

KEMTRAK

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TECHNICAL NOTE

Kemtrak manufactures a range of industrial photometric analyzers
for real-time concentration, color & turbidity control.

NBP007

v1.00

Publisher

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TECHNICAL NOTE

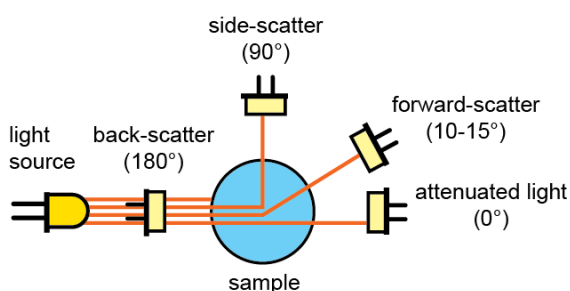
NBP007

- Measurement of suspended solids, emulsions, suspensions, dispersions & foams
- Concentration measurement
- Interface detection
- Cell & biomass density
- Crystallization control
- CIP cycle control & optimization
- Product differentiation & identification

HOW THE TECHNOLOGY WORKS

The Kemtrak NBP007 measures the amount of suspended solids in a sample using backscattered light. Suspended solids is a general term that will be used in this bulletin, however it refers to emulsions, suspensions, dispersions & foams. The suspended phase may be either solids *e.g.* calcium carbonate or two immiscible liquid phases *e.g.* milkfat or a gas in a liquid (*foam*).

The measurement of backscattered light is also a measurement of turbidity, however one must be aware of significant differences between backscattered light (180°) and other turbidity measurement technologies such as attenuated light measurement (light passing directly through the sample at 0°), forward-scattered light (typically 10-15°) and side-scattered light (at 90° in accordance with ISO 7027:1999).



Attenuated, forward and side scatter turbidity measurement techniques requires light to enter into the sample, be scattered by particulates suspended in the sample and then emitted. As light must pass through a distance of sample before being emitted, it is essential the optical density *i.e.* concentration of particulates in the sample, is not too high or no light will be emitted. Such techniques are typically used for low and very low sample

concentrations or turbidities (<1% total suspended solids down to 0.0005% or 0.01 – 4000 FNU/NTU).

Backscatter differs in that a region of sample is illuminated and the light scattered back from the region of illumination is measured – light does not have to pass through the sample before measurement. As the concentration of the sample varies, more or less light will be scattered back to the detector making this measurement technique suitable to measure all the way up to 100% solids. The lower limit or measurement resolution of backscatter is typically around 0.001% suspended solids or 10 FNU/NTU.

Scattered light measurement is a function of concentration and particle size and to a lesser extent refractive index and color. If you intend to measure concentration using any scattered light measurement technology then it is essential the particle size is constant. Samples where the refractive index of the suspended particles and continuous phase are similar, will not scatter light (light will pass straight through the sample) and should be avoided *e.g.* sweetened condensed milk. As the measurement is made in the near infrared (NIR, 850nm and higher) sample color generally has no influence – however if the sample is known to be highly colored the influence of the color should always be checked in advance.

A unique benefit of the [Kemtrak reflectance probes](#) is that they will not go blind at any concentration of suspended solids. The output of the [Kemtrak NBP007](#) will continue to increase with sample concentration ensuring a reliable measurement at any concentration. The NBP007-L (low range) analyzer is recommended for process concentrations up to 10% total solids, while the NBP007-H (high range) analyzer should be used for accurate monitoring of suspended solids exceeding 10%.

INSTALLATION GUIDELINES

For total suspended solids measurement, it is essential to install the probe at a location where particle size is constant (homogenized sample), the sample is free from entrained air and at a location where temperature is stable.

- 1. Interface detection:** Our main success today has been with interface detection - typically product-product and product-water interfaces as there are many such interfaces in a dairy/creamery. What the NBP007 can do is measure at all concentrations during the transition that will allow the operator to know exactly when to collect product. Other products generally only indicate when the pipe contains water, not full concentration product. The NBP007 increases efficiency (more product, reduced start-up times) plus reduces waste which is costly to treat. The greatest advantage with this application is that improvements are easily measurable and realized in terms of cost reduction (e.g. reduction in time, increase in product, reduced waste etc.).
- 2. Milk fat measurement:** It is essential that the dairy sample is homogenized. So long as the sample is homogenized then we can measure milk fat concentration anywhere in the dairy/creamery.

