

Detecting the Hidden Features in the Plastic

With the Help of TAGTEC Technology



The TAGTEC Technology

TAGTEC markers are based on inorganic luminescent particles that are highly resistant and insensitive to chemical and physical influences. This means that plastic products can still be reliably identified and recycled even after long life cycles, high levels of contamination and heavy use. With a particle size between $2\mu\text{m}$ and $8\mu\text{m}$, the markers are invisible to the human eye and do not change the product properties due to their small size and number of particles.

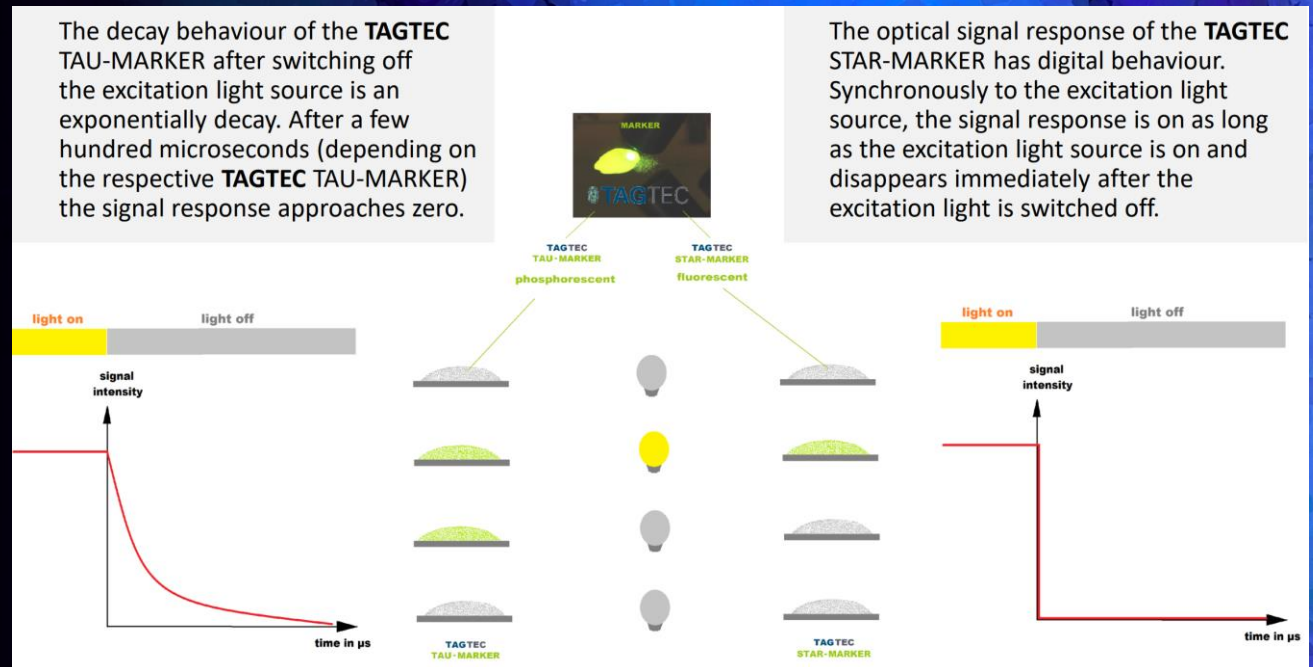
Another advantage of marking based on these luminescent particles is that they are toxicologically harmless, are even approved for contact with food and meet the high requirements of the ÖkoTex standard. The pigments can be easily integrated into any plastic product via masterbatches and are firmly bonded on the matrix. Three innovative, leading companies in this field have joined forces to take the production of intelligent plastics to a new level.



Fluorescence or Phosphorescence

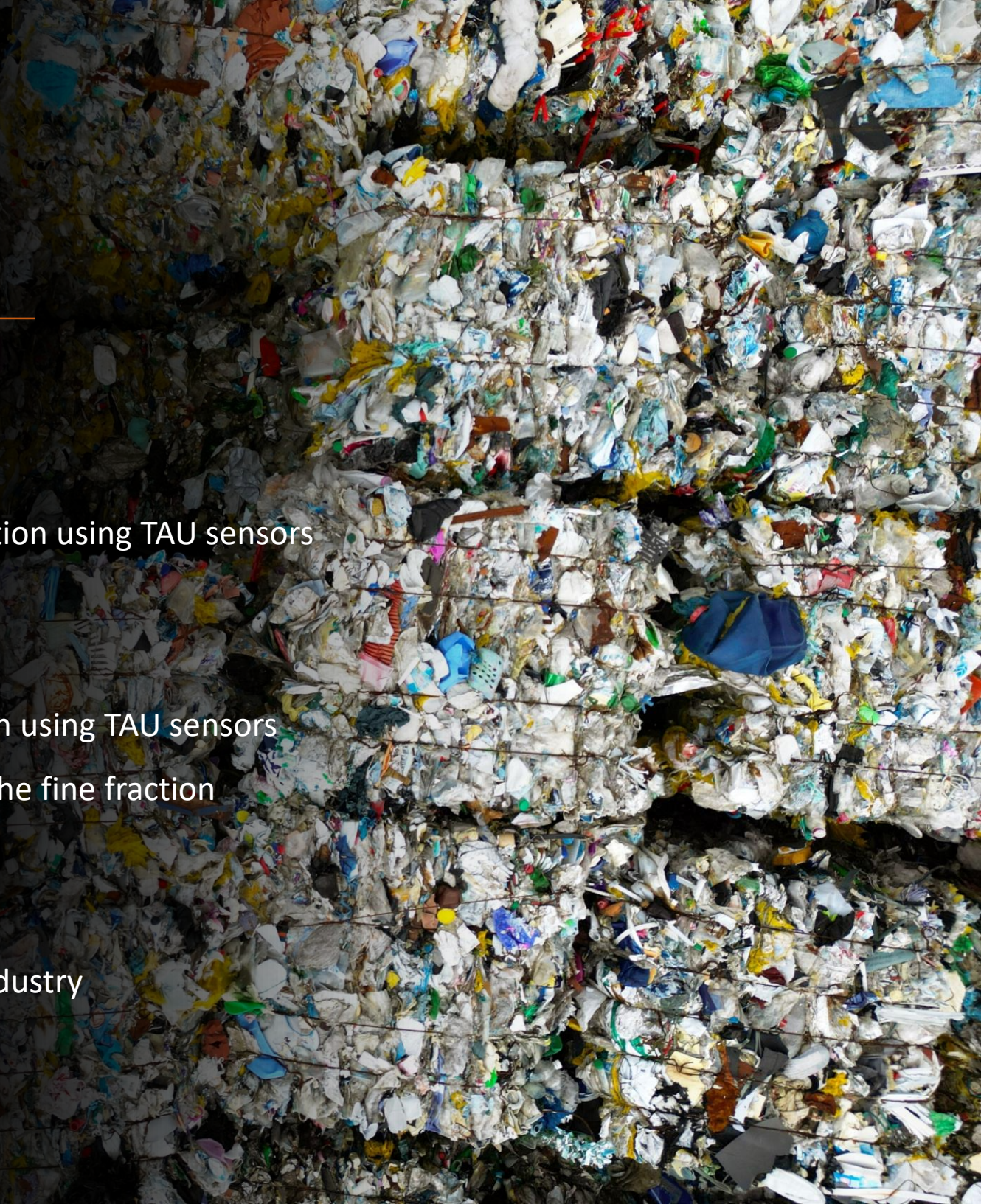
With fluorescent pigments, the material is excited with light of a certain wavelength, for example UV light (primary light) and then the optical emission of the fluorescent particles (secondary light) is detected. The secondary emission takes place in the visible or NIR range (so-called downconversion). Pigments with phosphorescent behavior show an exponentially decaying course of the secondary light after the excitation light is switched off. A characteristic value for this is the time constant TAU.

