

Water / Chemical Mixture Concentration Measurement



Water/chemical mixture concentration can be accurately monitored across the full 0 to 100% range using a Kemtrak DCP007-NIR photometric process analyzer. Near-infrared (NIR) spectroscopy is the ideal technology for this application because it transforms concentration measurement from a periodic laboratory check into a continuous real-time data stream.

Compared to offline laboratory testing, inline NIR measurement eliminates the cost of chemical reagents, removes human error in manual sampling, eliminates the sampling delays of 30–60 minutes typical of laboratory methods, and allows immediate process adjustments – ultimately reducing off-spec product and increasing yield.

Unlike conductivity sensors, which are commonly used but non-linear across wide concentration ranges and sensitive to ionic contaminants, NIR measurement provides accurate, specific results across a 0–100% concentration range for a broad range of chemical systems including alcohols, glycols, caustics, organic solvents, and acids.

APPLICATION SCOPE

The table below summarizes recommended measurement configurations for common water/chemical mixture applications. Depending upon water measurement range and individual chemical background absorbance, optical pathlengths are in the range 0.5 – 3mm.

Chemical Class	Considerations
Water / Alcohol (e.g. ethanol, IPA)	Isosbestic point available; measure at ~1440 nm to minimize temperature sensitivity
Water / Glycol (e.g. MEG, DEG)	Lower volatility; background absorption moderate
Water / Acid (e.g. H2SO4, HCl, HNO3)	Corrosion-resistant wetted materials required; short OPL for high concentration acids
Water / Caustic (e.g. NaOH, KOH)	Window fouling risk; reference wavelength compensation important
Water / Organic Solvent (e.g. acetone, THF)	Volatility compensation critical; inline measurement strongly preferred over sampling

MEASUREMENT PRINCIPLES

NIR Absorption and the Hydroxyl Band

Water is readily measured in the near-infrared region of the light spectrum using its characteristic hydroxyl (O-H) absorption. The approximately 1400 nm region corresponds to the first overtone of the O-H stretch vibration in both water and ethanol (Figure 1), and is the recommended

measurement region for water concentrations greater than 1%.

At this wavelength, the water signal is strong and clearly separated from other common background absorbers, enabling precise and selective measurement. A second, broader combination band appears near 1900–1950 nm and can provide complementary measurement capability in some applications.

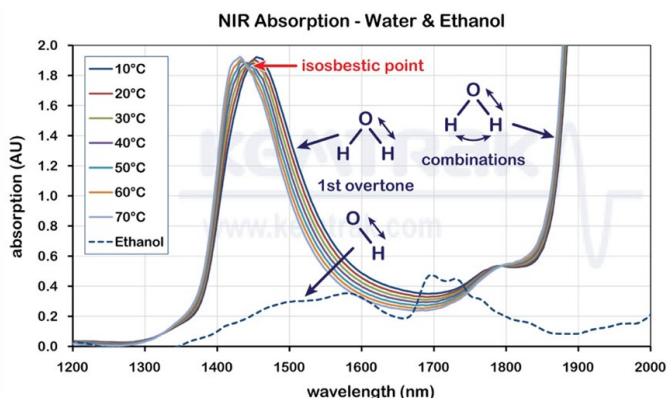


Figure 1: NIR absorption spectra of water (10°C–70°C) and ethanol. The isosbestic point at approximately 1440 nm is the recommended measurement wavelength, as total absorbance is independent of temperature at this point. The reference wavelength should be placed below 1300 nm where absorption is minimal.



Isosbestic Point and Temperature Compensation

An isosbestic point is a specific wavelength at which the total absorbance of a mixture remains constant regardless of temperature, because the individual component spectra intersect at that point. As shown in Figure 1, the water/ethanol system exhibits an isosbestic point at approximately 1440 nm. Configuring the photometer to measure at this wavelength minimizes sensitivity to temperature-driven spectral shifts.

For highest accuracy, operation at the isosbestic point and/or stable temperature (variation less than 10°C during operation) is recommended. If neither condition can be met, the DCP007-NIR accepts an external temperature signal (4–20 mA or PT100) to apply an absorbance compensation correction..

Background Absorption and Optical Pathlength Selection

The absorption contribution from the non-water component(s) is referred to as the background absorption. The water measurement signal is derived from the difference between the total absorbance and this background at the chosen measurement wavelength. For example, in a water/ethanol mixture at 1440 nm with a 1.5 mm optical pathlength (OPL), this difference is approximately 1.7 AU.

Optical pathlength (OPL) is the physical distance light travels through the sample inside the measurement cell. (Figure 2). A longer OPL increases sensitivity but also increases total absorbance. The OPL is selected based on the expected background absorption of the specific chemical system:

- The maximum total absorbance (A_{total}) must not exceed 3 AU. Exceeding this limit causes detector saturation and non-linear response, degrading measurement accuracy.
- As a practical rule, the water-free chemical background absorbance should not exceed 1 AU, leaving headroom for the water signal.
- For high-background systems (e.g. concentrated acids or strongly absorbing organic solvents), a shorter OPL (0.5–1 mm) may be used although it should be noted that this can affect measurement resolution. For low-background systems, a longer OPL is appropriate to maximize sensitivity.

