



Table 1 is representative of the Z-200 C and C+ models, provided the user has properly prepped the material akin to spark OES. The results shown are typically averages of 3 tests plus a 3 second pre-burn, for a total test time of about 12 seconds. The CE values are calculated by the analyzer using the AWS formulation.

We also show CE and chemistries for X-45 when using type standardization (i.e., single point calibration to an X-45 material). In general, there are some small biases that can occur when using the general calibration curves, generally when concentration levels are below 0.05%. Comparing the Ni and V results for X-45 full calibration (0 - .5%) versus type standardization in **Table 1** is a good example. We typically find that using the full calibration curves may bias the CE value by ± 0.03 in either direction. And this bias almost always originates from small biases in very low concentrations in a few of the elements comprising the CE value. Therefore if the measured CE is within 0.03 units to a threshold value for weldability (for example, close to 0.4 as in **Table 2**) then type standardization may be the right choice.

Canadian Welding Standard

The Canadian CE calculation, shown in the formula below, adds an additional requirement. The CE value includes a contribution of 5 times the boron concentration. Boron levels in steel are typically less than 5 ppm (0.0005%), below the limit of detection (LOD) of the Z and most mobile spark OES units. In fact for the Z-200 C and C+, we estimate the LOD for boron at about 80 ppm (0.008%).

$$CE (CAN) = \%C + F * [\%Mn/6 + \%Si/24 + \%Cu/15 + \%Ni/20 + (\%Cr + \%Mo + \%V + \%Nb)/5 + 5 * \%B]$$

For the Canadian CE calculation the Z utilizes the following approach. Provided boron is not detected, then a maximum value of 0.008% B is used for the CE calculation, since this is our estimated LOD. This value is multiplied by 5, and then by the weighting factor F which is dependent on the carbon concentration, thus biasing the CE slightly high but at least in the conservative direction.

Table 3 shows the CE results for the steels tested using the AWS formulation, the Canadian formulation with boron set to 10 ppm (0.00010%), and the Canadian formulation with B set to our LOD value of 80 ppm (0.008%). We have combed through thousands of OES tests for pipeline steels in Canada and have yet to find a boron result great than 10 ppm. Therefore results for the Canadian CE values using 10 ppm and 80 ppm make for a good comparison. As shown in Table 3, the impact on the CE is minimal. Using 80 ppm for boron inflates the CE value typically by about 0.03 for a range of carbon steels – emphasizing this is in the conservative direction of overestimating the ease of weldability. Our recommendation is to therefore make weldability decisions on our CE value, unless the CE is within 0.03 of a threshold level of weldability like those shown in Table 2.

Summary

The SciAps Z has demonstrated the ability to measure carbon equivalents, as well as carbon content in low alloy and carbon steels. The Z-200 C and C+ are the world's only handheld analyzers capable of measuring carbon content. The carbon analysis method, which usually averages 2-3 tests plus a pre-burn, applies the same averaging to the other alloying elements and yields the required precision to produce a meaningful CE value. Weldability may be determined by the LIBS measurement based on published criteria. The weldability is shown to work acceptably for both the IIW (Dearden and O'Neill) and AWS formulations of CE, and a method for utilizing the Canadian convention with boron included is provided.

Table 3 Comparison of CE values for AWS and Canadian Conventions

Alloy	CE - AWS	CE-CAN (B=80 ppm)	CE-CAN (B=10 ppm)	Δ
X-45	0.36	0.33	0.30	0.03
1018	0.36	0.41	0.38	0.04
1030	0.54	0.60	0.56	0.04
X-45 Type Cal	0.37	0.40	0.36	0.04
A36 Type Cal	0.33	0.37	0.33	0.04

Table 2 Published weld classification versus carbon equivalent numbers.

Carbon Equiv. #	Weldability
0 - 0.35	Excellent
0.36 - 0.40	Very Good
0.41 - 0.45	Good
0.46 - 0.50	Fair
> 0.50	Poor

Table 1

Sample	C.E.	C (%)	Cr (%)	Cu (%)	Ni (%)	Si (%)	V (%)	Mn (%)	Mo (%)	Nb (%)
X45										
Avg	0.359	0.107	0.014	<0.02	0.054	0.205	0.047	1.480	<0.01	0.024
Stdev	0.009	0.008	0.002		0.008	0.015	0.001	0.046		0.005
RSD	2.6%	7.2%	14.7%		14.7%	7.2%	3.1%	3.1%		18.5%
1018										
Avg	0.364	0.180	0.121	0.226	0.129	0.255	0.010	0.840		< 0.015
Stdev	0.012	0.012	0.001	0.005	0.003	0.011	0.001	0.009		
RSD	3.2%	6.9%	1.0%	2.2%	2.5%	4.2%	8.3%	1.1%		
1030										
Avg	0.540	0.333	0.203	0.207	0.140	0.241	0.049	0.834		< 0.015
Stdev	0.023	0.024	0.004	0.004	0.008	0.021	0.002	0.041		
RSD	4.3%	7.2%	1.8%	1.8%	5.8%	8.5%	3.7%	4.9%		
A36 TypeCal										
Avg	0.370	0.165	0.142	0.290	0.147	0.234	0.017	0.819	0.038	< 0.015
Stdev	0.010	0.010	0.002	0.007	0.008	0.015	0.002	0.016	0.002	
RSD	2.8%	6.1%	1.2%	2.6%	5.6%	6.4%	9.7%	2.0%	4.9%	
X45 TypeCal										
Avg	0.329	0.091	0.013	0.007	0.020	0.214	0.038	1.411	< 0.01	< 0.015
Stdev	0.015	0.007	0.001	0.001	0.003	0.014	0.001	0.060		
RSD	4.5%	7.7%	6.7%	8.0%	17.3%	6.4%	2.9%	4.3%		



Videos <https://goo.gl/xKR1vn>

SciAps

5 Constitution Way, Woburn, MA 01801
+1339.927.9455
www.sciaps.com - sales@sciaps.com