Naturally, the fluorescence of a marker must be determined during the excitation of the marker pigment, which requires optical filters to separate the primary light from the secondary light. Phosphorescent markers, on the other hand, are excited using a short but powerful light pulse. Depending on the marker type, the excitation wavelength can be in the UV, visible or NIR range. Detection takes place after the primary light source is switched off. The afterglow of the phosphorescent marker is evaluated using TAU determination.



Plastics Recycling

- Collecting the waste
- Reprocessing the plastic waste
- Separating and sorting the coarse fraction using TAU sensors
- Shredding the coarse fraction
- Cleaning the fine fraction
- Separation and sorting the fine fraction using TAU sensors
- Extruding, filtering and regranulating the fine fraction
- TAU checking the recyclate
- Filling the recyclate
- Deliveries to the plastics processing industry



Marker based Detection and Sorting of Plastics Using TAGTEC Technology

How can recycled PET originally from the food sector, for example, be distinguished from recycled PET from the hygiene sector, especially if both recycled products have the same color? As long as the products are still products where the shape of the packaging is largely recognizable, an AI-supported, image-processing system can provide good service. But what happens to film packaging that no longer retains its original shape or the digital code is unrecognizable, or after the original products have been shredded or extruded?

An inorganic marker is distributed homogeneously and in very small quantities in the plastic product and is also temperature-resistant, food-safe, phosphorescent or fluorescent enables reliable identification of the plastic in question throughout the entire cycle.

Sorting and Separating on the Conveyor Belt with the Help of TAU Sensors



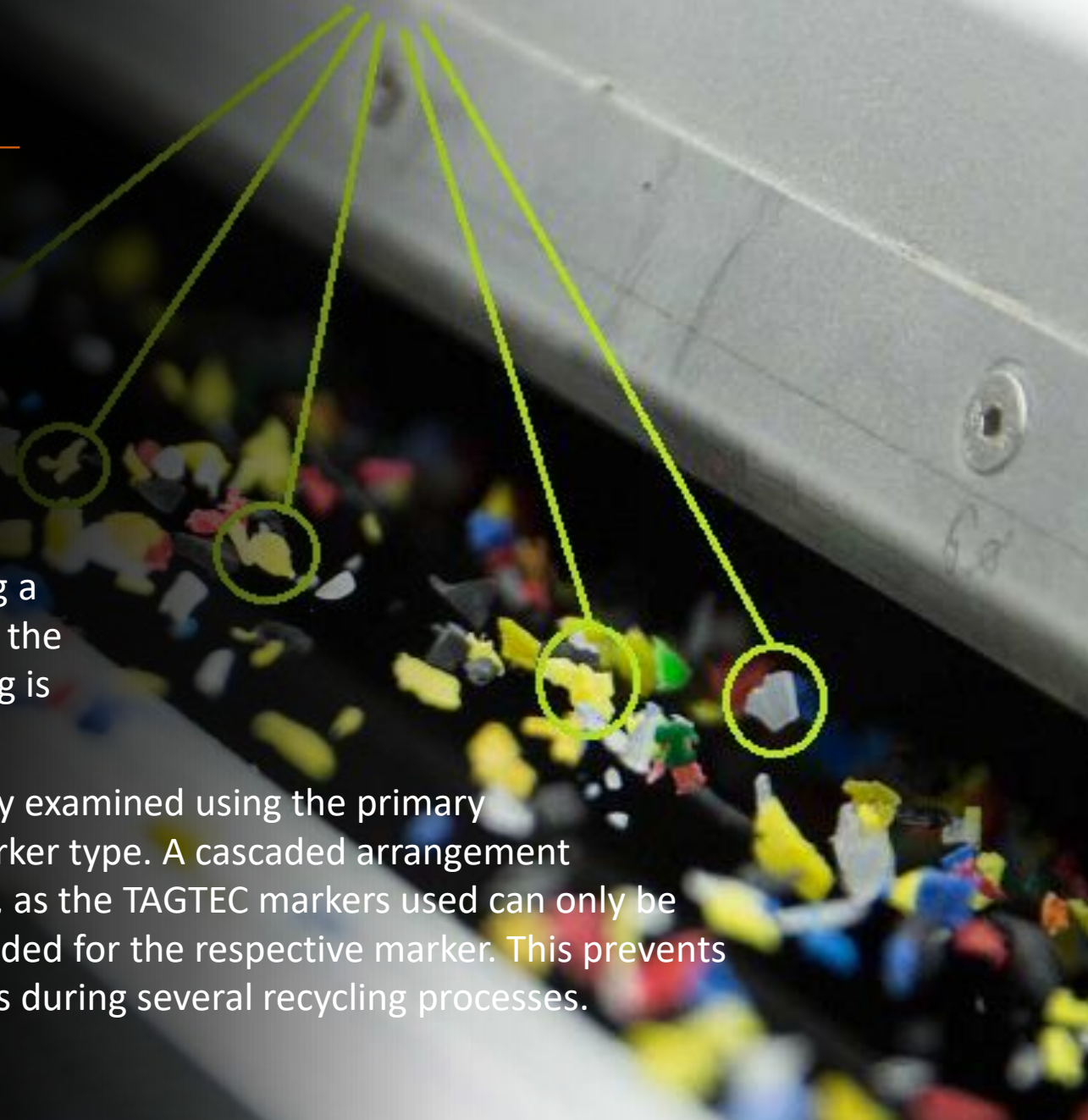
Due to high selectivity and the associated high efficiency of phosphorescent markers, TAU technology is primarily used in the recycling sector. TAU sensor technology can therefore already be used in pre-sorting (coarse fraction), for example for sorting whole, pressed plastic bottles, plastic cans or plastic canisters. Due to the relatively short time constant of less than $500\mu\text{s}$, scan rates up to the kHz range are possible.

The decay time (time constant TAU) and the marker concentration (intensity of the secondary light) are measured using a measuring bridge, which is positioned transversely and at a height distance of several hundred millimeters from the conveyor belt. The primary light generated by the sensor system extends across the entire width of the conveyor belt. After the marker is detected by the TAU sensor system, a signal is sent to the respective compressed air nozzle.

Sorting and Separation of the Fine Fraction on the Chute Using TAU Sensors

To ensure that the fine fraction can also be detected, the flakes or fragments are transported along a chute, for example. A primary light curtain combined with a line detector is arranged under the glass chute, checking each fragment for the presence of TAU markers at a scanning frequency in the kHz range. After detecting a certain concentration of TAGTEC marker in the respective plastic particles, targeted sorting is carried out using compressed air nozzles.

