



Lab Report OES 23

Q4 TASMANT – Series 2

- Analysis of Iron & Steel

The Analysis of iron and steel is the most prominent analytical application for today's spark spectrometers. Besides the traditional commercial applications for this metal, a more demanding automotive industry has recently led to rapid alloy developments. These alloys have become popular in automotive manufacturing thanks to their light weight, high strengths and improved properties.

The Q4 TASMANT Series 2 rugged, compact design makes it suitable not only for laboratories but also for the melt shop floor. An integrated air conditioning system ensures high thermostability even in hot and humid environments. Maintenance work is drastically reduced: self-cleaning spark stand, long-lasting electrode, argon stop function help to save time and operational costs.



Sampling and Sample Preparation

The chemical composition of different stages of the steel refining process and casting are monitored by determining the composition of the steel samples taken from the liquid steel.

The samples are prepared by grinding or milling to have a flat and homogeneous surface.

All samples in this Lab Report have been prepared by grinding with Al-corundum paper (~60 grit).

Certified Reference Material (CRM)

Certified Reference Material (CRM) are reference material characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability.

The CRMs are certified by a recognized certifying organization using approved certification procedures as instructed in the most recent ISO Guide 35. The organization is usually a function of a federal government or recognized by a federal government or an accreditation organization. A CRM is the highest level to which an analytical reference material can be elevated because it is directly traceable to SI units and because of the attributed confidence in the company or organization which produced the material.

Precision and Accuracy

The International Organization for Standardization (ISO) defines **precision** as the closeness of agreement between independent test results obtained under stipulated conditions. Precision depends only on the distribution of

random errors and does not relate to the true value or the specified value, while **accuracy** is defined as the closeness of agreement between a test result and the accepted reference value.

Procedure & Equipment

The Australian standard AS 2883 is an example of a norm for the analysis of metals using arc/spark optical emission spectrometry, describing procedures for the setting up, calibration and standardization of the equipment.

For this data one Q4 TASMAN 130 has been set-up accordingly, providing:

- MultiVision™ dual-optics with full wavelength coverage (130-620 nm) at optimal resolution
- Minimized argon consumption and low-maintenance spark-stand
- SmartSpark™ – the new advanced digital spark source

Analytical solution packages (ASPs) are available for all 10 common metal bases. Each ASP includes analytical programs, optimized for different alloy groups, calibrations, source parameters and the full set of elements. The available analytical programs and standard calibration ranges for the Steel and Iron solution are summarized in the following two tables.

Analytical Programs and measuring time

Analytical Program	Description	typ. measuring time [s]
Fe100	Orientation	25
Fe110	Low Alloy Steel	25
Fe115	Free Cutting Steel	56
Fe120	Cast Iron	29
Fe130	Fe - Cr/Ni Steel (Stainless Steel)	25
Fe140	High Speed Steel	25
Fe150	Mn-Steel	25
Fe160	Ni-Resist/Cr-hard Steel	28

Table 1: Analytical Programs Calibration Ranges and for ASP Iron & Steel, Q4 TASMAN 130

