

Lab Report XRF 163

S6 JAGUAR

- High Precision Quality Control of White Portland Cement Made Simple and Fast

White Portland cement is an important product in the construction and restoration industry. It offers high solar reflectance and is used whenever color and aesthetic of the final application matters. The properties of white Portland cements allow for excellent color brilliance and color consistency. Besides shiny concrete for modern buildings, key applications include colored mortar, special plaster, cement based paint, and tile adhesives (Fig. 1).

White Portland cement has similar properties when compared to ordinary grey cement, except for its "whiteness". The whiteness of white cement is a function of minor elements, such as Mn and Fe, which need to be kept below certain concentration thresholds. Hence, precise analysis of these elements is critical for quality control (QC). This report highlights the excellent analytical performance of the S6 JAGUAR for white cement analyses.

S6 JAGUAR Portland Cement DOC-L80-EXS163 2019-07-23.indd 1 23.07.2019 07:03:54



Figure 1: Bridge with bright concrete (left) and bright stucco (right), which requires brightest plaster.

S6 JAGUAR – A versatile system tuned for your business

The S6 JAGUAR is the most powerful benchtop wavelength-dispersive X-ray fluorescence (WDXRF) spectrometer on the market. Outstanding analytical performance for a wide range of elements (F to U) is achieved by combining cutting-edge technical components with innovative geometric design. The S6 JAGUAR is ready for automation (Figure 2) – either as backup system or as main analyzer for your on-line QC strategy. A key strength of the S6 JAGUAR is the flexible configuration with multiple optional components and solutions to choose from (analyzer crystals, one-button software packages, XY autochanger, etc.). This allows us to tune the system for your specific requirements.

S6 JAGUAR – Designed for industrial environments

User-friendly operation and high instrument uptime is enabled by:

- SampleCare™ technology, protecting critical system components for low maintenance (Figure 3)
- Intuitive interface of the SPECTRA.ELEMENTS software with powerful user account control
- (optional) 24-position EasyLoad™ automated sample magazine for unattended analysis
- Sturdy design and robust, high quality components for long lifetime
- (optional) Ergonomic TouchControl™ display for "one-button" routine operation w/o PC peripherals

Sample Preparation

Pressed powder pellets are commonly used for quality monitoring of building materials such as cement. For this lab report, a POLAB® APM automatic sample preparation unit has been used to prepare pressed pellets (10 g of milled sample, 4 tabs of grinding aid). Automatic preparation units are not only easy to use; they also improve the reproducibility.

Analytical Conditions and Calibration

For this lab report, a S6 JAGUAR system configuration with three analyzer crystals and two detectors was selected. Peak counting times ranged between 24 s and 48 s. The analytical conditions and the crystal setup are listed in Table 1. A set of 8 raw real standards was used for calibration (see Table 2 for compositional range). A typical calibration curve, produced by Bruker's SPECTRA.ELEMENTS software, is shown in Figure 4.

Table 1: Analytical conditions – Vacuum mode was used,

Elements	Voltage [kV]	Current [mA]	Analyzer crystal	Filter	Detector
Na, Mg	40	10	XS-55	none	FlowCounter
Al, Si, P, S, Cl	40	10	PET	none	FlowCounter
K, Ca, Ti	40	10	LiF(200)	none	FlowCounter
Mn, Fe	40	10	LiF(200)	none	HighSense XE

Excellent Repeatability

A 30-hours repetition test demonstrates the impressive precision, stability, and accuracy of the S6 JAGUAR (Table 3). After each analysis, the pressed pellet sample was unloaded from the sample chamber and re-loaded just before the next measurement. Particularly remarkable are the very low standard deviations for trace level concentrations of Fe (0.162 ± 0.001 wt.% Fe_2O_3) and Mn (72 ± 1 ppm MnO).

Table 2: Compositional range of the standards.

[wt.%]	Concentration Range
Na_2O	0.095 – 0.189
MgO	0.539 – 0.984
Al_2O_3	2.05 – 2.74
SiO_2	12.52 – 17.50
P_2O_5	0.017 – 0.030
SO_3	0.028 – 0.060
Cl [ppm]	301 – 897
K_2O	0.273 – 0.384
CaO	42.45 – 46.17
TiO_2	0.071 – 0.105
MnO [ppm]	66 – 85
Fe_2O_3	0.137 – 0.186

