

AA Hollow Cathode Lamps — Recommended Operating Conditions

Single Element, Multi-Element and Continuum Lamps

Operation

A number of factors affect successful lamp operation. These relate to lamp warm-up time, lamp intensity and the isolation of the preferred analytical line. Each hollow cathode lamp is different in these respects. For example, the warm-up characteristics, line intensity and spectral isolation for arsenic are quite different to those for copper or iron.

Warm-up

Particularly with a single-beam instrument, it is important to allow at least ten minutes of lamp warm-up before attempting an analytical measurement. Some elements, or lamps that use higher operating currents, may require longer times. This time will allow the lamp to reach a relatively stable output. With double-beam operation, the warm-up period is not observable. Nevertheless, it is wise to allow for warm-up before attempting any analytical measurements.

Intensity

Each analytical line from a hollow cathode lamp has a characteristic intensity that relates to the observable signal-to-noise level of the atomic absorption instrument. The greater the intensity of the analytical line, the lower the noise level. Such differences in the measured noise level between different lamps are quite normal.

Fill Gas

All lamps are filled with neon gas for freedom from interfering lines at the most sensitive wavelengths, except the Cs and Al/Ca/Mg lamps, which are filled with argon and the D₂ lamp, which is filled with deuterium.

Single Element Lamps

Element	Coded Part Number	Uncoded Part Number	Window Material	Current (mA)		Wavelengths (nm)	Recommended Slit (nm)	Relative Sensitivity	Relative Intensity
				Rec.	Max.				
Ag Silver	5610105200	5610127200	Pyrex	4	10	328.1 338.3 309.3	0.5 0.5 0.5	1 2 1	100 90 80
Al Aluminium	5610100100	5610122000	Fused silica	10	15	396.2 (Z) 237.3 257.4 256.8	0.5 0.5 0.5 0.5	2 5 11 17	100 3 5 3
As Arsenic	5610100300	5610122200	Fused silica	10	12	193.7 197.2 189.0 242.8	0.5 1.0 1.0 1.0	1 2 0.5 1	50 100 54 60
Au Gold	5610102100	5610124000	Fused silica	4	10	267.6 249.8 208.9	1.0 0.2 0.2	2 1 2	100 100 40
B Boron	5610100700	5610122600	Fused silica	20	20	208.9 553.6 350.1	0.2 0.5 0.5	2 1 600	40 100 20
Ba Barium	5610100400	5610122300	Pyrex	20	20	234.9 223.1	1.0 0.2	1 1	100 15
Be Beryllium	5610100500	5610122400	Fused silica	5	15	223.1 306.8	0.2 0.5	1 4	15 100
Bi Bismuth	5610100600	5610122500	Fused silica	5	10	227.7 422.7 239.9	0.5 0.5 0.2	1 1 200	15 100 10
Ca Calcium	5610101000	5610122900	Fused silica	10	10	228.8 326.1 240.7	0.5 0.5 0.2	1 400 1	40 100 20
Cd* Cadmium	5610100800	5610122700	Fused silica	4	10	242.5 (Z) 304.4 346.6	0.2 0.5 0.2	2 15 40	90 40 100
Co Cobalt	5610101300	5610123200	Fused silica	7	15	357.9 429.0 520.8	0.2 0.5 0.2	1 7 200	40 100 20
Cr Chromium	5610101200	5610123100	Pyrex	7	15	520.8 520.5 852.1	0.2 0.2 1.0	200 500 1	20 15 50
Cs Cesium	N/A	5610122800	Pyrex	20	20	455.5 324.8	0.5 0.5	5 1	100 100
Cu Copper	5610101400	5610123300	Fused silica	4	10	327.4 (Z) 217.9 218.2 222.6	0.5 0.2 0.2 0.2	2 8 10 40	50 3 2 5
Eu Europium	N/A	5610123600	Pyrex	10	20	244.2 459.4 333.4	1.0 1.0 0.5	270 1 300	15 100 10
Fe Iron	5610102700	5610124600	Fused silica	5	15	248.3 372.0 386.0	0.2 0.2 0.2	1 10 15	15 100 50
Ga Gallium	N/A	5610123800	Fused silica	4	15	294.4 287.4 272.0	0.5 0.5 0.5	1 1 30	100 60 10
Gd Gadolinium	N/A	5610123700	Pyrex	20	20	368.4 405.8	0.2 0.2	1 1.5	60 100
Ge Germanium	N/A	5610123900	Fused silica	5	10	265.2 269.1 303.9	1.0 0.5 0.5	1 5 20	100 15 50
Hf Hafnium	5610102200	5610124100	Fused silica	10	15	307.3 368.2 253.7	0.2 0.5 0.5	1 6 1	15 100 100
Hg Mercury	5610103400	5610125300	Fused silica	4	8	303.9 271.0	0.5 0.2	1 20	100 5
In Indium	N/A	5610124400	Fused silica	5	10	208.9 264.0 (Z)	0.5 0.2	1 3	100 100
Ir Iridium	5610102600	5610124500	Fused silica	10	10	265.5 254.4 766.5	0.2 0.2 1.0	4 5 1	80 50 100
K Potassium	5610104200	5610126200	Pyrex	5	10	769.9 404.4 550.1	1.0 0.5 0.2	2 400 1	80 5 50
La Lanthanum	N/A	5610124700	Pyrex	20	20	403.7 357.4 670.8	0.5 0.5 1.0	3 6 1	90 100 100
Li Lithium	5610103000	5610124900	Pyrex	5	10	323.3 610.4	0.2 0.5	400 7000	0.2 5
Mg Magnesium	5610103200	5610125100	Fused silica	4	10	285.2 202.6	0.5 1.0	1 30	100 3
Mn Manganese	5610103300	5610125200	Fused silica	5	15	279.5 403.1 321.7	0.2 0.2 0.2	1 12 3000	90 100 3