Element	Orientation		Low Alloy Steel		Free Cutting Steel		cast iron		Cr/Cr-Ni steel		High-speed-steel		Fe - Mn-steel		Ni-resist/Cr-hard	
	Fe 100		Fe 110		Fe 115		Fe 120		Fe 130		Fe 140		Fe 150		Fe 160	
	min %	max %	min %	max %	min %	max %	min %	max %	min %	max %	min %	max %	min %	max %	min %	max %
Al	0.0003	9	0.0002	1.3	0.0002	1.3	0.0002	0.12	0.0003	5.5	0.0002	0.045	0.0002	9	0.0002	0.2
As	0.0005	0.09	0.0004	0.09	0.0004	0.09	0.0004	0.09	0.0006	0.1	0.0005	0.08				
B	0.0001	2.2	0.0001	0.013	0.0001	0.013	0.0002	0.09	0.0002	2.2						
Bi	0.0025	0.12	0.0025	0.12	0.0025	0.12	0.0025	0.025								
C	0.001	4.5	0.001	1.5	0.001	1.5	1.7	4.5	0.001	2.6	0.001	2.6	0.001	2.6	1.5	4.2
Ca	0.0001	0.005	0.0001	0.005	0.0001	0.005			0.0001	0.005						
Ce	0.002	0.25	0.002	0.05	0.002	0.05	0.002	0.25							0.002	0.05
Co	0.0005	19	0.0005	2.2	0.0005	2.2	0.0005	0.26	0.0005	19	0.0005	9	0.0005	0.12		
Cr	0.001	42	0.0004	9.5	0.0004	9.5	0.0005	8.5	0.001	42	0.001	12	0.001	4	0.0008	33
Cu	0.0005	8	0.0002	0.8	0.0002	0.8	0.0002	2.5	0.0003	8	0.0002	0.4	0.0002	0.55	0.0003	8
La	0.0005	0.07	0.0004	0.025	0.0004	0.025	0.0005	0.07								
Mg	0.0002	0.2	0.0001	0.003	0.0001	0.003	0.0004	0.2							0.0005	0.06
Mn	0.0005	30	0.0004	2.8	0.0004	2.8	0.0005	2.4	0.0005	26	0.0005	2.2	4	30	0.0005	4.5
Mo	0.001	11	0.001	2.5	0.001	2.5	0.001	2	0.001	6.5	0.001	11	0.001	2.2	0.001	4
N	0.005	1.1	0.002	0.035			0.002	0.015	0.0025	1.1	0.0025	0.08	0.0025	0.1		
Nb	0.001	2.8	0.0004	0.35	0.0004	0.35	0.0005	0.12	0.0005	2.8			0.0005	0.45		
Ni	0.001	52	0.0005	6.5	0.0005	6.5	0.0006	7	0.0007	52	0.001	2	0.0025	4.5	0.0008	40
P	0.001	2.2	0.0005	0.09	0.0005	0.09	0.0004	2.2	0.0005	0.07	0.0005	0.07	0.0005	0.2	0.0005	0.35
Pb	0.002	0.25	0.0015	0.25	0.0015	0.25	0.002	0.045	0.0015	0.03						
S	0.005	1.3	0.0003	0.13	0.0003	0.13	0.0003	0.2	0.0003	1.2	0.0003	0.09	0.0003	0.12	0.0003	0.18
Sb	0.005	0.22	0.0025	0.11	0.0025	0.11	0.0025	0.22								
Se	0.001	0.4	0.0005	0.4	0.0005	0.4	0.0005	0.06								
Si	0.002	6	0.001	4.5	0.001	4.5	0.001	5	0.001	4	0.001	2.2	0.001	1.8	0.5	6
Sn	0.001	0.22	0.0005	0.15	0.0005	0.15	0.0005	0.2	0.0005	0.13	0.0005	0.05	0.0005	0.12		
Ta	0.02	0.55	0.02	0.55	0.02	0.55										
Te	0.001	0.09	0.001	0.05	0.001	0.05	0.0015	0.09								
Ti	0.0005	2.5	0.0002	0.35	0.0002	0.35	0.0002	0.35	0.0002	2.5	0.0002	0.025	0.0002	1.1		
V	0.0005	11	0.0005	0.9	0.0005	0.9	0.0005	0.5	0.0008	0.9	0.0005	11	0.0008	0.9		
W	0.005	19	0.005	3.3	0.005	3.3	0.005	0.2	0.005	4.5	0.01	19				
Zn	0.001	0.03	0.0004	0.025	0.0004	0.025	0.0004	0.03								
Zr	0.0005	0.22	0.0005	0.22	0.0005	0.22	0.0004	0.07	0.0005	0.2						

Results

The reproducibility of the Q4 TASMAN Series 2 and the method outlined is demonstrated by a series of repetitive measurements of certified reference material and production samples of different alloy groups and element concentrations.

Table 2.: CMRs of low-, medium-, and high-carbon, Low Alloy Steels

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al	V	W
MEAN ¹⁾	0.047	1.0212	1.743	0.0096	0.012	0.2054	0.036	1.088	0.565	0.151	0.0045	0.354
STD ²⁾	0.0008	0.0072	0.0076	0.0003	0.0004	0.0016	0.0009	0.008	0.004	0.0014	0.0001	0.0028
1	0.048	1.017	1.736	0.0092	0.013	0.208	0.036	1.081	0.568	0.152	0.0045	0.353
2	0.048	1.031	1.743	0.0096	0.012	0.205	0.035	1.091	0.57	0.15	0.0044	0.35
3	0.046	1.012	1.737	0.0094	0.012	0.204	0.036	1.077	0.561	0.153	0.0047	0.357
4	0.048	1.024	1.743	0.0099	0.012	0.205	0.037	1.099	0.565	0.149	0.0045	0.356
5	0.047	1.022	1.755	0.0098	0.012	0.205	0.035	1.091	0.562	0.152	0.0045	0.352
<i>Certified Values</i>												
Value	0.047	1.02	1.74	0.009	0.012	0.204	0.036	1.09	0.568	0.15	0.004	0.354
Error	0.003	0.02	0.02	0.001	0.001	0.01	0.003	0.02	0.009	0.005	0.002	0.008