What is homogenization?

Since milk is an oil and water combination, it doesn't stay mixed. When a cow is milked, and as the milk settles, a layer of cream forms at the top of the milk. Homogenized milk is run through tiny tubes, sometimes during the pasteurization process to keep fat and liquid molecules together. Fat molecules are reduced in size and tend to disperse more evenly throughout the milk so that creaming on the top of milk doesn't occur.

For dairy applications where fat concentration measurement is desired, it is recommended to install the measurement probe after a separator and the pasteurizer (early in the process to avoid risk of fat damage in the product) and at a location where the temperature is stable. The process media must be free from entrained air and homogenized to ensure the particle size distribution is constant.

A calibration must be made with the process sample using laboratory data, a simple procedure typically taking a few hours to complete.

For standardization or determination of milk fat at lower concentrations (typically <5%), it is essential that the particle size distribution and background signal from the non-fat components are consistent. The non-fat components, primarily the dispersed protein casein micelles, will gradually vary over the course of a year so regular recalibration will be required. While the resolution of the instrument is ca. 0.001% total suspended solids, experience has shown that it is not possible to monitor milk fat concentration with greater than 0.1% accuracy. This is because the protein micelles are significant in relation to the signal from the milk fat and poor separator efficiency and variations in the homogeneity of the process media often results in a noisy signal below 0.1% solids concentration.

It is not possible to measure the scattered light of samples with high refractive index at concentrations above ca. 15% solids, notably sweetened dairy products such as sweetened condensed cream.

- 3. Product damage:** So long as the product does not change in concentration, any change in measurement is due to changes in the particle size which is a result of excessive shear forces during manufacturing (pumping, piping, mixing etc).

The NBP007 can measure changes brought about to a cream sample by the application of shear forces, such as the beating cream until it becomes butter. The beating process adds shear force to the oil in water emulsion of the cream causing the particle size to change until the phases invert (the oil-in-water emulsion becomes a water-in-oil emulsion) which is butter. It is normal to thicken cream during food processes however if the emulsion inverts (goes from water continuous to oil continuous) the entire batch must be discarded. The NBP007 can measure at every point in this process - before, at and after the phase inversion point. Existing technology

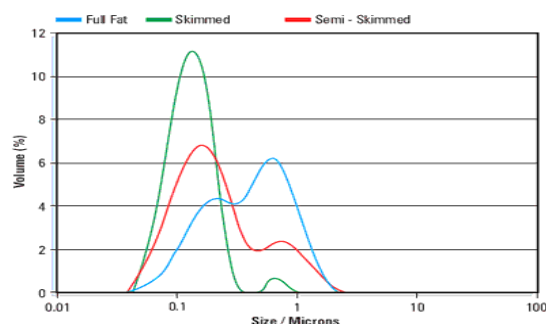
only indicates when it is too late and the product must be discarded.

4. **Particle size changes:** The size range interval where the particle size difference becomes wavelength dependent is in the region from 0.05 to 0.3 μ m.

The NBP007-L simultaneously measures at two wavelengths e.g. 850nm and 470nm, and the change in the ratio of the backscatter of each wavelength is an indication of particle size change. This measurement is relevant for applications in the pulp & paper segment where whiteness is a key control factor. We have also considered this measurement for dairy applications however we only offer this function as an experimental feature at no additional cost.

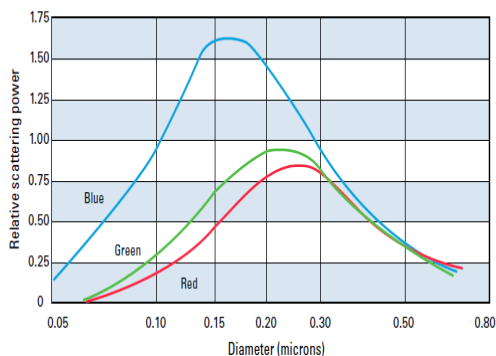
Here is a quick discussion of how the technology works.