(Z) Recommended wavelength for Zeeman AA

* These lamps contain Cd above 0.1% by weight. As with all hollow cathode lamps, handle with care and dispose of properly following local regulations.

The Table

This table lists operating conditions for each analytical wavelength, under the following headings:

- Window Material — Pyrex for those elements with absorbing wavelengths above 300 nm. Fused silica when wavelengths below 300 nm are required.
- Recommended Current — provides an adequate intensity. Higher currents will always reduce the working life of the lamp and for some elements will produce a reduction in absorption signal.
- Maximum Current — to prevent permanent lamp damage, never exceed this value.
- Wavelengths — the wavelengths indicated are those most commonly used in atomic absorption.
- Recommended Slit — the recommended spectral bandpass at each wavelength for the recommended current. Where there is an adjacent line, a smaller slit may provide a more sensitive and linear calibration, but a higher noise level is likely. Conversely, a larger slit will reduce noise, but a less sensitive calibration with greater curvature may be obtained.
- Relative Sensitivity — of alternate wavelengths is an approximate indication of the reduction in absorbance signal that may be expected relative to the most sensitive line. The most sensitive wavelength is assigned a value of 1. Alternative wavelengths are used to avoid sample dilution when the element is present in high concentrations.
- Relative Intensity — an indication of the lamp signal intensity at each wavelength using the recommended current and slit. The most intense wavelength is assigned a value of 100.