¹⁾ MEAN = arithmetic average

²⁾ STD = absolute standard deviation (1σ)

³⁾ %RSD = relative standard deviation in percent

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al	V	W
MEAN	0.337	0.769	0.1686	0.0065	0.034	5.114	1.287	0.446	0.056	0.096	0.797	0.091
STD	0.0013	0.0054	0.0016	0.0003	0.0009	0.0087	0.0045	0.0015	0.0007	0.0081	0.0089	0.0017
1	0.338	0.763	0.166	0.0063	0.032	5.114	1.281	0.447	0.057	0.093	0.782	0.091
2	0.336	0.776	0.169	0.0061	0.035	5.106	1.289	0.444	0.056	0.092	0.804	0.09
3	0.338	0.773	0.169	0.0064	0.033	5.124	1.284	0.447	0.057	0.092	0.798	0.091
4	0.336	0.765	0.169	0.0068	0.034	5.104	1.29	0.445	0.055	0.11	0.804	0.094
5	0.335	0.768	0.17	0.0069	0.035	5.121	1.292	0.447	0.056	0.091	0.797	0.09
<i>Certified Value</i>												
Value	0.332	0.775	0.169	0.006	0.033	5.11	1.28	0.445	0.057	0.093	0.802	0.091
Error	0.01	0.016	0.004	0.001	0.002	0.05	0.02	0.008	0.003	0.003	0.008	0.005

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al	V	W
MEAN	1.384	0.1256	0.3752	0.0087	0.006	0.1264	0.011	2.831	0.293	0.02	0.028	0.017
STD	0.0031	0.002	0.0041	0.0003	0.0005	0.0066	0.001	0.012	0.003	0.0024	0.0005	0.0016
1	1.384	0.126	0.373	0.0088	0.0069	0.138	0.011	2.821	0.298	0.021	0.028	0.016
2	1.388	0.126	0.375	0.0082	0.0066	0.124	0.01	2.828	0.292	0.021	0.028	0.015
3	1.384	0.128	0.371	0.0089	0.0066	0.123	0.011	2.851	0.292	0.022	0.028	0.018
4	1.379	0.125	0.375	0.0088	0.006	0.121	0.012	2.825	0.29	0.018	0.028	0.017
5	1.383	0.123	0.382	0.0088	0.0058	0.126	0.013	2.829	0.294	0.016	0.029	0.019
<i>Certified Value</i>												
Value	1.38	0.123	0.37	0.008	0.006	0.122	0.011	2.82	0.293	0.023	0.027	0.016
Error	0.02	0.008	0.008	0.001	0.001	0.002	0.001	0.03	0.007	0.001	0.002	0.004

Performance Disclaimer and Remarks

The published values have been acquired from quite different type of materials and should be regarded as “typical” values. The given performances only apply for homogeneous samples, appropriately prepared and are subject to technical modification. Calibration ranges can be extended with samples provided by customer.

Table 3: Production sample, Low Alloy Steel, Designations 1.0580, St52

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al
MEAN	0.155	0.258	1.249	0.019	0.011	0.081	0.017	0.088	0.200	0.014
STD	0.0005	0.0015	0.0031	0.0005	0.0005	0.0008	0.0007	0.0005	0.0005	0.0005
%RSD³⁾	0.32	0.58	0.25	2.41	4.33	1.03	4.18	0.57	0.25	3.16
1	0.155	0.258	1.253	0.018	0.011	0.081	0.017	0.088	0.200	0.014
2	0.155	0.257	1.251	0.019	0.012	0.082	0.018	0.087	0.200	0.014
3	0.155	0.257	1.244	0.019	0.011	0.082	0.018	0.088	0.200	0.014
4	0.156	0.261	1.250	0.018	0.012	0.080	0.018	0.088	0.199	0.015
5	0.156	0.257	1.245	0.019	0.011	0.081	0.016	0.088	0.199	0.015
6	0.156	0.258	1.251	0.019	0.011	0.080	0.017	0.087	0.200	0.014
7	0.155	0.256	1.247	0.019	0.012	0.080	0.018	0.087	0.199	0.014