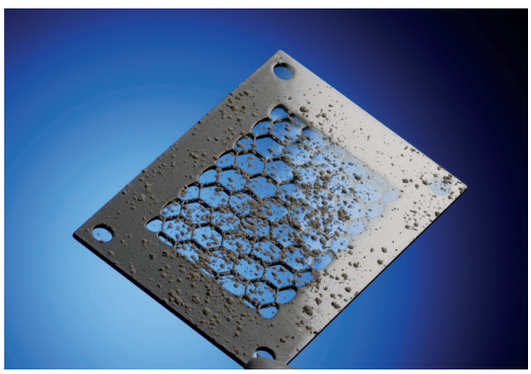


Figure 3: Vacuum seal for detector protection



Figure 2: S6 JAGUAR – Ready for Automated Quality Control of Cement Products

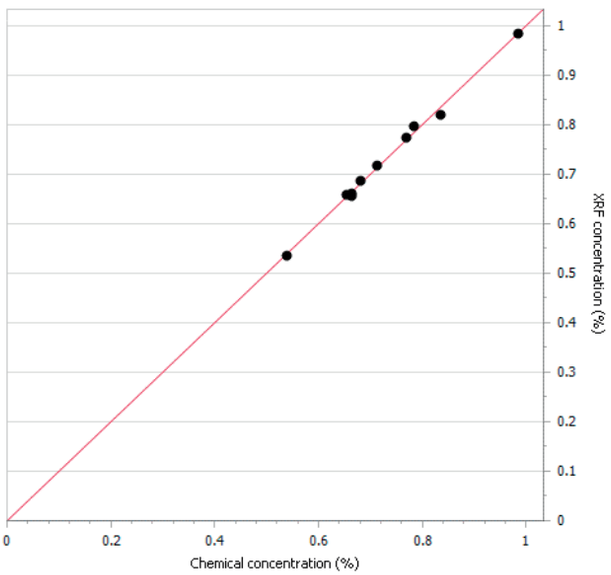


Figure 4: Calibration curves for MgO (R^2 = 0.996). Plot produced by Bruker's SPECTRA.ELEMENTS software.

Table 3: 30-hours Stability, Precision, and Accuracy.

[wt.%]	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl [ppm]	K_2O	CaO	TiO_2	MnO [ppm]	Fe_2O_3
Rep-1	0.151	0.659	2.496	15.84	0.018	0.041	435	0.332	44.08	0.088	72	0.162
Rep-2	0.159	0.678	2.498	15.83	0.018	0.041	437	0.333	44.10	0.092	73	0.162
Rep-3	0.159	0.665	2.494	15.84	0.018	0.041	437	0.332	44.08	0.088	72	0.162
Rep-4	0.153	0.665	2.495	15.85	0.019	0.041	420	0.329	44.07	0.092	71	0.163
Rep-5	0.156	0.663	2.491	15.83	0.018	0.041	420	0.330	44.09	0.091	74	0.162
Rep-6	0.159	0.666	2.498	15.80	0.018	0.041	426	0.331	44.14	0.091	72	0.162
Rep-7	0.155	0.664	2.498	15.81	0.018	0.042	430	0.331	44.12	0.091	72	0.162
Rep-8	0.150	0.660	2.491	15.82	0.018	0.041	429	0.329	44.11	0.091	71	0.162
Rep-9	0.159	0.669	2.492	15.85	0.018	0.041	430	0.331	44.08	0.091	72	0.162
Rep-10	0.155	0.663	2.507	15.86	0.018	0.042	424	0.332	44.06	0.091	73	0.162
Average	0.156	0.665	2.496	15.83	0.018	0.041	429	0.331	44.09	0.091	72	0.162
Abs. Std. Dev.	0.003	0.005	0.005	0.02	<0.001	<0.001	6	0.001	0.02	0.001	1	<0.001
Rel. Std. Dev. [%]	2.1	0.8	0.2	0.1	1.7	1.0	1.4	0.4	0.0	1.5	1.2	0.2
Known composition	0.138	0.663	2.51	15.9	0.019	0.048	423	0.334	44.21	0.092	74	0.164
Abs. diff.	0.018	0.002	0.014	0.07	0.001	0.007	6	0.003	0.12	0.001	2	0.002

Conclusion

This report proves the outstanding analytical capabilities of the S6 JAGUAR for quality control of white Portland cement and similar industrial commodities. Excellent repeatability and accuracy is achieved for trace levels of color relevant elements such as Mn and Fe. An acquisition time of <6 minutes results in high sample throughput. Even better performance is possible when adding optional hardware features such as a LiF(220) analyzer crystal for improved spectral resolution and trace element detection of heavier, color-relevant elements (e.g., V, Cr, Ni, Cu).

The S6 JAGUAR is a compact benchtop WDXRF unit, which can compete with full-size WDXRF systems on many levels. The innovative technical design, the high-power 400 W X-ray tube, the HighSense™ technology, and the versatile configuration features allow us to value-optimize the system to fulfil your analytical needs. Low cost of operation is achieved by using the integrated vacuum mode instead of helium, as well as by Bruker's SampleCare™ technology, which ensures high system uptime. The S6 JAGUAR comes with our intuitive and powerful software SPECTRA.ELEMENTS. Thus, routine quality control analyses of cement products and related raw materials require minimal training.

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