This is a typical particle size distribution of milk:



Here is the wavelength dependence on scattering:

Figure 7. Relative Light Scattering Power versus Rutile Particle Size.



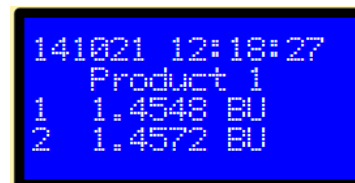
Here are some results from the NBP007 measuring milkfat samples simultaneously at 850nm and 470nm.

1. This is what the display of the instrument looks like when zeroed:

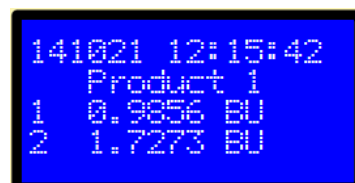


The first channel (1) is 850nm and the second channel (2) is 470nm

2. A piece of solid paper placed in front of the probe essentially scattering both signals equally (100% solids do not have a particle size dependence):



3. The probe is placed in 1.5% homogenized milk

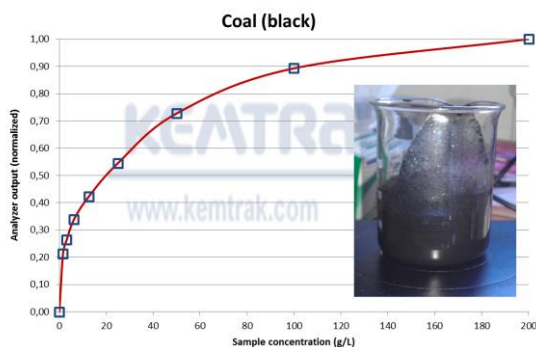
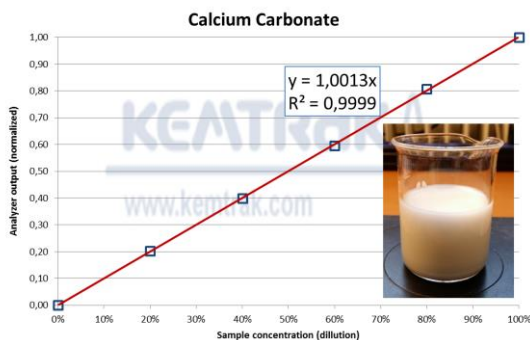


Note that there is 1.75x more signal (scattering) on the milk sample at 470nm than at 850nm.

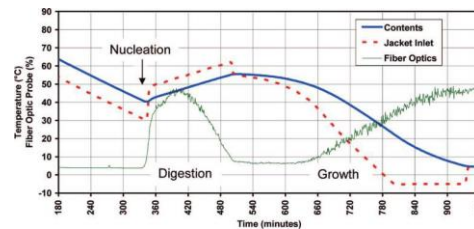
- 5. Product concentration:** The Kemtrak NBP007 can monitor virtually any suspended solids at high concentrations. This includes slurries, emulsions, suspensions, dispersions & foams.

As scattered light measurement is a function of concentration and particle size (and to a lesser extent refractive index and color), it is essential that the particle size is constant when measuring concentration.

Some examples of concentration measurement include calcium carbonate, titanium dioxide, silica, alumina and even black carbon.



- 6. Crystallization:** The Kemtrak NBP007 can be used to aid in the control of commercial batch size crystallization processes. In a typical control scheme, the fiber-optic probe is used to detect an initial nucleation event, to control a subsequent digestion step for fines dissolution with the potential for modification of nuclei size, number, and purity, and then to monitor a growth period.