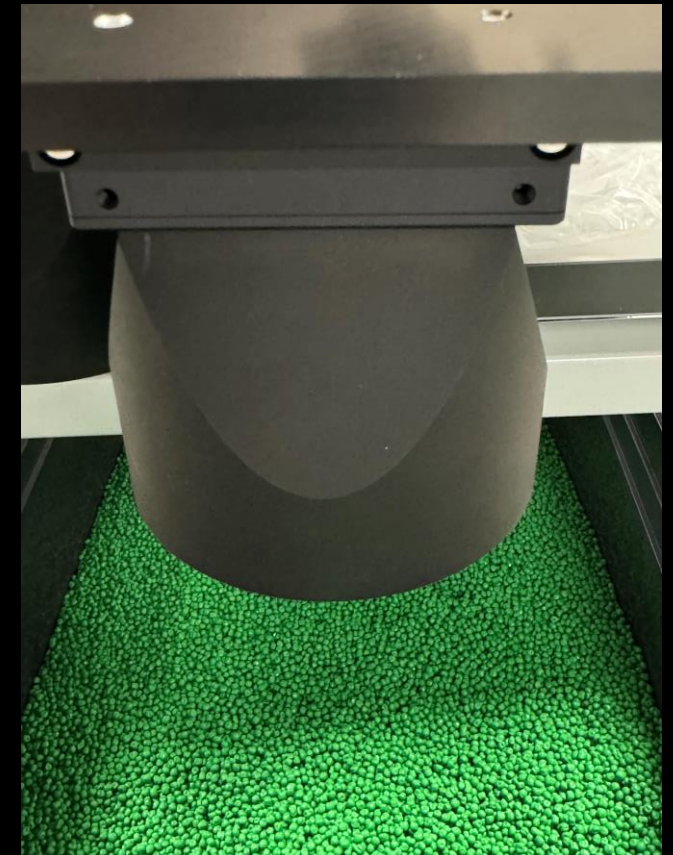
The plastic products can also be specifically examined using the primary light source suitable for the respective marker type. A cascaded arrangement allows different marker types to be sorted, as the TAGTEC markers used can only be excited with the primary light source intended for the respective marker. This prevents successive mixing of the individual markers during several recycling processes.



TAU Control during Recyclate Production

After sorting and separation of the fine fraction, extrusion takes place. As the TAGTEC marker particles survive the extrusion process without damage, the proportion of TAU-marked recyclate in the total recyclate can already be determined on the vibrating feeder. With the help of the DOCAL Windows® software, the system operator gains an insight into the concentration of the TAGTEC marker contained in the recyclate. The right inline sensor technology is available for every marker used and its concentration in the recyclate.

For example, the recyclate can be excited in the red wavelength range using an intensive light pulse (primary light), while the phosphorescent light emitted by the recyclate (secondary emission) takes place in the near infrared range (NIR). Other TAGTEC markers, on the other hand, can be excited with UV light, blue light or in the NIR range. TAGTEC markers are also known as down converters, as the center wavelength of the secondary light is always longer than that of the primary light.



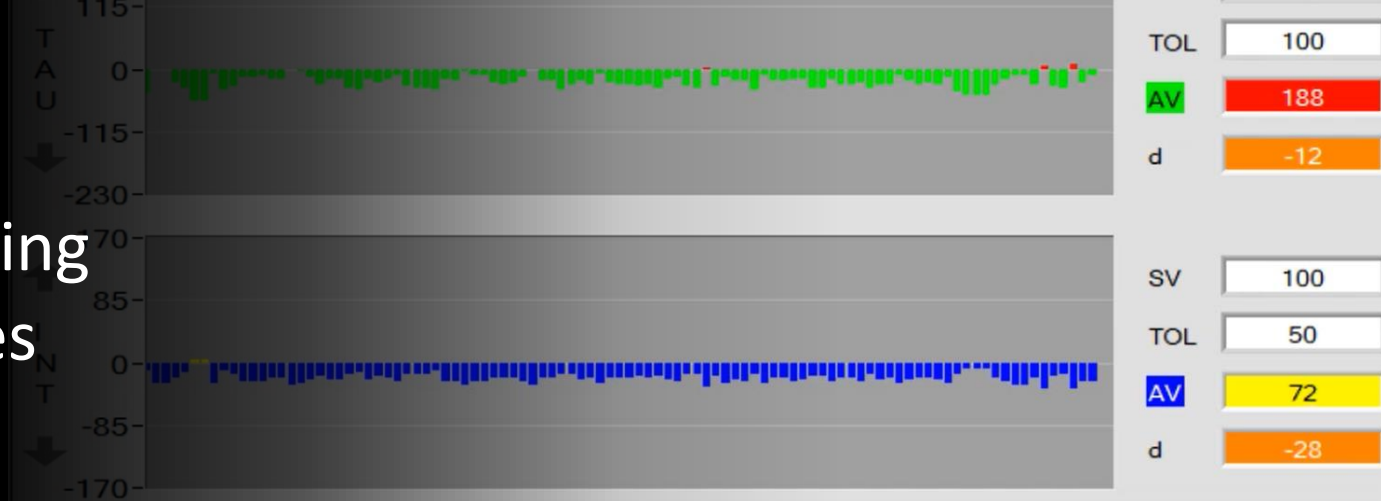
Calibration of the TAU Sensors

Calibration is extremely simple using DOCAL Windows[®] software. As with the VIS range (RAL color charts), various ceramic tiles with defined TAU value (time constant) and INT value (intensity) are available. Depending on the primary light source, an orange or white ceramic tile is used for the „white balance“. These ceramic tiles are particularly robust and durable. Each ceramic type provides a different intensity response, which means that highly accurate calibration can also be carried out on site.

Each tile is measured in the factory and given a 5-digit number. Furthermore, the TAU value and the INT value are noted on each ceramic tile by means of a label. After downloading the calibration tile file from the network and entering the 5-digit number associated with the ceramic tile, the target values are adopted.



Presentation and Recording of the TAU and INT Values Determined Inline



The DOCAL Windows® software is used to display the TAU and INT values numerically and graphically, as well as their deviation dTAU and dINT from the target value. At the same time, the data is stored in a file on the panel PC and can also be transferred via fieldbus (ProfiNet) or Ethernet.

This means that the system operator is informed of any trends in the product virtually in real time and can intervene if necessary. The QA department also has access to the data stored in a file via the serial interface and can also log into ongoing data recording while the measured values are being recorded.



Determining the Recyclate TAU and INT Values Using a Mobile TAU Measuring System

The mobile TAU measuring system can be used to monitor without a TAU sensor system installed in the production plant, but to obtain the measurement data more quickly than in the laboratory. A recyclate sample can be taken on site from production and fed to the mobile unit (hopper capacity: 11 liters). The mobile TAU measuring system is calibrated in the same way as the inline and laboratory units using ceramic tiles.