Element	Coded Part Number	Uncoded Part Number	Window Material	Current (mA)		Wavelengths (nm)	Recommended Slit (nm)	Relative Sensitivity	Relative Intensity
				Rec.	Max.				
Mo Molybdenum	5610103500	5610125400	Fused silica	7	15	313.3 320.9 589.0	0.5 0.2 0.5	1 15 1	100 10 100
Na Sodium	5610105300	5610127300	Pyrex	5	10	589.6 (Z) 330.3 334.9	0.5 0.5 0.2	2 500 1	60 2 10
Nb Niobium	5610103800	5610125700	Pyrex	20	20	358.0 408.0 405.9	0.5 0.5 0.5	1 1 1	50 70 100
Nd Neodymium	5610103600	5610125500	Pyrex	20	20	492.5 486.7 232.0	0.2 0.2 0.2	1 7 1	100 20 5
Ni Nickel	5610103700	5610125600	Fused silica	4	10	352.5 351.5 362.5	0.2 0.2 0.2	5 10 500	100 30 10
P Phosphorus	5610107700	5610126000	Fused silica	20	20	213.6	1.0	1	100
Pb Lead	5610102900	5610124800	Fused silica	10	12	217.0 283.3 (Z) 261.4	1.0 0.5 0.5	1 2 40	20 100 30
Pd Palladium	5610104000	5610125900	Fused silica	5	15	244.8 247.6 340.5	0.2 0.2 1.0	1 2 7	1 1 100
Pt Platinum	5610104100	5610126100	Fused silica	10	20	265.9 299.8 794.8	0.2 0.5 0.2	1 6 3	30 100 60
Rb Rubidium	N/A	5610126600	Pyrex	20	20	780.0 794.8 420.2	0.2 0.2 0.2	1 1 100	100 60 20
Re Rhenium	5610104400	5610126400	Pyrex	20	20	421.6 346.0 346.5	0.2 0.2 0.2	300 1 2	10 100 70
Rh Rhodium	5610104500	5610126500	Pyrex	5	15	345.2 343.5	0.2 0.5	3 1	40 100
Ru Ruthenium	N/A	5610126700	Pyrex	10	15	349.9 392.6	0.2 0.2	1 10	100 60
Sb Antimony	5610100200	5610122100	Fused silica	10	15	217.6 231.2	0.2 0.5	1 2	20 100
Sc Scandium	N/A	5610126900	Pyrex	10	15	391.2 327.4 326.9	0.2 0.2 0.2	1 3 5	100 20 10
Se Selenium	5610105000	5610127000	Fused silica	10	12	196.0 204.0	1.0 0.5	1 15	100 60
Si Silicon	5610105100	5610127100	Fused silica	10	15	251.6 250.7 252.4	0.2 0.5 0.5	1 3 4	100 60 50
Sm Samarium	N/A	5610126800	Pyrex	10	20	288.2 429.7 476.0	0.2 0.2 0.5	2 1 2	80 20 100
Sn Tin	5610106100	5610128100	Fused silica	7	15	235.5 286.3 (Z) 300.9	0.5 0.5 0.5	1 2 4	60 100 80
Sr Strontium	5610105400	5610127400	Pyrex	10	15	266.1 460.7	0.5 0.5	20 1	10 100
Ta Tantalum	5610105500	5610127500	Fused silica	20	20	271.5 275.8	0.2 0.5	1 5	50 100
Te Tellurium	5610105600	5610127600	Fused silica	10	12	214.3 225.9 238.6	0.2 0.5 0.2	1 15 150	10 100 60
Ti Titanium	5610106200	5610128200	Pyrex	20	20	364.3 365.4 399.0	0.5 0.2 0.5	1 1 2	100 40 90
Tl Thallium	5610105800	5610127800	Fused silica	10	15	276.8 258.0	0.5 1.0	1 75	100 20
V Vanadium	5610106500	5610128500	Fused silica	20	20	318.5 318.4 306.6	0.2 0.2 0.5	1 2 4	40 60 50
W Tungsten	N/A	5610128300	Fused silica	20	20	439.0 255.1 400.9	0.5 0.2 0.5	8 1 4	100 5 100
Y Yttrium	N/A	5610128700	Pyrex	10	15	407.4 410.2 414.3	0.5 0.5 0.5	8 1 2	80 100 50
Zn Zinc	5610106800	5610128800	Fused silica	5	10	213.9 307.6	1.0 1.0	1 8000	100 60
Zr Zirconium	5610106900	5610128900	Pyrex	20	20	360.1 468.8	0.2 0.2	1 8	60 100

AA Hollow Cathode Lamps — Recommended Operating Conditions

Multi-Element Lamps

Elements	Coded Part Number	Uncoded Part Number	Window Material	Current (mA)		Wavelengths (nm)	Rec. Slit (nm)	Relative Sensitivity	Relative Intensity
				Rec.	Max.				
Ag/Cd/Pb/Zn*	5610108700		Fused silica	5	10	328.1	0.5	1	100
Ag	Silver					338.3	0.5	2	90
Cd	Cadmium					228.8	0.5	1	40
Pb	Lead					283.3	0.5	2	100
						217.0	1.0	1	20
Zn	Zinc					213.9	0.5	1	100
Ag/Cr/Cu/Fe/Ni	5610109500		Fused silica	10	12	328.1	0.5	1	100
Ag	Silver					338.3	0.2	2	90
Cr	Chromium					357.9	0.2	1	40
						429.0	0.5	7	100
						520.8	0.2	200	20
Cu	Copper					324.8	0.5	1	100
Fe	Iron					327.4	0.5	2	50
						248.3	0.2	1	15
						372.0	0.2	10	100
						386.0	0.2	15	50
Ni	Nickel					386.0	0.2	15	50
						232.0	0.2	1	5
						352.5	0.2	5	100
						351.5	0.2	10	30
Al/Ca/Mg	5610108800		Fused silica	10	12	309.3	0.5	1	80
Al	Aluminium					396.2	0.5	2	100
Ca	Calcium					422.7	0.5	1	100
Mg	Magnesium					239.9	0.2	200	10
						285.2	0.5	1	100
						202.6	0.5	30	3
Ca/Mg	5610107100	5610129100	Fused silica	7	12	422.7	0.5	1	100
Ca	Calcium					285.2	0.5	1	100
Mg	Magnesium								
Co/Cr/Cu/Fe/Mn/Ni	5610107600	5610129200	Fused silica	10	15	240.7	0.2		
Co	Cobalt					425.4	0.5		
Cr	Chromium					357.9	0.2		
Cu	Copper					324.8	0.2		
Fe	Iron					248.3	0.2		
Mn	Manganese					279.5	0.2		
Ni	Nickel					232.0	0.2		
						352.5	0.2		

