I-CAL 4000 HPC

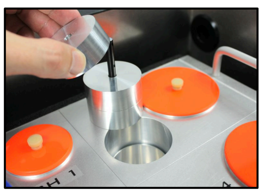
CALMETRIX I-CAL 4000 HPC FOR CEMENT AND CONCRETE SCIENCE

Background: Isothermal Calorimetry in cement and concrete testing.

Isothermal calorimetry measures the heat generated by a cementitious binder as an indicator for the rate of reaction. Isothermal calorimeters, as opposed to semi-adiabatic calorimeters, allow for testing at controlled temperature, thus enabling accurate studies of temperature effects on the rate of reaction. The curing temperature greatly affects the reaction rate and thus the engineering properties of cementitious materials.

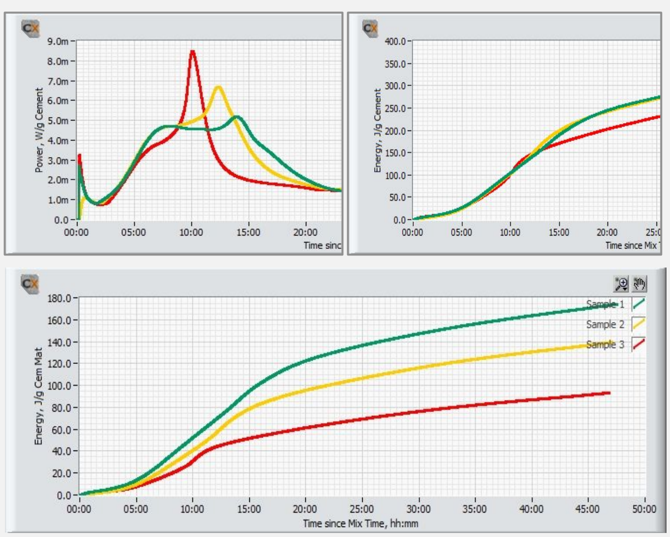
I-Cal 4000 HPC High Precision Calorimeter for Cement / Concrete Professionals.

The I-Cal 4000 HPC is an 4-channel Isothermal Calorimeter that can be used to test cement paste, mortar or **even real concrete**. Testing on real concrete is particularly important to detect unwanted interactions between complex admixture molecules and binders. A thermal hydration curve is plotted as the ambient temperature around the sample is kept constant. The temperature is easily



set via software interface with a feedback loop to ensure optimal control, while precision sensors measure the heat flow generated by the cementitious binders reacting in concrete during the first days. I-Cal 4000 HPC features Calmetrix's proprietary system of variable reference cells to adjust the thermal reference mass for each sample, thereby allowing for increased flexibility and better precision, while its configuration of individual cells reduces cross-talk. I-Cal 4000 HPC complies with ASTM C1679 and ASTM C1702, and is recommended for heat of hydration measurements of up to seven days.

Example: analyze performance of blends with high cement substitution levels
(Applicable Instruments: any I-Cal instrument)

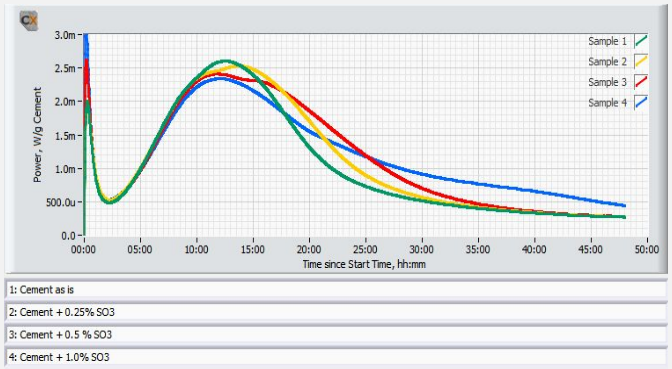


Calorimetry is a convenient tool to assess the performance of blended cements. In this example, we are studying three blends, with 50%, 60% and 70% slag (green, yellow and red, respectively). The top left graph shows power normalized by mass of cement. The narrow and more intense main peak of hydration is indicative of an issue. The upper right graph shows total heat of hydration also normalized by mass of cement. The overlapping green and yellow curves show that increasing slag from 50% to 60% does not disrupt the cement hydration reaction. But the red curve is well below, indicating that the increase from 60% to 70% slag has a negative effect on cement hydration. This is likely attributable to sulfate depletion as aluminate glass present in the slag consumes sulfate in the cement to a point where it can no longer retard the aluminate reaction.