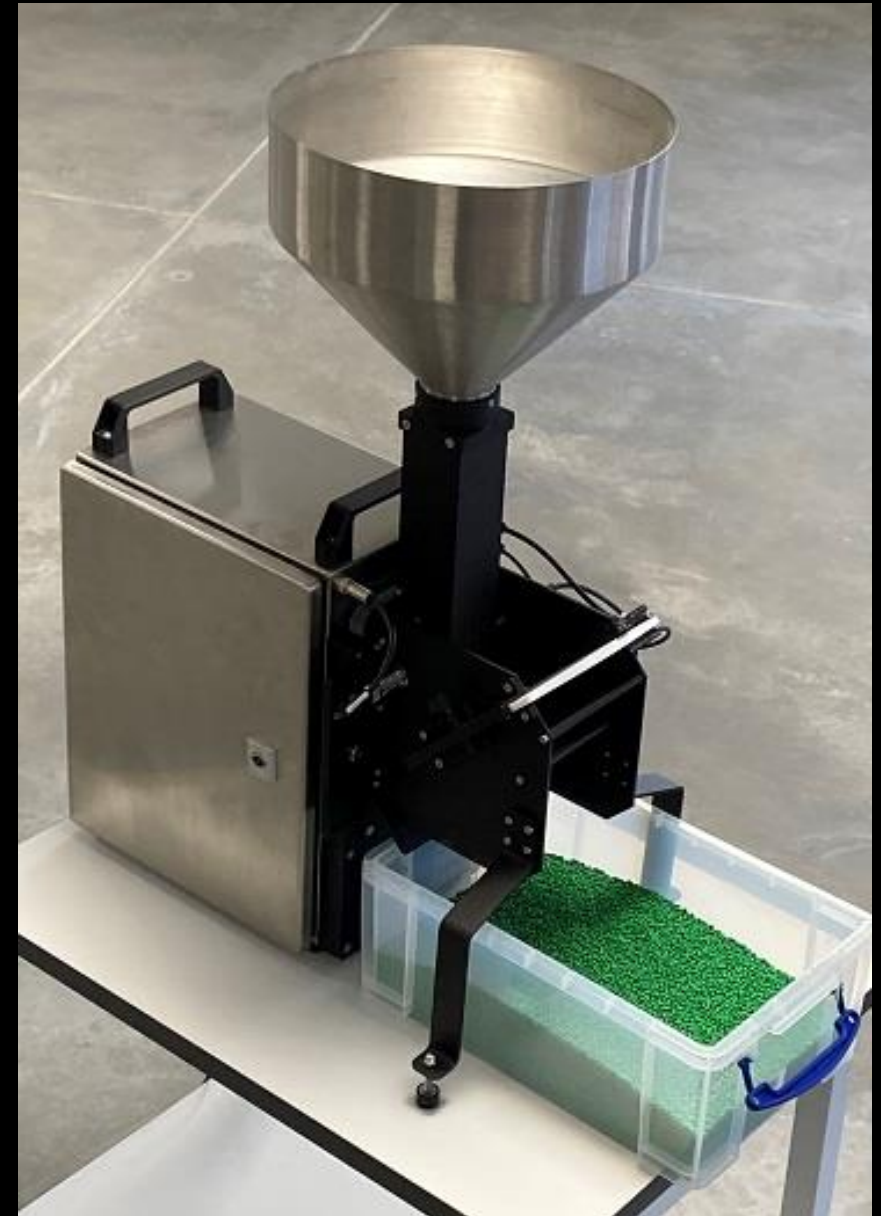
Measurements are taken over the entire quantity of recyclate fed through the hopper. The DOCAL Windows[®] software and trigger sensors start the measurement automatically and stop it again after recyclate sample has passed through. This achieves a highly accurate average value for TAU and INT, as the random position of the individual granules is compensated for.



Determination of the Recyclate Values TAU and INT in the Laboratory

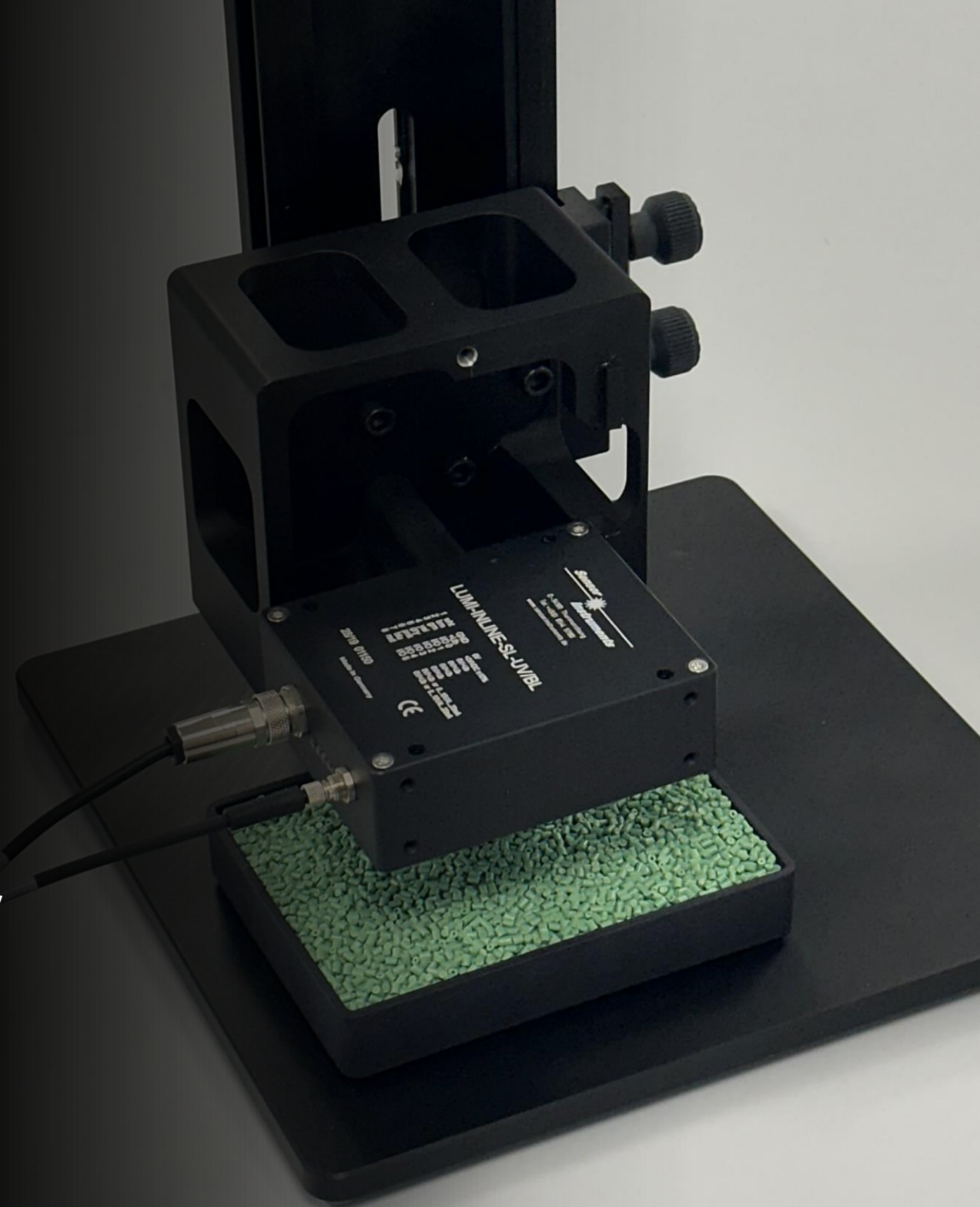
The TAU laboratory device can also be used to determine the TAU and the INT value of a recyclate sample. The high measuring accuracy is achieved by measuring the recyclate flow and continuously averaging the measured values in the DOCAL Windows® software. This eliminates the influence of the random position of the individual pellets in the light spot of the TAU measuring device.