The OPL is factory set.

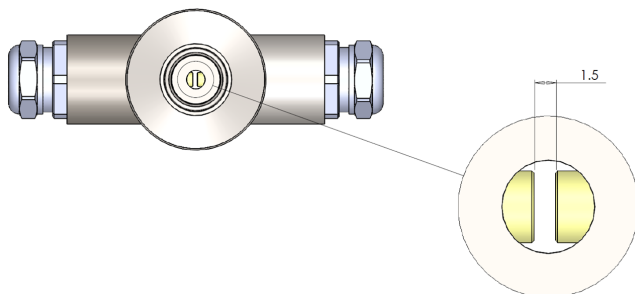


Figure 2 Example of a Photometer Inline Measurement Cell with 1.5mm Optical Pathlength

Reference Wavelength

In addition to the measurement wavelength, the DCP007-NIR uses a reference wavelength to detect and compensate for changes in sample clarity caused by non-dissolved substances, particulates, and window fouling (coating build-up on the optical windows). The reference wavelength is placed where sample absorption is minimal – typically below 1300 nm, as shown in Figure 1.

Volatility and the Advantage of Inline Measurement

An often-overlooked source of error in offline laboratory testing is volatility. For mixtures containing volatile components (such as alcohols, ketones, or low-boiling solvents), preferential evaporation during sample collection and transport causes the sample composition to shift before measurement. The laboratory result therefore reflects a degraded sample, not the actual process chemistry.

The DCP007-NIR measures the process in real time, under process pressure, within a sealed system. This eliminates volatility-related sampling errors entirely and ensures that the measurement reflects the true concentration in the pipe.

Concentration Range and Resolution

With a photometric resolution of 0.001 AU, the DCP007-NIR achieves the following concentration resolution at the 1400 nm region:

- 0–100% range: $\pm 0.05\%$ (± 500 ppm)
- 0–10% range: $\pm 0.01\%$ (± 100 ppm)

For applications requiring detection from trace to 1% water concentration, an alternative wavelength/OPL configuration is necessary.

INSTRUMENT: KEMTRAK DCP007-NIR



Figure 3 DCP007-NIR Field Mounted Process Photometer Unit

The Kemtrak DCP007-NIR (Figure 2) is a rugged, inline photometric process analyzer designed for precise, continuous concentration monitoring. Using LED technology for light generation and fiber optics to connect to an inline measurement cell, the DCP007-NIR provides accurate, drift-free measurements directly in the process stream as

opposed to sample extraction and offline testing.

The instrument operates at up to two discrete wavelengths in direct and/or referenced absorbance mode. A wide variety of measurement cell types with multiple available optical pathlengths enables adaptation to virtually any liquid process application.

Unlike conventional photometers, the DCP007-NIR features a zero-maintenance design with long-life solid-state LED light sources, automatic zeroing, and no moving parts – ensuring high reliability, minimal downtime, and a very low total cost of ownership.

INSTRUMENT SPECIFICATIONS

Parameter	Value	Notes
Measurement range	0–100% water / chemical	Subranges can be configured
Accuracy	±0.05%	0–100% range
Resolution (0–100% range)	±500 ppm (±0.05%)	Assumes 1.5mm OPL
Resolution (0–10% range)	±100 ppm (±0.01%)	Assumes 1.5mm OPL
Photometric resolution	0.001 AU	
Measurement wavelengths	Up to 2 discrete	Factory configured
Recommended NIR region	~1400 nm (1st overtone)	Range >1% water concentration
Max total absorbance (A _{total})	≤ 3 AU	Exceeding causes non-linearity
Max background absorbance	≤ 1 AU	Water-free chemical background
Temperature compensation	External signal input (4-20mA or RTD)	Required if ΔT > 10°C or non-isosbestic operation
Process connection	ANSI/DIN Flange, NPT/G Thread, Triclamp Sanitary Flange. Others available	
Light source	Long-life LED	Zero maintenance
Interface	Ethernet-based interface	Configuration & data up/download



DCP007-NIR FEATURES

- **Real-time continuous measurement:** Immediate process feedback; no waiting for laboratory results
- **Inline, sealed measurement:** Eliminates volatility errors and sampling-related inaccuracies
- **Isosbestic point operation:** Minimizes temperature sensitivity without external compensation
- **External temperature input:** Enables accurate measurement when temperature varies > 10°C
- **Reference wavelength compensation:** Corrects for window fouling and particulates automatically
- **Zero-maintenance LED light source:** No lamp replacements; long service intervals; low cost of ownership
- **No moving parts:** High reliability and minimal downtime in industrial environments
- **Automatic zeroing:** Drift-free measurements without manual baseline adjustment
- **Fiber optic connection to cell:** Electronics isolated from harsh process environments
- **Web-based interface:** Remote configuration, monitoring, and data export from any browser
- **Wide OPL / cell selection:** Adaptable to 0–100% range across alcohols, glycols, acids, caustics, and solvents
- **Outperforms other sensors:** Specific, linear response across full concentration range; unaffected by ionic contaminants

GET IN TOUCH

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