The bottom graph shows heat of hydration (energy) by mass of total binder (cement + slag). Heat of hydration is closely correlated to strength gain, especially at early ages. Therefore, the gradually decreasing energy is expected, as higher cement substitution rates are known to have a decreasing effect on early strength gain.

Data generated by I-Cal is retrieved and analyzed with Calmetrix's state-of-the art CalCommander software, which combines ease of use and a suite of analytical tools. CalCommander includes software tools for reporting, the determination of activation energy, set time estimation, compressive strength prediction, heat of hydration testing and sulfate optimization.

Example: sulfate optimization using the depletion peak
(Applicable Instruments: any I-Cal instrument)



Many issues of adverse interaction between admixtures and other materials in concrete are caused by sulfate imbalance. With an isothermal calorimeter, it is easy to optimize sulfate forms and total SO_3 for cements, both with and without admixtures in the mix. This example shows the effect of SO_3 addition to a cement without admixture on the rate of the hydration reaction.

The Cement "as is" (green) has no visible sulfate depletion peak. Addition of sulfate in (0.25%, 0.5% and 1% in the yellow, red and blue curves) moves the sulfate depletion to a later time relative to the main peak. The total energy increases until an optimum is reached, likely in-between the red and blue curves.

Applications and uses.

I-Cal 4000 HPC is a high precision calorimeter with a large sample size, which makes it suitable for all applications in cement and concrete applications. Like Calmetrix's other isothermal calorimeters, the I-Cal 4000 HPC's main uses are found in R&D and Investigative work on concrete properties, and daily QC needs in Cement and Concrete production.

I-Cal 4000 HPC is typically used to perform the following tasks:

- prediction and estimation of compressive strength or setting times
- sensitivity tests on temperature variations
- testing and resolution of sulfate imbalance issues
- determination of heat of hydration of cement (e.g. ASTM C1702) or cementitious materials
- mix design optimization, selecting type and dosage of admixture, SCM
- troubleshooting complex mixes, detect potential material – admixture incompatibility
- sensitivity tests on variations in admixture or other material content
- determination of activation energy for maturity, strength and thermal crack prediction

Users of I-Cal 4000 HPC can be found in laboratories of Cement Producers, Universities, Concrete Producers, Fly Ash Distributors, Admixture Producers and Testing Laboratories.

Specifications.

Specifications			
Operating Voltage	110 - 240 VAC - 50/60Hz	Sample size	up to 125ml/~340g mortar (12oz.)
Number of Test Channels	4	Baseline over 72 hours *	
Operating Temperature Range	5 to 70°C (41 to 158°F)	Drift,	< 0.05 μW/g/h
Ambient Temperature Range	5 to 40°C (41 to 104°F)	Random noise	< +/-2 μW/g
Software Compatibility	CalCommander on Windows XP or later	Dimensions	L21.5"xW16.5"xH22" (55 cm x 42 cm x 56 cm)
Max.recommended test duration	7 days	Weight	104 lbs (47 kg)

* Baseline is measured at 23 °C for 3 days on a 50 g sample. A straight line is fitted to the power (J/g/s) versus time (h) data using a linear regression procedure. The long term drift is the slope and the baseline noise level is the standard deviation around this regression line.

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Calmetrix Inc.
P.O. Box 70
Arlington, MA 02476-0001 USA
T: +1 (617) 203-2090
e: info@calmetrix.com
w: www.calmetrix.com