The INT value provides information about the respective enrichment of the recyclate with TAGTEC marker particles, while the TAU value reflects the respective marker itself. The capacity of the funnel is also 11 liters. The measurement is sensor-triggered and then completed. Using DOCAL Windows® software, the TAU and INT values are displayed graphically and numerically, and the data transmitted via a serial interface (RS232, USB, Ethernet or ProfiNet).



Compact Laboratory System for TAU and INT Measurement of Recyclates

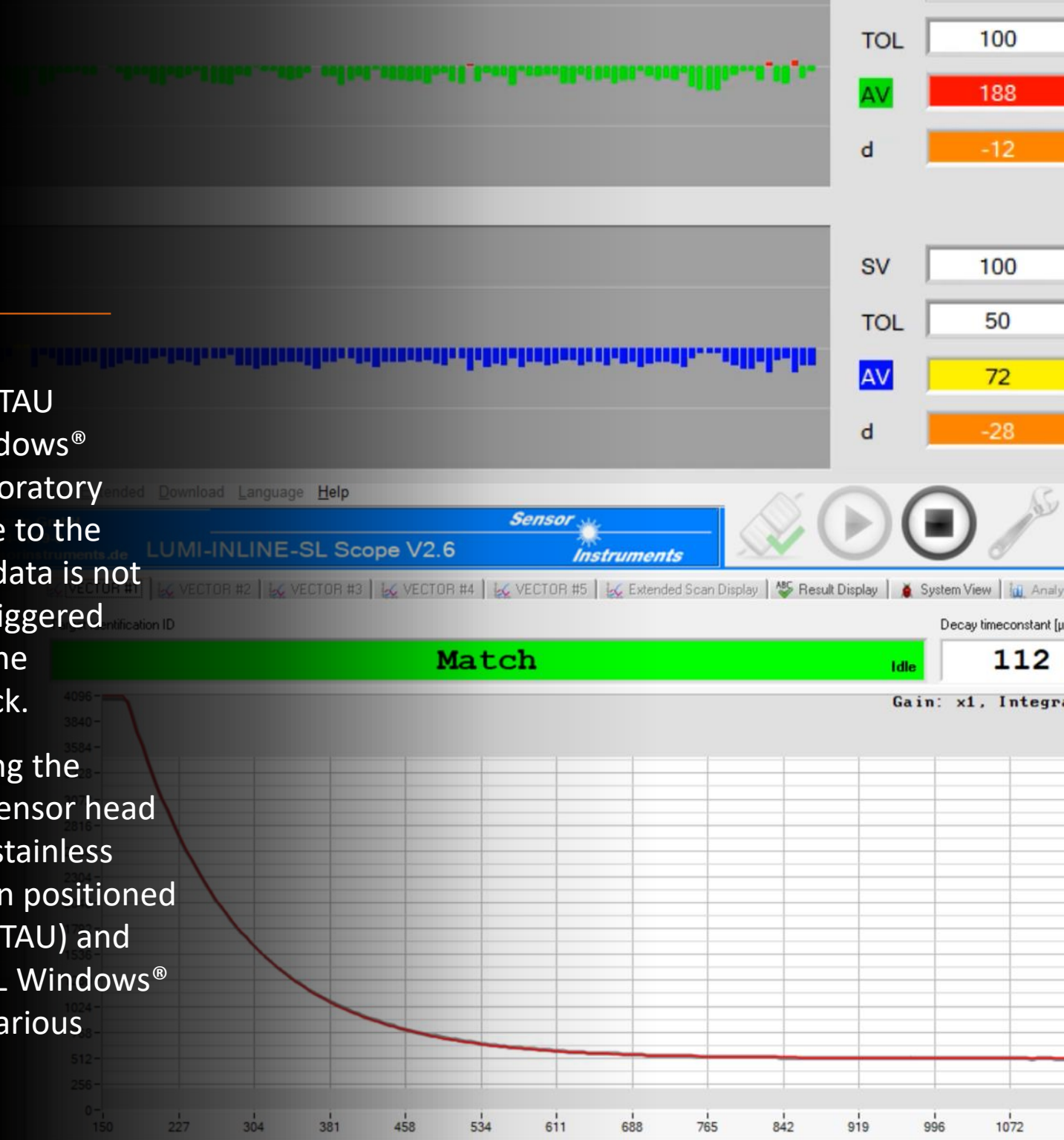
A very compact and cost-effective TAU measuring system (MST series) was realized with the aid of a measuring table top and an optomechanical rail. The recyclate sample is filled into the supplied bowls and moved sideways under the light spot in a figure-of-eight movement. This also achieves accuracy comparable to inline measurement.



DOCAL Software for Laboratory Equipment

In addition to the inline and mobile TAU measuring systems, the DOCAL Windows® software can also be used in the laboratory in the same way. The only difference to the inline use is that the measurement data is not recorded continuously, but rather triggered by means of additional sensors on the laboratory device or via a mouse click.

Calibration is carried out by loosening the two wing screws on the LUMI-TAU sensor head so that it can be removed from the stainless steel housing. The TAU sensor is then positioned on the calibration unit (CALIB-LUMI-TAU) and calibration (supported by the DOCAL Windows® software) can begin by adding the various ceramic tiles.



Plastics Processing

- **Storage of the recyclate in silos:** Modern silo systems are equipped with advanced control technology that monitors and controls the operation to ensure a smooth process.
- **Drying the recyclate:** Recyclate can absorb moisture during storage, which can have negative impact on the material properties.
- **Conveying and dosing the recyclate:** The recyclate is transported from the dryer to the processing machines. Conveying systems such as screw conveyors or pneumatic conveying systems are used for this.
- **Mixing and homogenizing:** To ensure uniform material quality, the recyclate is often mixed with virgin material or other additives.
- **Extrusion:** The mixed material is melted in extruders and pressed through a die to produce new plastic products such as films, profiles or pellets.
- **Injection molding:** Alternatively, the recyclate can be processed in injection molding machines to produce complex molded parts. Here, the material is injected into a mold and cooled under pressure.



TAU Measurement of Recyclates in the Plastics Processing Industry

Due to the increasing use of recyclates in the processing industry, the supply of TAGTEC masterbatch in the manufacture of new plastic products can be reduced by using recyclates that already contain TAGTEC markers to a certain extent, so that the end product has the intended amount of the respective TAGTEC marker.