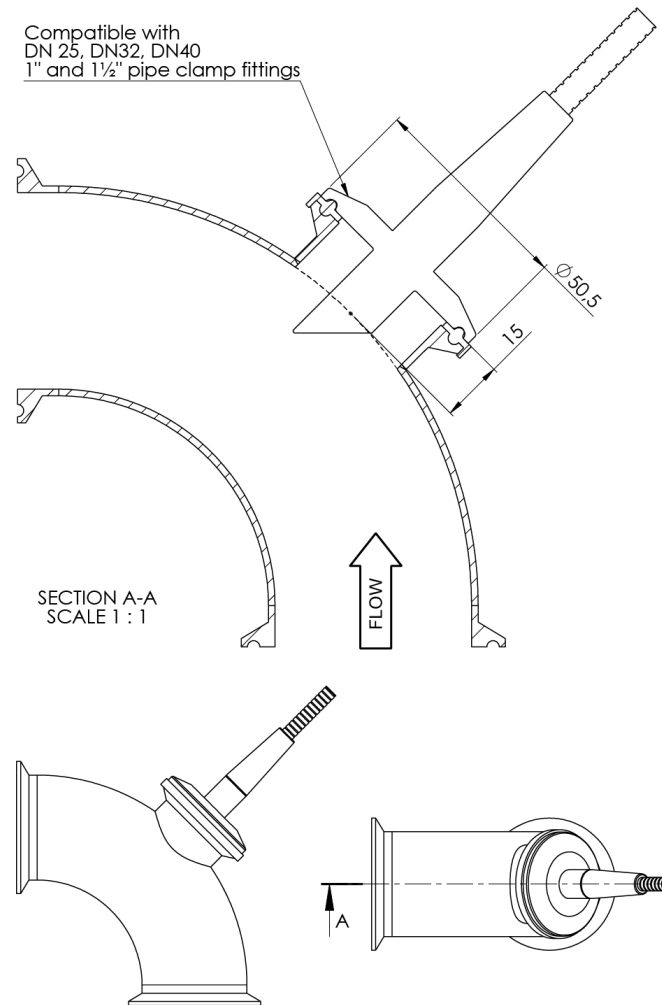
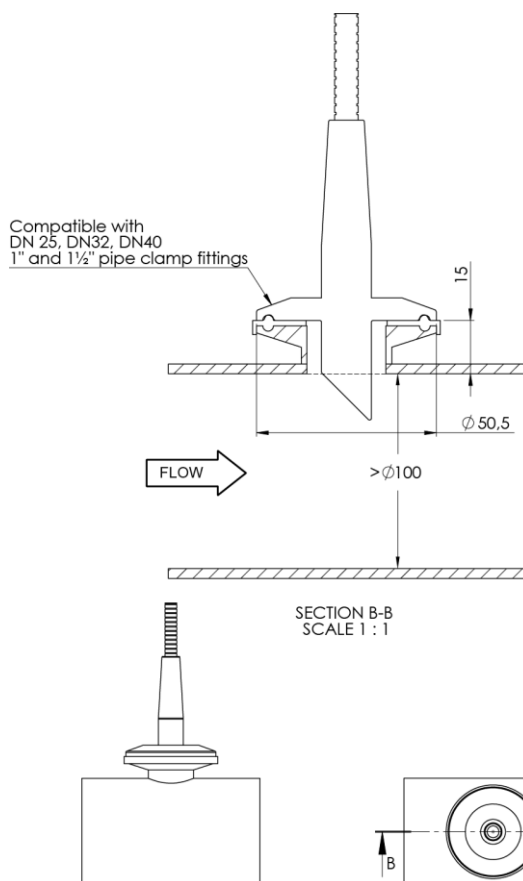
Typical fiber-optic signal profile and temperature curves. The example is for cooling crystallization of a compound using a commercial-scale (12,000 L) crystallizer. (Source: Use of a Fiber-Optic Turbidity Probe to Monitor and Control Commercial-Scale Unseeded Batch Crystallizations, The Dow Chemical Company, Organic Process Research & Development 2009, 13, 114–124).

- 7. Other Applications:** The Kemtrak NBP007 can also be utilized to monitor separator efficiency, product identification, and can detect small changes in concentration resulting from leaking valves.

MOUNTING THE BACKSCATTER PROBE

The backscatter probe should be installed so that the distance from the pipe wall is 10cm (4") or greater. If this is not possible, it is recommended to install the backscatter probe on a pipe bend or installed sloped, at an angle between 15 and 45°.

Model NBP007 TriClamp® backscatter type probe



Model NBP007 PG13.5 backscatter immersion type probe

