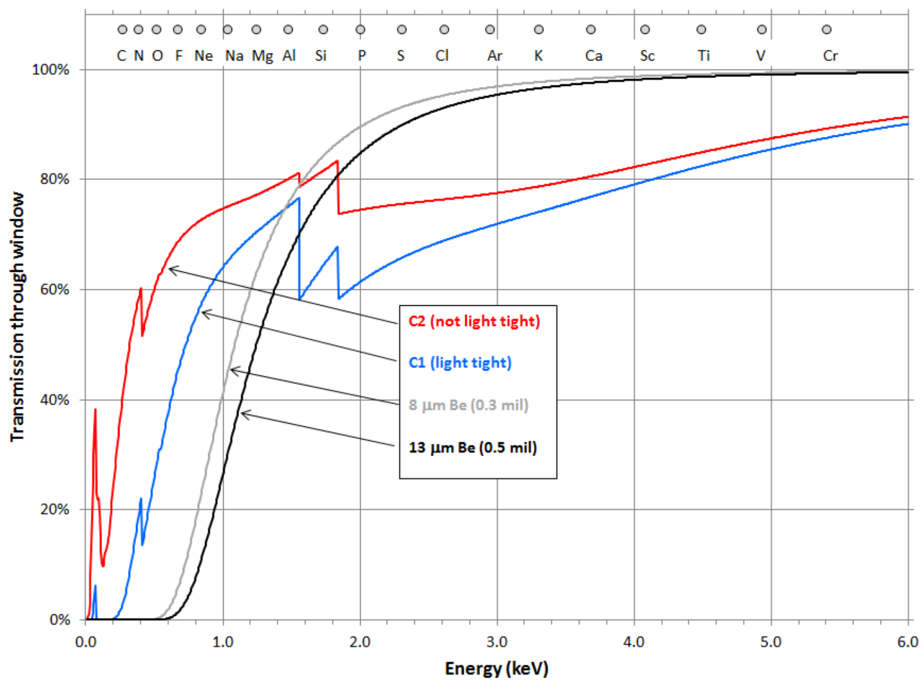
Amptek C-Series Windows Frequently Asked Questions

What are the advantages of the C series windows?

The C series windows offer less attenuation (higher intrinsic efficiency) than the standard Be windows for X-ray energies below 1.5 keV (elements with K lines lower than Al or L lines below Zn). The C windows are about a factor of 2 more efficient for Na K_α X-rays (1.04 keV) than the thinnest Be windows (8 μm). With Be windows, it is virtually impossible to measure elements below Na in the periodic table, and even Na and Mg are marginal. The C windows make it practical to measure light elements, down to Li.

One should measure in vacuum to take full advantage of the C series windows. Attenuation in air can be more important than attenuation in the windows for low energies. For Na K_α X-rays, the attenuation length in air is only 2.2 mm; an air path of 2.2 mm will attenuate these X-rays as much as a Be window. This not only reduces the sensitivity at Na, but path length variations become very important: an additional 0.2 mm of air changes the Na K_α intensity by 10%, making accurate analysis difficult. Even changes in atmospheric pressure can make a measurable difference in attenuation.



Are there any disadvantages to the C series windows?

Above 1.5 keV, the C series windows offer slightly more attenuation (lower efficiency) than the Be windows. For X-rays above 6 keV, the efficiency for the two window types is nearly identical.

The C series windows are made from silicon nitride and are coated with aluminum. The characteristic X-rays of Al, Si, and N will all be observed in the spectrum. All Amptek detectors contain aluminum (e.g. the multilayer collimator is coated with aluminum) so its characteristic X-rays are always present. The Si interference can be a disadvantage in some applications.

The C2 windows are not light tight. They are intended for use only in a dark system. Operating a C2 detector in light will not damage the detector but the photocurrent through the detector will make it impossible to detect X-rays. The C1 windows can be operated in normal ambient light.

Are the C series windows strong enough to hold vacuum?

Yes, the C series windows will hold vacuum. The detector hybrid has a vacuum inside, so the C series windows usually hold 1 atmosphere of pressure. Use in a vacuum chamber, the pressure across the window is actually reduced. These detector will withstand thousands of cycles of pumping and then returning to atmospheric pressure.