Elements	Coded Part Number	Uncoded Part Number	Window Material	Current (mA)		Wavelengths (nm)	Rec. Slit (nm)	Relative Sensitivity	Relative Intensity
				Rec.	Max.				
Cu/Fe/Mn/Zn	5610109600		Fused silica	10	12	324.8	0.5	1	100
Cu	Copper					327.4	0.5	2	50
Fe	Iron					248.3	0.2	1	15
						372.0	0.2	10	100
						386.0	0.2	15	50
Mn	Manganese					279.5	0.2	1	90
						403.1	0.2	12	100
Zn	Zinc					213.9	0.2	1	100
						307.6	0.2	8000	60
Cu/Fe/Si/Zn	5610109700		Fused silica	10	12	324.8	0.5	1	100
Cu	Copper					327.4	0.5	2	50
Fe	Iron					248.3	0.2	1	15
						372.0	0.2	10	100
						386.0	0.2	15	50
Si	Silicon					251.6	0.2	1	100
						250.7	0.2	3	60
Zn	Zinc					213.9	0.2	1	100
						307.6	0.2	8000	60
Cu/Zn	5610119200	5610129300	Fused silica	7	10	324.8	0.2	1	100
Cu	Copper					327.4	0.2	3	60
Zn	Zinc					213.9	0.5	1	100
						307.6	0.5	8000	60
Na/K	5610107000	5610129000	Pyrex	5	10	589.0	0.5	1	100
Na	Sodium					589.6	0.5	2	60
						766.5	1.0	1	100
K	Potassium					769.9	1.0	2	80
						404.4	0.5	400	10

Continuum Lamps

Element	Coded Part Number	Window Material	Current (mA)	
			Rec. Max.	
D ₂	Deuterium	G8431-80000	Fused silica	Software-controlled

High Intensity UltrAA Lamps

Recommended operating conditions for UltrAA lamps are different from those for unboosted hollow cathode lamps. In some cases, the spectrometer does not provide the benefit of automatic lamp recognition and automatic selection of the recommended operating parameters.

Note: Operation of the UltrAA lamp as a normal hollow cathode lamp without the boost active is not recommended, as this has been shown to reduce lamp life. For maximum lamp life and best performance from the UltrAA lamp, always operate the lamp with the boost applied.

If necessary, set the following lamp operating currents manually to ensure best performance and optimum lamp lifetimes.

All lamps are coded unless otherwise indicated, have a quartz window, and are filled with neon gas, except the Al/Ca/Mg lamp, which is filled with argon.

UltrAA lamp operation requires a control module to provide the boost current. This may be either external or integrated in the instrument.

The Tables

These tables list operating conditions for each analytical wavelength, under the following headings:

- Recommended Current — provides an adequate intensity. Higher currents will always reduce the working life of the lamp and for some elements will produce a reduction in absorption signal.
- Maximum Current — to prevent permanent lamp damage, never exceed this value.
- Wavelengths — the wavelengths indicated are those most commonly used in atomic absorption.
- Recommended Slit — the recommended spectral bandpass at each wavelength for the recommended current. Where there is an adjacent line, a smaller slit may provide a more sensitive and linear calibration, but a higher noise level is likely. Conversely, a larger slit will reduce noise, but a less sensitive calibration with greater curvature may be obtained.