A TAU and INT measurement of the recyclate can be carried out at various points in the manufacturing process:

- In the silo
- In the material feed hopper
- At the dosing unit

Sensor
Instruments
D-94169 Thurmsbang
Tel. +49(0) 8544 97190
www.sensorinstruments.de

LUMI-TAU-INLINE-SL-IR/IR

IO0	GND	0V	+24VDC $\pm 10\%$
IO1	+5V	0V/+5V	0V/+5V
IO2	IO0	0V/+5V	0V/+5V
IO3	IO1	0V/+5V	0V/+5V
IO4	IO2	0V/+5V	0V/+5V or 0-10V/A 20mA
IO5	IO3	0V/+5V	0V/+5V or 0-10V/A 20mA
IO6	IO4		



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Recyclate TAU Measurement at the Silo

A sight glass is mounted at a suitable point on the granulate silo and then a LUMI-TAU-INLINE sensor is placed. The TAU and INT values are also evaluated using the DOCAL Windows® software. The sight glass is also offered by Sensor Instruments, as both the type of the glass (here crown glass, B270) and the thickness of the glass are decisive for proper measuring.

Both parts of the sight glass are optimally adapted to ensure an unimpeded flow of granulate on the one hand and to place the sensor close to the product on the other. The measuring accuracy can also be increased here if measurements are taken while the pellets are moving. The random position of the granules in the light spot is compensated for by averaging the measured values.



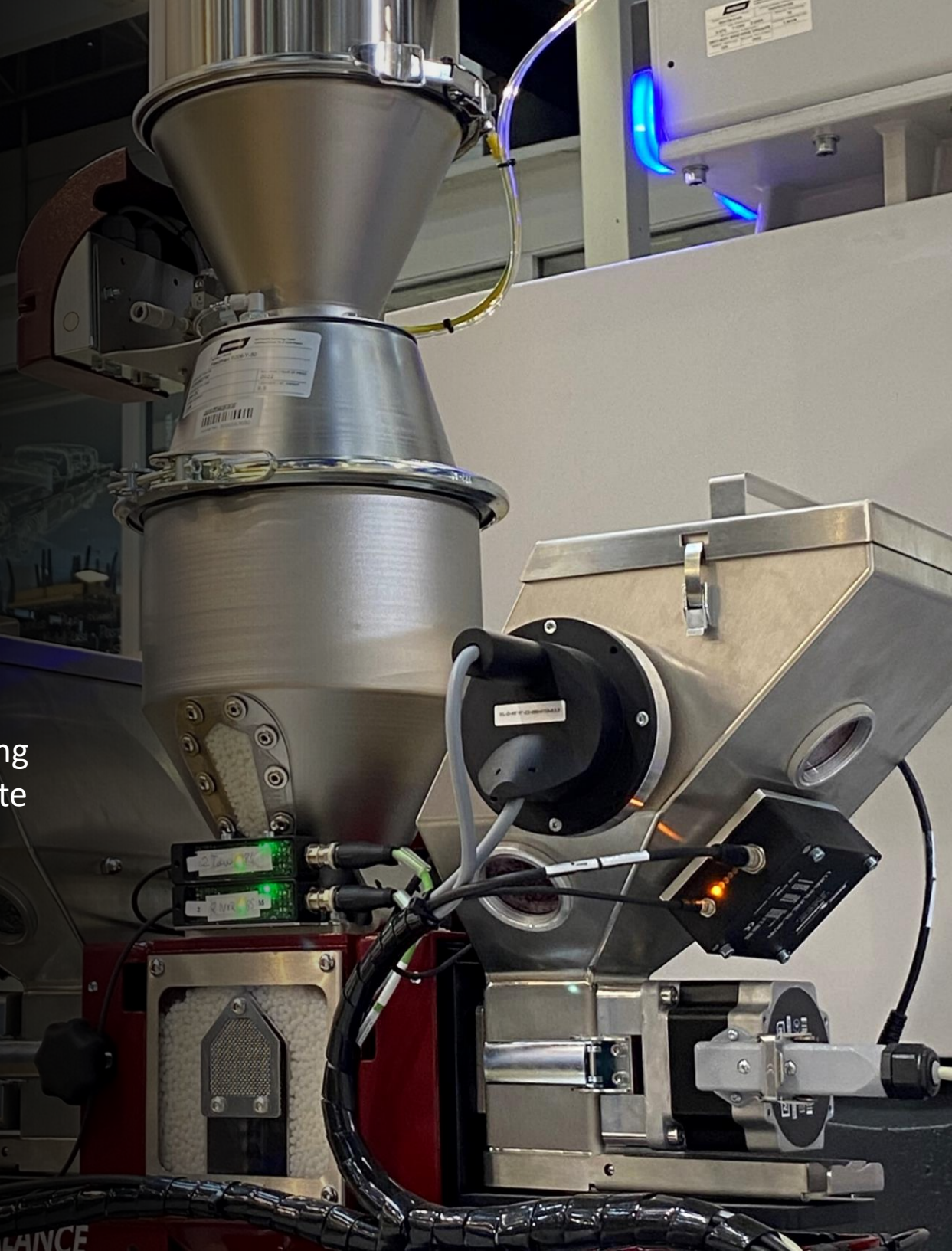
Recyclate TAU and INT Inspection during Material Feeding

A recyclate measurement with regard to the TAU and INT value can also be carried out at the material feed container. The system operator is informed of the TAGTEC marker concentration in the recyclate used at an early stage. Furthermore, the measurement data can be transmitted to the quality assurance department in real time using the DOCAL Windows® software. The sight glasses that are also provided on the silos for this measuring task are used here.



