Evaluating the Performance of XRF Instrumentation

When evaluating the performance of analytical instrumentation, potential users are generally concerned with two criteria:

1. How fast is it?
2. How accurate is it?

What many do not understand, is that there are two distinct factors that must be considered under the general question of "how accurate is it?". These are:

- **Precision –** a measure of repeatability, or the degree of agreement between individual measurements of a set of measurements, all of the same quantity.
- **Accuracy –** a measure of reliability, and is the difference between the True Value of a measured quantity and the Most Probable Value which has been derived from a series of measures. The True Value is in effect, never known as we will explain shortly.

To understand the difference, it is helpful to imagine sighting a rifle using a target. Take a look at the target in figure 1. Notice that the bullet holes made by our imaginary rifle are in a tight pattern, yet they are far from the bulls eye in the center of the target. Hence, the precision of our rifle is very good – it is repeatable within a very tight area. The accuracy of our rifle however, leaves something to be desired. So we must adjust the calibration of the sights on our rifle to bring the bullet pattern to the center of the target.

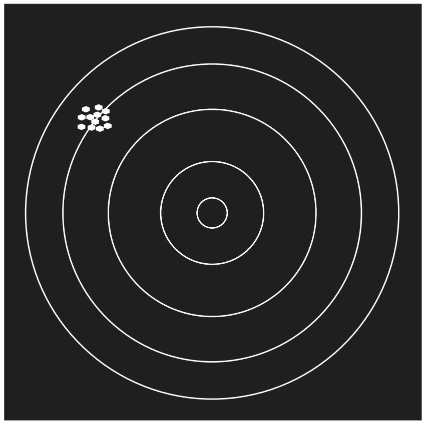

Figure 1

Most analytical instrumentation reports precision data along with the measurement result. Precision is easily calculated, since it is a function of the statistical analysis of the raw data. Accuracy however, must be determined by measuring samples with known values, and comparing the measured results to the known values. The important thing to remember though, is that there is error associated with the known values of any sample, since even the best laboratory methods used to provide these values have statistical limitations in both precision and accuracy. Hence, True Value is really never known, even in a "certified standard."

With regard to XRF instrumentation, extending the time of measurement also improves the precision. The increase in measurement time is analogous to moving our target closer, so that our bullet pattern becomes tighter – until we finally reach a point of diminishing returns. With XRF, each fourfold increase in measurement time will improve the precision by a factor of 2.

NITON instruments report a *two-sigma precision* along with the result for each analyte. What this represents is an error band of *two standard deviations* on either side of the result. The two-sigma precision indicates a 95 percent confidence interval for the data, meaning that if 100 consecutive measurements were made on the same sample, 95 of them would repeat within this margin of error, four of the remaining would fall in the three-sigma band, and the remaining one would lie close, but just outside of the three-sigma band. Remember, this is not an indication of accuracy, but a measurement of repeatability around a Most Probable Value. Accuracy must be assessed by comparing the measured result and precision to *"known values"* from a reference standard.

The attached data sheets demonstrate NITON instruments' accuracy in comparison to certified reference materials of various types, along with typical analysis data and precision for both 5 second and 20 second measurement times.

The data on these sheets should be considered typical of the instrument configuration used. Actual data results for individual instruments may vary slightly from that shown.

XLt 800 Typical Analytical Performance Data Sheet

300 Series Stainless Steel

SS 304		BS 80E			NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**304/321**		**304**		**304**	
Cr	18.31	0.125	18.33	0.83	18.42	0.63	18.29	0.32
Ni	9.52	0.06	9.56	0.87	9.45	0.66	9.70	0.34
Mn	1.73	0.06	2.14	0.51	1.94	0.40	1.99	0.21
Mo	0.38	0.02	0.40	0.10	0.42	0.08	0.38	0.05
Fe	bal		67.51	1.73	67.82	1.33	68.05	0.68

SS 316		BS CA316-1			NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**316**		**316**		**316**	
Cr	17.44	0.05	17.81	0.85	17.82	0.65	17.55	0.33
Ni	11.21	0.10	11.30	0.93	11.27	0.69	11.30	0.37
Mo	2.08	0.05	2.03	0.20	2.18	0.16	2.16	0.08
Mn	1.54	0.04	1.94	0.51	1.72	0.40	1.83	0.20
Fe	bal		64.47	1.71	64.79	1.33	65.31	0.68

