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Focus on Reactivity

Process and Quality Control with polab® Cal

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What is polab®Cal?

An automated reactivity analyzer that measures precisely the heat evolution during the hydration of cement and clinker. This enables continuous monitoring of hydration processes, providing direct insights into the material's reactivity – a key indicator for strength development and product performance.

polab®Cal: Automated Reactivity Measurement for the Cement Industry

Precise control of clinker and cement reactivity is crucial for maintaining product consistency, optimizing resource efficiency, and reducing CO_2 emissions. polab®Cal, a fully automated isothermal calorimeter, provides a completely new approach for quantifying reactivity: fast, reliable, and seamlessly integrated into process control.

Temperature controlled environment
The isothermal heat flow calorimeter and the sample preparation unit are housed within a fully standardized, air-conditioned enclosure. This environment ensures a constant temperature throughout the entire system, precisely aligned with the internal temperature conditions of the calorimeter.

To maintain thermal stability, the internal temperature control of the calorimeter and the conditioning system operate independently. Additionally, control cabinets containing heat-emitting electronic components are positioned outside the temperature-controlled zone, to prevent any thermal interference with the measurement environment.

Automated sample handling
The complete sample handling process, from preparation and vial loading to measurement and disposal, is fully automated. The control is managed via software (AQC-net) and a programmable logic controller (PLC). Throughout all process steps, ambient and material temperatures are precisely regulated, providing stable conditions for reliable results. Hydration reactions are initiated by adding an activating fluid, typically deionized water. The conditioning system regulates the temperature of the sample material and the fluid to ensure consistent reaction behavior and fast measurement tracking.

Your advantages with polab®Cal

Main System Components:

- Housing made of lightweight metal profiles with **insulated glass windows**
- **Thermal separation** shelves for effective heat decoupling
- Integrated **air conditioning system** with precise temperature control
- **Vibrational feeder** with integrated load cell for material dosing
- **Dosing system** with high-precision pump and electrically operated **mixing unit** for suspension
- **Tempering storage** unit with max. 50 positions for pre-conditioning of the material
- **Isothermal I-Cal Flex calorimeter** with precision-controlled temperature range from 2–90°C

System Features:

- **Fully automated sample preparation:** including dosing, weighing, pre-conditioning, mixing and measurement
- **Temperature-controlled environment:** ensures constant stable conditions and reproducible results
- **High sample throughput:** enables up to 6 analyses/hour/I-Cal Flex device (depending on duration) and preparation of up to 18 samples/hour
- **Flexible lab integration:** connects to polab® lab automation or operates as a standalone unit
- **Optional calorimeter setup:** equipped with one I-Cal Flex calorimeter (8 channels), expandable to up to three calorimeters (24 channels)

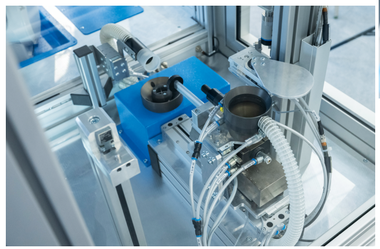
Your Benefits with polab®Cal:

- **High data density and precise reactivity analysis:** high resolution and reproducibility for real-time quality control in continuous operation
- **Early quality assessment and reducing testing effort:** monitoring real-time reactivity changes by reducing delayed physical testing for process feedback
- **New process and control parameter:** continuous monitoring of clinker reactivity and indirect feedback of material fineness
- **Advanced research capabilities:** analyzing additives and sulfate carriers or studying complex cement designs
- **Foundation for intelligent control systems:** optional software extension containing individual modules for flexible process integration

The Next Level: Artificial Intelligence meets Automation

IQCnet is a modular, AI-powered software solution designed for real-time process and quality control in cement production – driven by reactivity data from polab®Cal.

IQCnet: The Software for Intelligent Quality Control



The integration of automated isothermal calorimetry and an intelligent control software enables real-time process control in cement manufacturing. Rapid reactivity data from polab®Cal, combined with machine learning models, enables precise and proactive process adjustments.

This innovative solution marks the next step into data-driven quality control, providing cement plants a robust tool for optimizing resource efficiency and product performance. The software offers a modular approach, where each module delivers a targeted functionality allowing flexible integration across the entire production process.

Module 1 - Fineness Controller

The module dynamically adjusts separator speed to control the fineness of the material based on reactivity data from polab®Cal. Operating within predefined safety constraints, the core function is to stabilize the designated reactivity value of the final product and simultaneously keeping it at a constant level.

Module 2 – Cement Composition Controller

The module adjusts the proportions of raw materials via weigh feeder to control the chemical composition and reactivity of the final product. It ensures compliance with designated cement specifications while dynamically maintaining the target reactivity. This allows laboratories to achieve precise formulation control and simulate production conditions with high accuracy.

Module 3 – Prediction of Reactivity Value

The module uses machine learning and real-time data from XRD, XRF and particle size distribution to predict reactivity. Ongoing model training with hourly updated calorimetric data ensures adaptability across varying raw material compositions and process conditions. It accelerates control decisions and process adjustments before actual reactivity values from polab®Cal are available.

Module 3 can operate independently if analysis data from XRD, XRF, PSD and reactivity from polab®Cal are available.

Module 4 – Prediction of Expected Compressive Strength

The module supports compressive strength forecasting at 2 and 28 days. The machine learning model continuously learns from extensive process and quality data from polab®Cal, compressive strength, particle size, mineralogy and chemistry. Predictions are continuously refined by comparing them with actual strength measurements.

Module 4 can operate independently if analysis data from XRD, XRF, PSD and reactivity from polab®Cal are available.

Module 5 – Econ Decision Engine

The module integrates economic consideration that evaluates control actions based on current electricity prices and raw material costs. It combines input from fineness and composition control modules to identify the most economically viable combination of adjustments.

Module 5 operates only in combination with Module 1 and Module 2, as it depends on their control input for economic evaluation.

The modular structure allows flexible combinations adapted to specific process requirements. Below are selected configurations showing exemplarily application scenarios:

Configuration	Requirements	Key Benefits
Module 1	Separator speed, reactivity	Dynamic fineness adjustment based on reactivity data
Module 1 + 3	XRD, XRF, PSD, reactivity, separator speed	Early reactivity prediction & dynamic fineness adjustment
Module 1 + 2 + 4	XRD, XRF, PSD, reactivity, separator speed, weigh feeder, compressive strength	Composition & fineness control combined with predictive strength forecasting
Module 1 + 2 + 3 + 5	XRD, XRF, PSD, reactivity, separator speed, economic data from electricity & raw materials	Integrated process optimization based on cost efficient control decisions

Your Benefits with IQCnet:

- **Closed-loop control mechanism:** continuously monitors and adjusts process parameters for a stable and optimized production process with minimal human intervention
- **Cost-efficient operation:** calculates the optimal control step combination based on cost-benefit analysis
- **Faster response and proactive adjustments:** predictive models enable earlier interventions throughout production process
- **Flexibility:** modules can operate independently or be combined, depending on specific requirements and applications
- **Early insights:** into product performance due to integrated prediction models
- **Fallback mechanism:** allowing uninterrupted operation if analytical devices (e.g. XRD) are temporarily unavailable

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