Single Element UltrAA Lamps

Element	Part Number	Current (mA)		Wavelengths (nm)	Recommended Slit (nm)	
		Recommended	Maximum			
As	Arsenic	5610108100	10	15	193.7	0.5
Au	Gold	5610109000	4	10	242.8	1.0
B	Boron	5610135700	10	12	249.8	1.0
Bi	Bismuth	5610134200	10	12	223.1	1.0
			10	12	227.7	0.2
Co	Cobalt	5610134100	7	15	240.7	0.5
			7	15	242.5 (Z)	0.2
Cu	Copper	5610109100	4	10	324.8	0.5
			4	10	327.4 (Z)	0.5
Fe	Iron	5610108600	7	10	248.3	0.2
Ge	Germanium	5610134300	8	12	265.2	1.0
Mn	Manganese	5610133700	10	15	279.5	0.2
			10	15	403.1	0.2
Ni	Nickel	5610108500	7	10	232.0	0.2
Pb	Lead	5610108200	10	12	217.0	1.0
			10	12	283.3 (Z)	0.5
Pd	Palladium	5610135800	5	12	247.6	1.0
			5	12	244.8	1.0
Pt	Platinum	5610135900	10	12	265.9	0.5
Sb	Antimony	5610108000	7	10	217.6	0.5
Se	Selenium	5610108300	10	12	196.0	1.0
Si	Silicon	5610133400	10	15	251.6	0.2
Sn	Tin	5610133900	10	15	235.5	0.5
			10	15	286.3 (Z)	0.5
Te	Tellurium	5610134000	10	15	214.3	0.2
Tl	Thallium	5610108400	7	10	276.8	0.5

(Z) Recommended wavelength for Zeeman AA

* These lamps contain Cd above 0.1% by weight. As with all hollow cathode lamps, handle with care and dispose of properly following local regulations.

Multi-Element UltrAA Lamps

Elements	Part Number	Current (mA)		Wavelengths (nm)	Recommended Slit (nm)
		Recommended	Maximum		
Ag/Cd/Pb/Zn*	5610108900	5	10	328.1	0.5
Ag	Silver			228.8	0.5
Cd	Cadmium			217.0	1.0
Pb	Lead			283.3	0.5
				213.9	1.0
Zn	Zinc				
Ag/Cr/Cu/Fe/Ni	5610134900	10	15	328.1	0.2
Ag	Silver			357.9	0.2
Cr	Chromium			324.8	0.2
Cu	Copper			248.3	0.2
Fe	Iron			232.0	0.2
Ni	Nickel				
Al/Ca/Mg	5610133600	10	12	309.3	0.5
Al	Aluminium			396.2	0.5
Ca	Calcium			422.7	0.5
				239.9	0.2
Mg	Magnesium			285.2	0.5
				202.6	0.5
As/Cu/Fe (uncoded)	5610135300	10	15	193.7	0.5
As	Arsenic			324.8	0.5
Cu	Copper			248.3	0.2
Fe	Iron				
Co/Cr/Cu/Fe/Mn/Ni	5610134500	10	12	240.7	0.2
Co	Cobalt			357.9	0.2
Cr	Chromium			324.8	0.2
Cu	Copper			248.3	0.2
Fe	Iron			279.5	0.2
Mn	Manganese			232.0	0.2
Ni	Nickel				
Co/Mo/Pb/Zn	5610135200	10	12	240.7	0.2
Co	Cobalt			242.5 (Z)	0.2
Mo	Molybdenum			313.3	0.2
Pb	Lead			217.0	0.2
				283.3 (Z)	0.2
Zn	Zinc			213.9	0.2
Cu/Fe/Mn/Zn	5610135000	10	12	324.8	0.2
Cu	Copper			248.3	0.2
Fe	Iron			279.5	0.2
Mn	Manganese			213.9	0.2
Zn	Zinc				
Cu/Fe/Si/Zn	5610135100	10	12	324.8	0.2
Cu	Copper			327.4	0.5
				248.3	0.2
Fe	Iron			251.6	0.2
Si	Silicon			213.9	0.2
Zn	Zinc				
Cu/Zn	5610134600	4	10	324.8	1.0
Cu	Copper			213.9	1.0
Zn	Zinc				
Ni/Se (uncoded)	5610135400	10	12	232.0	0.2
Ni	Nickel			196.0	1.0
Se	Selenium				