Element [%]	As	B	Bi	Ce	Co	Mg	Nb	Pb	Sb	Sn
MEAN	0.008	0.0007	<0.0025	<0.0020	0.0072	0.001	0.0062	<0.0015	0.014	0.014
STD	0.0002	0.0001			0.0002	0.00005	0.0001		0.0012	0.0005
%RSD	2.17	10.42			2.51	6.20	2.07		8.54	3.16
1	0.0081	0.0006	<0.0025	<0.0020	0.0073	0.0007	0.0062	<0.0015	0.015	0.014
2	0.0083	0.0006	<0.0025	<0.0020	0.0071	0.0007	0.0061	<0.0015	0.013	0.014
3	0.0084	0.0006	<0.0025	<0.0020	0.0072	0.0007	0.0061	<0.0015	0.013	0.014
4	0.0081	0.0007	<0.0025	<0.0020	0.007	0.0007	0.0061	<0.0015	0.013	0.014
5	0.0082	0.0007	<0.0025	<0.0020	0.0074	0.0008	0.0064	<0.0015	0.016	0.015
6	0.0085	0.0007	<0.0025	<0.0020	0.0074	0.0007	0.0060	<0.0015	0.013	0.014
7	0.0086	0.0008	<0.0025	<0.0020	0.0069	0.0008	0.0063	<0.0015	0.015	0.015

Element [%]	Ta	La	Ti	V	W	Zn	Zr	N	Ca	Fe
MEAN	<0.020	0.0043	0.001	0.0024	<0.0050	0.0027	0.0032	0.012	0.0016	97.824
STD		0.0002	0.00005	0.0001		0.0001	0.0001	0.0005	0.0001	0.0073
%RSD		5.56	4.75	3.63		2.66	2.86	4.28	5.50	0.01
1	<0.020	0.0048	0.0011	0.0024	<0.0050	0.0027	0.0031	0.012	0.0017	97.82
2	<0.020	0.0043	0.0011	0.0023	<0.0050	0.0028	0.0030	0.011	0.0015	97.82
3	<0.020	0.0042	0.0010	0.0024	<0.0050	0.0028	0.0031	0.012	0.0016	97.83
4	<0.020	0.0043	0.0010	0.0026	<0.0050	0.0027	0.0032	0.011	0.0018	97.83
5	<0.020	0.0042	0.0010	0.0024	<0.0050	0.0028	0.0033	0.011	0.0017	97.83
6	<0.020	0.0041	0.0011	0.0025	<0.0050	0.0026	0.0032	0.012	0.0016	97.81
7	<0.020	0.0040	0.0010	0.0024	<0.0050	0.0028	0.0032	0.012	0.0016	97.83

Table 4: Production sample, Stainless Steel, Designations 1.4404, 316L

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al	As
MEAN	0.018	0.343	1.572	0.022	0.029	16.59	2.065	10.17	0.443	0.005	0.0087
STD	0.0005	0.0022	0.0037	0.0002	0.0005	0.0262	0.0106	0.0309	0.0013	0.0002	0.0003
%RSD	2.69	0.64	0.23	0.91	1.73	0.16	0.51	0.30	0.29	4.44	3.61
1	0.018	0.345	1.571	0.022	0.028	16.58	2.073	10.14	0.443	0.0048	0.0090
2	0.019	0.343	1.565	0.022	0.028	16.58	2.079	10.18	0.443	0.0052	0.0088
3	0.018	0.347	1.570	0.022	0.029	16.60	2.071	10.19	0.442	0.0051	0.0089
4	0.018	0.344	1.576	0.022	0.029	16.54	2.064	10.19	0.446	0.0048	0.0088
5	0.019	0.341	1.575	0.022	0.029	16.61	2.064	10.11	0.443	0.0050	0.0085
6	0.019	0.340	1.573	0.022	0.029	16.63	2.062	10.20	0.442	0.0051	0.0080
7	0.018	0.343	1.576	0.022	0.028	16.59	2.043	10.19	0.444	0.0055	0.0088

Element [%]	B	Co	Nb	Pb	Sn	Ti	V	W	Zr	N	Ca	Fe
MEAN	0.0006	0.173	0.0097	0.0071	0.0081	0.0043	0.058	0.022	0.018	0.036	0.0024	68.39
STD	0.0001	0.0007	0.0003	0.0008	0.0002	0.0001	0.0006	0.0024	0.0010	0.0007	0.0001	0.0352
%RSD	14.05	0.41	2.90	11.32	2.64	2.71	1.10	10.93	5.63	1.96	3.83	0.05
1	0.0005	0.172	0.0100	0.0072	0.0079	0.0044	0.059	0.023	0.019	0.036	0.0025	68.42
2	0.0006	0.172	0.0098	0.0085	0.0082	0.0043	0.058	0.022	0.019	0.037	0.0024	68.39
3	0.0007	0.172	0.0098	0.0076	0.0081	0.0043	0.058	0.022	0.019	0.035	0.0023	68.36
4	0.0007	0.173	0.0100	0.0077	0.0084	0.0044	0.058	0.017	0.018	0.036	0.0022	68.42
5	0.0006	0.173	0.0091	0.0064	0.0078	0.0045	0.059	0.020	0.019	0.035	0.0024	68.44
6	0.0006	0.173	0.0097	0.0061	0.0082	0.0044	0.058	0.023	0.016	0.036	0.0023	68.33
7	0.0008	0.174	0.0098	0.0064	0.0078	0.0041	0.057	0.025	0.018	0.035	0.0024	68.39

