)
CQ09050-CH13	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	50Torr	Ref. Cell, Quartz Ø9 x 50mm, Acetylene (¹³ C ₂ H ₂)
CQ09075-HCN13	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	100Torr	Ref. Cell, Quartz Ø9 x 75mm, Hydrogen Cyanide (H ¹³ C ¹⁴ N)
CQ09150-CO12	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	600Torr	Ref. Cell, Quartz Ø9 x 150mm, Carbon Monoxide (¹² C ¹⁶ O)
CQ09150-CO13	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	600Torr	Ref. Cell, Quartz Ø9 x 150mm, Carbon Monoxide (¹³ C ¹⁶ O)
CQ09150-CO2	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	200Torr	Ref. Cell, Quartz Ø9 x 150mm, Carbon Dioxide (CO ₂)
CQ09150-NO2	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	400Torr	Ref. Cell, Quartz Ø9 x 150mm, Nitrogen Dioxide (NO ₂)
CQ09075-CH4	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	200Torr	Ref. Cell, Quartz Ø9 x 75mm, Methane (CH ₄)
CQ09075-C2H6	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	200Torr	Ref. Cell, Quartz Ø9 x 75mm, Ethane (C ₂ H ₆)
CQ09075-C2H4	\$ 434.50	£ 273.70	€ 404,10	¥ 4,149.50	200Torr	Ref. Cell, Quartz Ø9 x 75mm, Ethylene (C ₂ H ₄)

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