SS 321		BS 321A			NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**321**		**321**		**321**	
Cr	17.2	0.06	17.54	0.82	17.09	0.60	17.18	0.31
Ni	9.38	0.05	9.31	0.87	9.61	0.67	9.62	0.34
Mo	0.20	0.01					0.22	0.05
Mn	1.22	0.02	1.41	0.50	1.51	0.38	1.56	0.19
Cu	0.284	0.01					0.29	0.12
Ti	0.51	0.015					0.57	0.20
Fe	bal		69.38	1.79	69.7	1.34	69.26	0.68

SS 347		IARM 8B			NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**347**		**347**		**347**	
Cr	17.61	0.06	18.07	0.86	17.96	0.64	17.85	0.31
Ni	9.06	0.04	8.69	0.86	8.92	0.66	9.14	0.33
Mn	1.43	0.01	1.29	0.51	1.55	0.38	1.53	0.19
Nb	0.63	0.02	0.61	0.10	0.64	0.07	0.66	0.05
Mo	0.50	0.01	0.44	0.12	0.53	0.09	0.50	0.05
Cu	0.26	0.01					0.32	0.12
Fe	bal		68.89	1.84	69.02	1.36	69.07	0.67

NITON Performance Documentation

The performance data on this sheet can be considered typical of the instrument configuration used to produce it.

Performance of individual instruments of this configuration under varying conditions may differ slightly from that shown here.

Each of the entries at left is the average of three repeat measurements on the specified reference standard for the approximate testing times shown. Actual measurement durations were within .5 seconds of the testing times indicated.

The certified values of each standard are those provided by the supplier(s) of the individual reference materials. The estimated error indicated is representative of the precision and accuracy error bands for the analytical methods used in certification of these materials.

NITON LLC nor it's subsidiaries make any guarantee neither expressed or implied as to the accuracy of the certification data of the materials used in this evaluation.

XLt 800 Typical Analytical Performance Data Sheet

NITON

Inconel & Incoloy

Inconel 690	IARM 201A				NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**690**		**690**		**690**	
Cr	29.9	0.08	29.19	1.08	29.12	0.73	29.39	0.45
Fe	9.09	0.04	8.72	0.61	8.78	0.41	8.74	0.25
Ni	59.9	0.06	60.41	1.36	60.19	0.93	60.13	0.57
Ti	0.3	0.01					0.42	0.21

Inconel 718	IARM 56C				NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**718**		**718**		**718**	
Cr	18.21	0.09	18.47	1.07	18.35	0.65	18.46	0.39
Fe	18.27	0.23	18.12	0.90	18.14	0.55	17.98	0.33
Nb	5.19	0.03	5.02	0.28	5.26	0.18	5.26	0.10
Mo	2.94	0.04	2.73	0.27	2.81	0.17	2.76	0.10
Ti	1.01	0.01	1.31	0.80	1.07	0.48	1.06	0.28
Ni	53.36	0.62	52.83	1.48	52.93	0.89	53.03	0.53

Inconel x750	BS 750A				NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**750**		**750**		**750**	
Cr	15.68	0.20	15.22	0.82	15.61	0.54	15.39	0.34
Fe	7.07	0.07	6.75	0.46	6.71	0.30	6.92	0.19
Ti	2.60	0.07	2.72	0.75	2.85	0.50	2.76	0.31
Nb	1.07	0.025	1.13	0.13	1.11	0.09	1.13	0.05
Mo	0.22	0.02					0.2	0.05
Ni	71.9	0.25	72.38	1.38	72.24	0.91	72.42	0.58

Incoloy 800	NIST 1246				NITON Data			
	Cert	Est.Error	2 Sec	+/-	5 Sec	+/-	20 Sec	+/-
Grade ID			**801/800**		**800**		**800**	
Ni	30.8	0.10	30.83	1.29	31.48	0.84	31.21	0.53
Cr	20.1	0.10	20.24	0.93	20.36	0.59	20.41	0.38
Fe	46.2	0.10	45.15	1.40	44.68	0.89	44.84	0.57
Mn	0.91	0.02	1.13	0.46	1.07	0.28	1.01	0.18
Cu	0.49	0.02	0.56	0.39	0.49	0.25	0.55	0.16
Mo	0.36	0.02	0.35	0.11	0.38	0.07	0.39	0.05
Ti	0.32	0.02					0.53	0.22

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