TAU and INT Measurement of Recyclates on the Gravimetric Dosing Unit

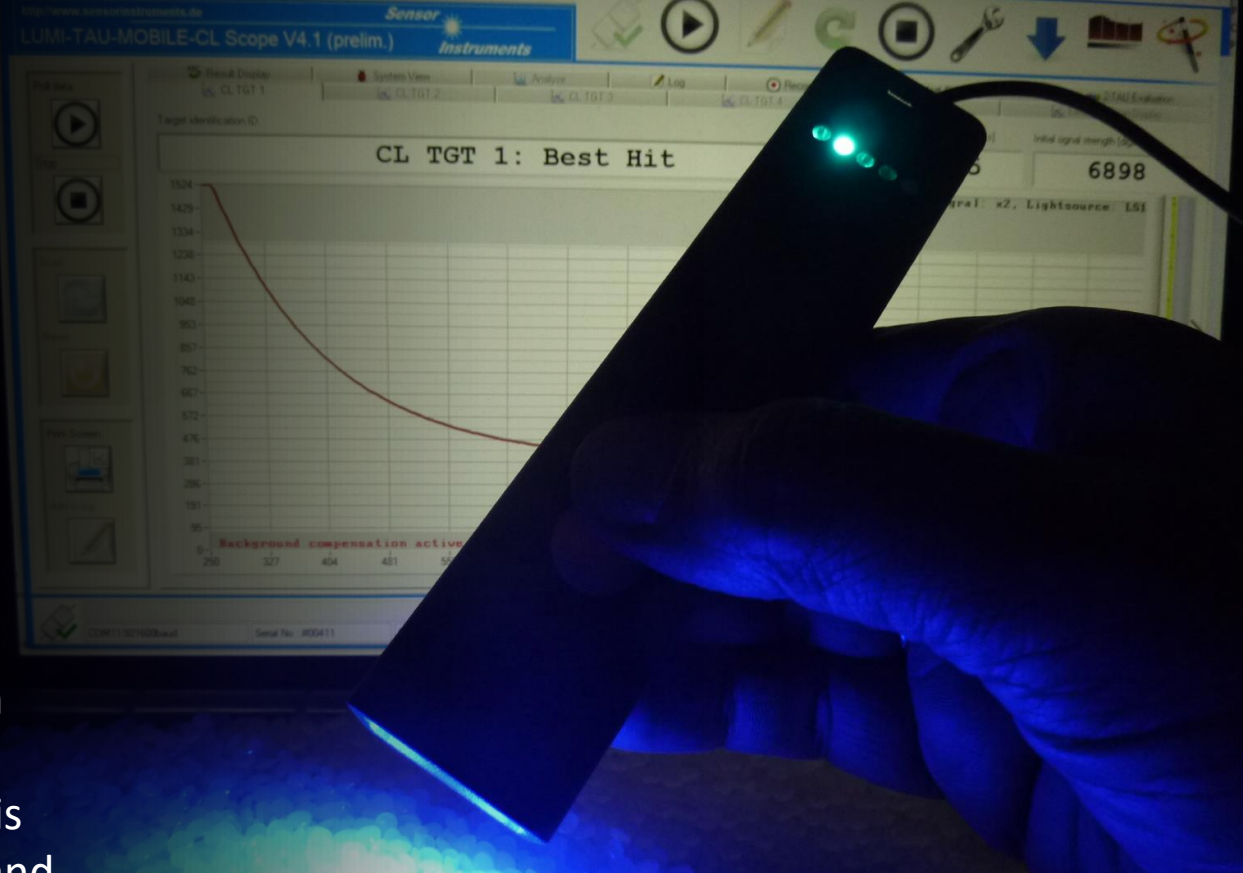
The dosing system offers a further option for measuring the TAU and INT value of the respective recyclate. The TAU sensor can be installed after attaching an appropriate sight glass. The measured data is evaluated using the DOCAL Windows® software. By transmitting the measured values of the respective recyclate to the control system of the dosing unit, the appropriate amount of TAGTEC masterbatch can now be added depending of the TAGTEC marker concentration, so that the required TAGTEC marker concentration is achieved in the end product.



Recyclate TAU and INT Measurement Using Handheld Devices

With the help of the LUMI-TAU handheld devices of the LUMI-TAU-MOBILE series, both end products and recyclates can be checked with regard to the TAU and INT values. For this purpose, devices are available in all primary and secondary wavelength ranges also intended for inline measurement.

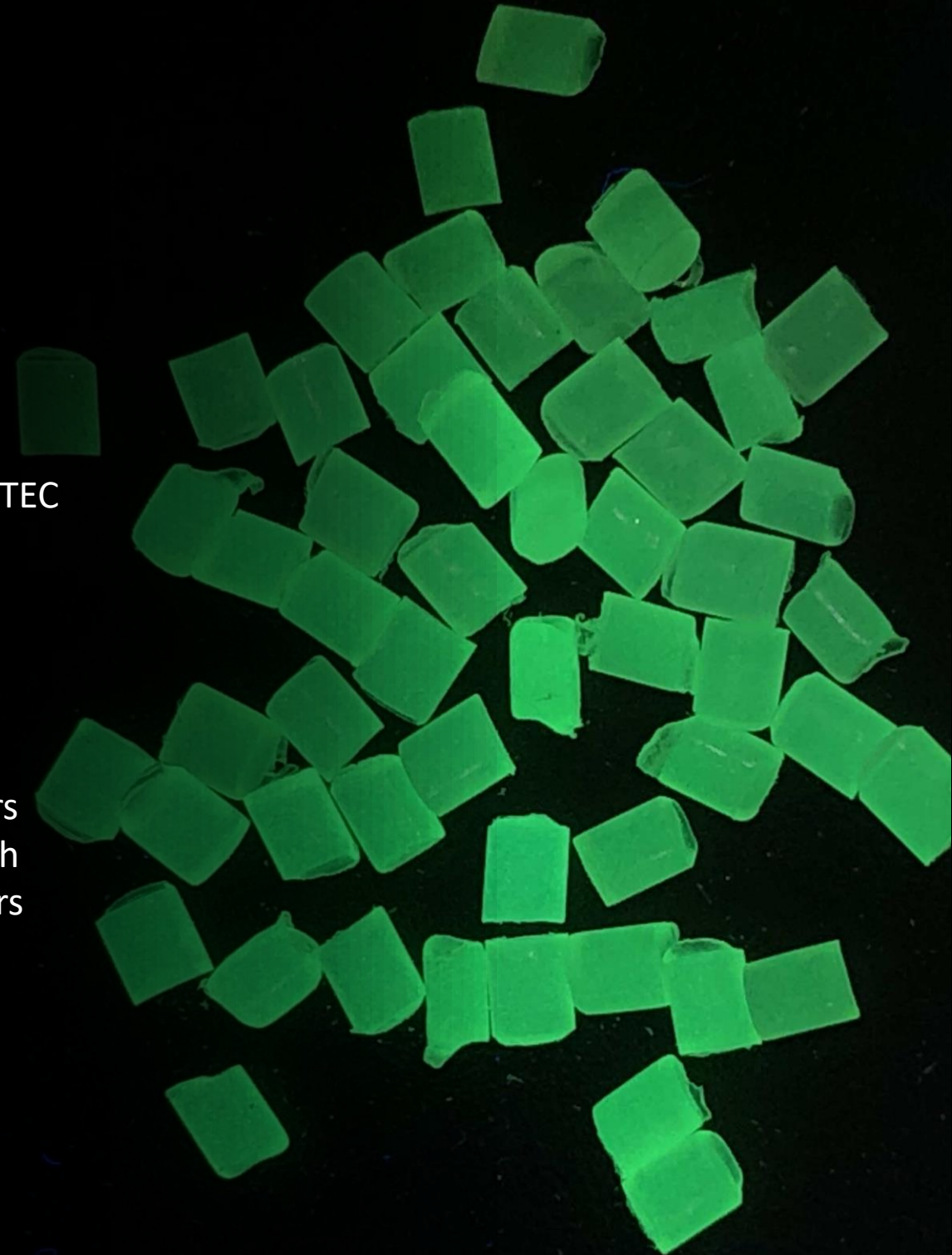
The correct marker concentration INT can be easily checked via the integrated LEDs and the marker type can also be checked. Furthermore, the LUMI-TAU-MOBILE handheld devices can be connected to a PC via USB interface. The integrated Bluetooth interface enables data transfer to a smartphone.