Are the C series windows more fragile than Be? Must one handle them more carefully?

One cannot touch the C series with any material and one cannot clean these windows. Any attempt to clean them will destroy them. Any contact will destroy them.

One must be very careful when using these detectors in vacuum systems. They are not damaged by the change of pressure during pumping or venting, but during the change of pressure, tiny particles (usually from debris) can be accelerated to very high velocity; if these strike the C windows, the windows will break. The vent must be designed to prevent high velocity air streaming into the chamber. Make sure there is no direct, straight line path from the vent to the window. A membrane or sintered metal filter can be used to limit vent speed. A narrow collimator in front of the detector will restrict damaging particles.

They are not more fragile during normal handling and installation. But they are more susceptible to breakage by small dust and debris particles and by contact with any materials.

Can the C series windows be used in helium (He) purged environments?

The standard C series windows should not be used in helium (they will leak helium). Amptek offers special, helium tight windows as an upgrade.

Can the C series windows be used for high energies as well as low energies?

Yes, the C series windows are find for high energies. Above roughly 6 keV, they offer essentially the same sensitivity as Be windows.

For what applications do you recommend the C series windows?

The C1 windows are very well suited to the EDXRF of samples containing Mg, Na, and heavier elements, particularly when a dark environment is not possible. They have been used in practice to measure down to the C K_α line (278 eV).

The idea application for the C2 windows is SEM-EDS, i.e. the excitation of characteristic X-rays by electrons in an SEM. Because these electrons have a short range in the sample, they excite the X-rays very close to the surface, yielding many X-rays from elements down to Li. The high efficiencies of these windows at the low energies makes these detectors very useful. Amptek's latest generation of FastSDDs offers a very thin dead layer, making it practical to detect characteristic X-rays down to the Li K_α line.

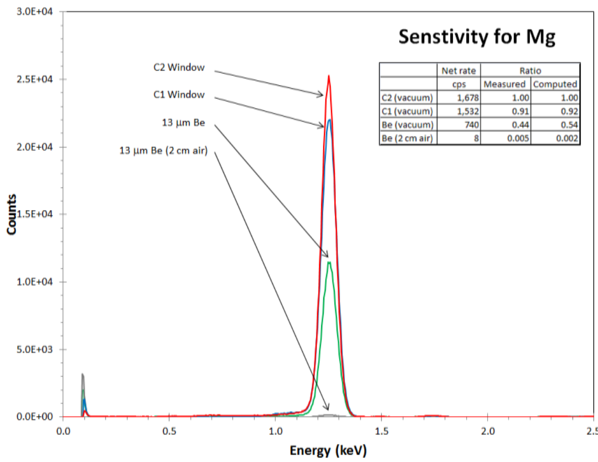
The C2 windows can certainly be used for EDXRF from light elements, i.e. measuring characteristic X-rays produced by X-ray excitation. But the X-ray yield for light elements is low and their attenuation length in most samples is low. A powerful, low energy X-ray source and a short air path is required for EDXRF of light elements.

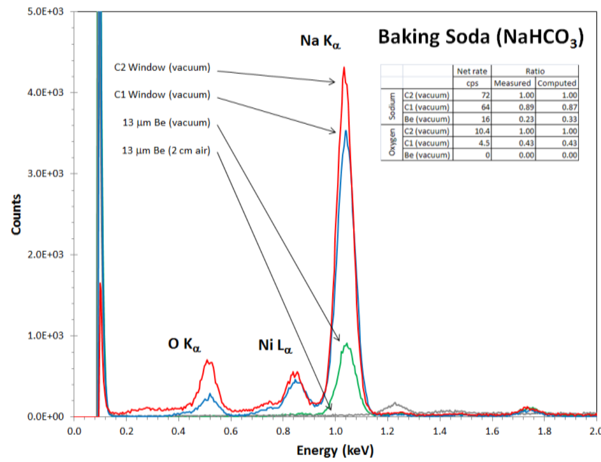
How accurate are the published attenuation curves?