Table 5: Cast Iron, SUS RG16

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al
MEAN	3.307	1.838	0.199	0.299	0.0026	1.106	0.0043	1.024	0.070	0.043
STD	0.0088	0.0046	0.0016	0.0025	0.0002	0.0031	0.0003	0.0052	0.0005	0.0005
%RSD	0.27	0.25	0.79	0.83	8.83	0.28	7.38	0.51	0.70	1.06
1	3.31	1.832	0.196	0.298	0.0023	1.104	0.0046	1.023	0.070	0.042
2	3.30	1.837	0.199	0.302	0.0025	1.108	0.0042	1.030	0.070	0.042
3	3.29	1.842	0.199	0.299	0.0023	1.109	0.0039	1.020	0.070	0.043
4	3.31	1.844	0.201	0.297	0.0029	1.103	0.0048	1.019	0.071	0.043
5	3.31	1.835	0.199	0.295	0.0024	1.103	0.0039	1.025	0.071	0.043
6	3.32	1.842	0.201	0.301	0.0027	1.111	0.0045	1.017	0.071	0.043
7	3.31	1.832	0.200	0.302	0.0028	1.103	0.0044	1.032	0.070	0.043

Element [%]	As	B	Bi	Ce	Co	Mg	Nb	Pb	Sb	Sn
MEAN	0.0015	0.053	<0.0025	0.020	0.0055	0.055	<0.0005	0.0027	0.011	0.196
STD	0.0001	0.0003		0.0009	0.0001	0.0032		0.0005	0.0005	0.0028
%RSD	7.20	0.66		4.42	2.16	5.84		19.28	4.33	1.41
1	0.0016	0.053	<0.0025	0.019	0.0053	0.054	<0.0005	0.0033	0.011	0.192
2	0.0013	0.053	<0.0025	0.021	0.0054	0.053	<0.0005	0.0024	0.012	0.197
3	0.0014	0.053	<0.0025	0.022	0.0056	0.050	<0.0005	0.0021	0.012	0.199
4	0.0014	0.053	<0.0025	0.021	0.0055	0.052	<0.0005	0.0021	0.011	0.192
5	0.0015	0.054	<0.0025	0.020	0.0055	0.056	<0.0005	0.0025	0.012	0.198
6	0.0016	0.053	<0.0025	0.020	0.0053	0.059	<0.0005	0.0027	0.011	0.198
7	0.0014	0.053	<0.0025	0.020	0.0056	0.059	<0.0005	0.0035	0.011	0.198

Element [%]	La	Ti	V	W	Zn	Zr	Se	N	Te	Fe
MEAN	0.0081	0.0080	0.107	0.009	0.0013	0.0022	0.0022	0.012	0.0072	91.604
STD	0.0006	0.0001	0.0012	0.0004	0.0001	0.0001	0.0002	0.0006	0.0007	0.0266
%RSD	7.22	1.70	1.09	4.30	8.75	5.62	10.35	5.26	10.29	0.03
1	0.0072	0.0079	0.105	0.0088	0.0014	0.0023	0.0020	0.012	0.0066	91.62
2	0.0082	0.0078	0.108	0.0089	0.0012	0.0020	0.0023	0.013	0.0072	91.64
3	0.0085	0.0079	0.106	0.0085	0.0012	0.0022	0.0022	0.012	0.0080	91.62
4	0.0085	0.0079	0.108	0.0091	0.0012	0.0021	0.0019	0.011	0.0068	91.60
5	0.0079	0.0081	0.106	0.0094	0.0013	0.0024	0.0026	0.013	0.0066	91.61
6	0.0076	0.0081	0.108	0.0098	0.0012	0.0023	0.0022	0.012	0.0066	91.55
7	0.0091	0.0082	0.106	0.0091	0.0015	0.0022	0.0025	0.012	0.0086	91.59