Use of Fluorescent Markers

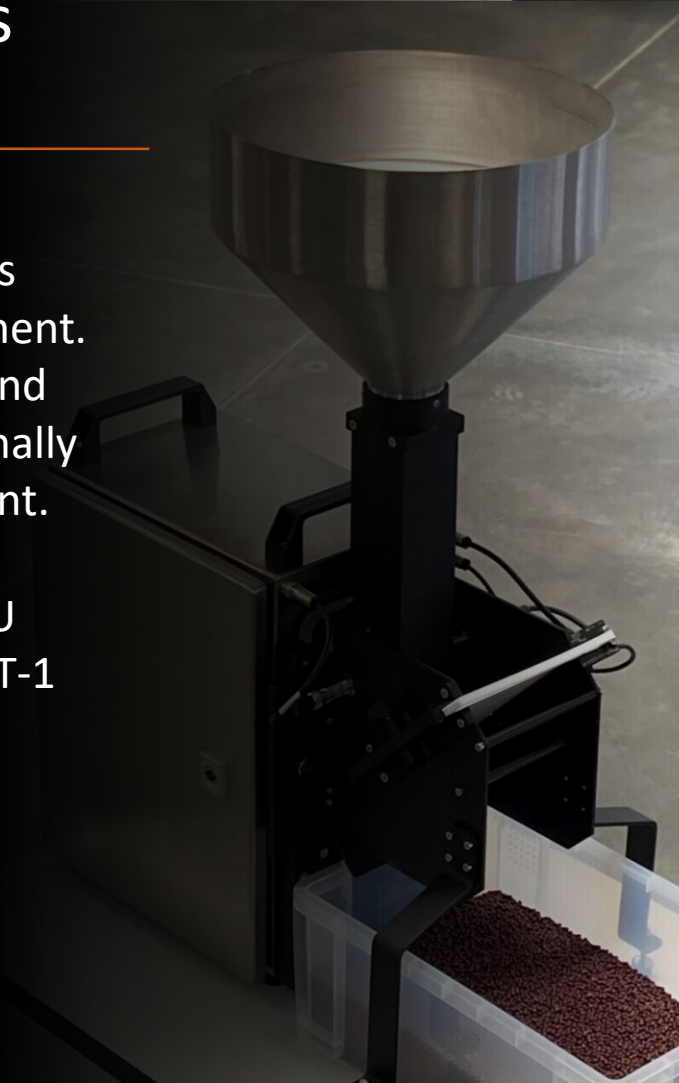
In addition to the TAU markers, fluorescent TAGTEC markers and the corresponding measuring devices are also available. Suitable fluorescent TAGTEC masterbatches are available with primary light in the UVA range and in the visible wavelength range. For example, UV light can be used for continuous excitation and simultaneous measurement in the visible wavelength range.

Depending on the marker used, fluorescence occurs in the blue, green, yellow, orange or red wavelength range. However, special fluorescent TAGTEC markers can also be excited with blue light, with secondary emission occurring simultaneously in the yellow, orange or red wavelength range.



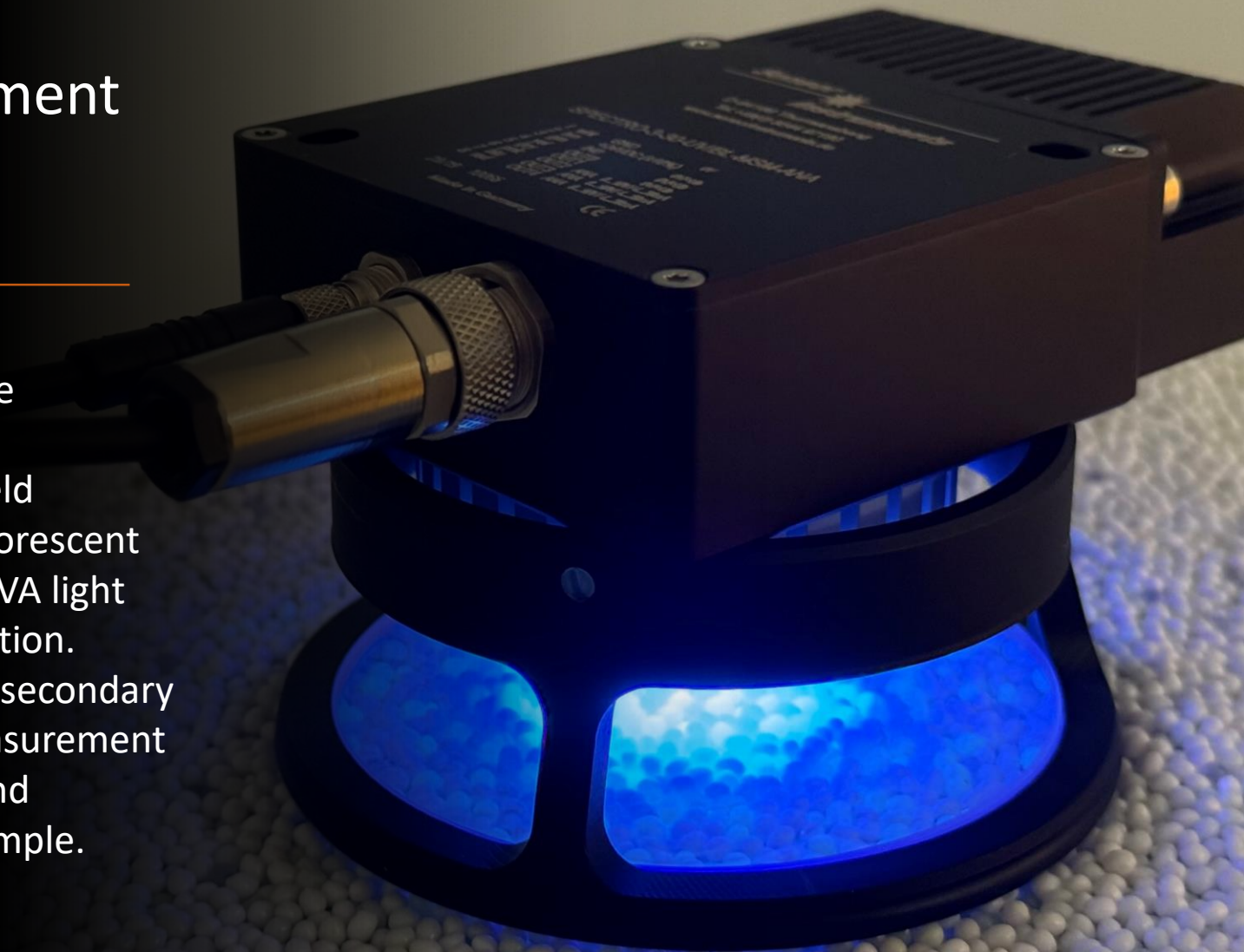
Measuring Devices for Fluorescence Measurement in Inline, Mobile and Laboratory Applications

Sensors from the SPECTRO-T-1 series are used for fluorescence measurement. The sight glasses, the mobile units and the laboratory equipment are externally similar to those for TAU measurement. Only the sensor technology for this differs from the devices used for TAU measurement. The CALIB-SPECTRO-T-1 calibration unit again uses ceramic color tiles that tend to fluoresce.



Handheld Devices for Fluorescence Measurement of TAGTEC Markers

With the SPECTRO-T-1 series and the corresponding offline attachments, including coated glass plate, handheld devices are also available for the fluorescent TAGTEC markers, with which both UVA light and blue light can be used for excitation. Narrow-band bandpass filters allow secondary emission to be filtered out. The measurement data can be read out using laptop and DOCAL Windows® software, for example.




Clarity about the Recyclate

Detect the Special among the Equal

Detecting TAGTEC markers in plastics of the same type

Our specialists are happy to tell you more about it

 +49 (0)8544 9719-0

 info@sensorinstruments.de

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