These curves represent nominal material parameters and normal incidence. Manufacturing variations will occur, so some variation in transmission is expected. In many applications, the beam of incident X-rays may not be at normal incidence. Even more commonly, a range of angles are incident on the window, causing the mean path length to be longer, hence greater attenuation will occur. It is best practice to calibrate each system with known standards.

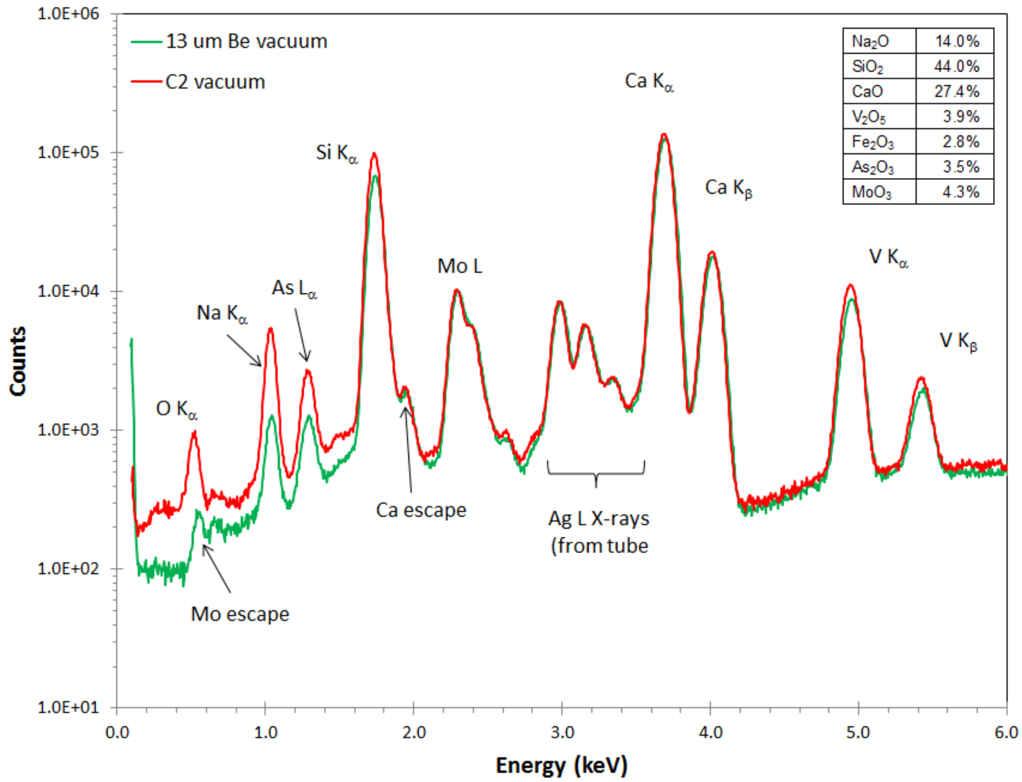
Do you have spectra from real samples illustrating these differences?

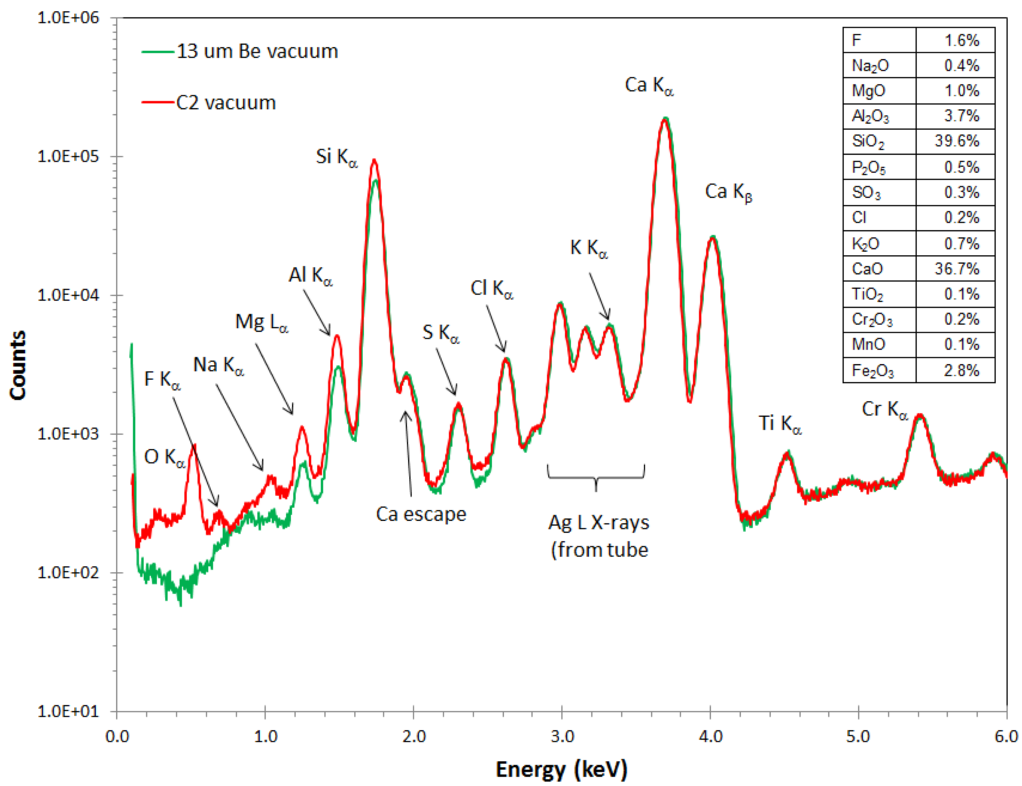
The plots below show spectra measured by an Amptek 25 mm2 SDD with a C1 window, a C2 window, and a 13 mm (1/2 mil) Be window in vacuum. The samples were 99% pure Mg (left) and backing soda ($NaHCO_3$) right. The tables compare the measured ratio of photopeak count rates with that calculated from the nominal attenuation curves. The increase in efficiency for the C windows is clear and in good agreement with published values. Also shown in a spectrum measured with the same Be window in air, with a 2 cm path length. Note that air attenuation is much more important than attenuation in the Be window.





The two figures below show spectra measured with an Amptek 25mm2 SDD with C2 and Be windows, in vacuum. These are glass XRF drift monitors, FLX-SP1 (top) and FLX-C2 (bottom), from Fluxana. The samples were excited by an Amptek Mini-X X-ray tube with an Ag anode at 8 kVp. The SiO2 and CaO peaks are very clear in the glass. The increased efficiency of the C2 window below 2 keV is clear in both plots, as is the clear separation and identification of the low energy peaks. Note the O K_α peak visible in both C2 spectra. The glass samples are approximately 50% oxygen by atomic concentration, you the intensity of the O K_α lines is only 10 cps. This shows clearly the challenge involved in doing EDXRF on light elements. An electron beam is a far more efficiency source for measuring light elements.


13 um Be vacuum
C2 vacuum
Na_2O 14.0%
SiO_2 44.0%
CaO 27.4%
V_2O_5 3.9%
Fe_2O_3 2.8%
As_2O_3 3.5%
MoO_3 4.3%
Ca K_α
Si K_α
Ca K_β
Mo L
V K_α
As L_α
Na K_α
V K_β
O K_α
Ca escape
Ag L X-rays (from tube
Mo escape
Counts
Energy (keV)
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
0.0
1.0
2.0
3.0
4.0
5.0
6.0


13 um Be vacuum
C2 vacuum
F 1.6%
Na_2O 0.4%
MgO 1.0%
Al_2O_3 3.7%
SiO_2 39.6%
P_2O_5 0.5%
SO_3 0.3%
Cl 0.2%
K_2O 0.7%
CaO 36.7%
TiO_2 0.1%
Cr_2O_3 0.2%
MnO 0.1%
Fe_2O_3 2.8%
Ca K_α
Si K_α
Ca K_β
K K_α
Al K_α
Cl K_α
Mg L_α
S K_α
Na K_α
F K_α
O K_α
Ti K_α
Cr K_α
Ca escape
Ag L X-rays (from tube
Counts
Energy (keV)
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
0.0
1.0
2.0
3.0
4.0
5.0
6.0