

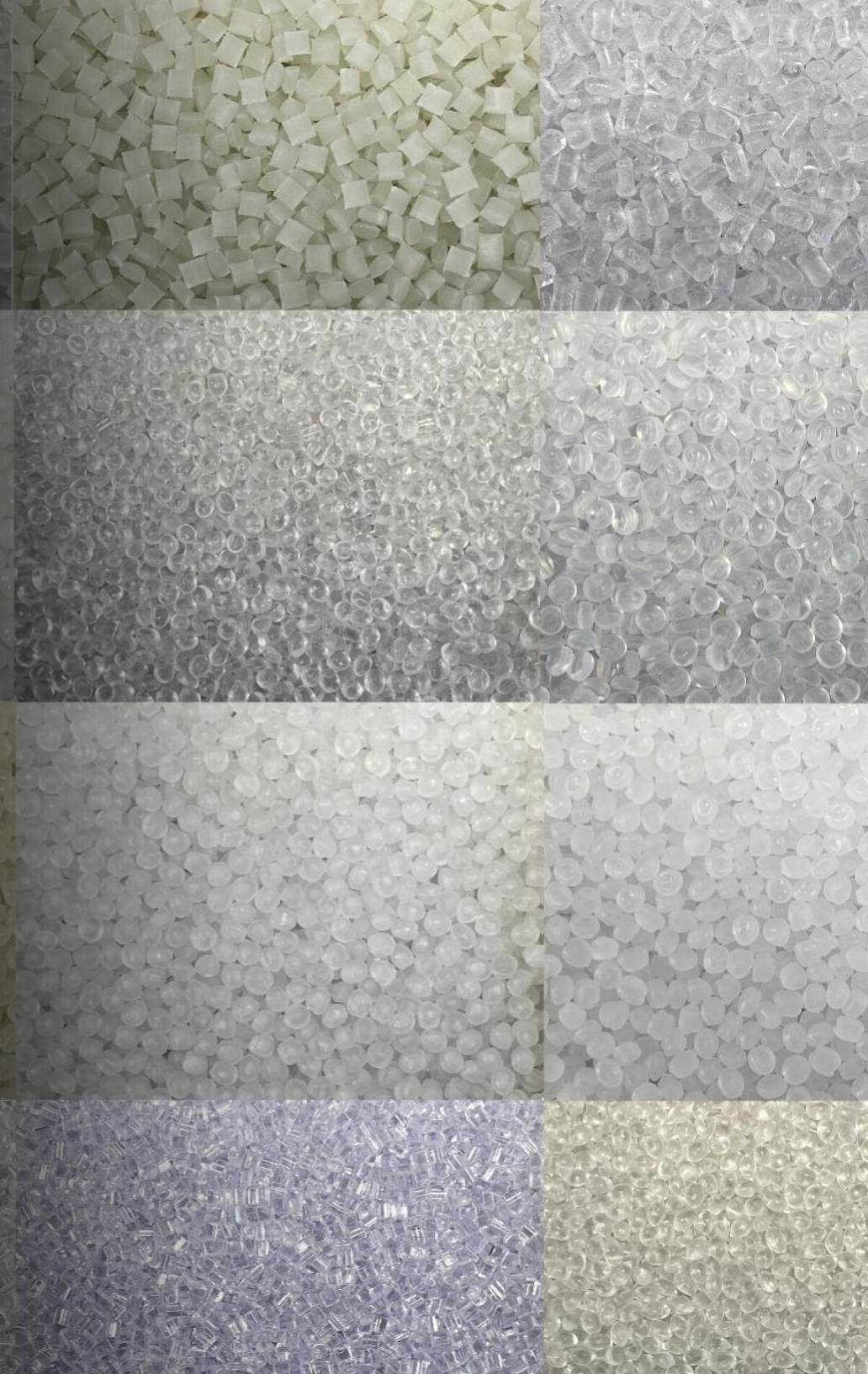
Differentiation of Plastic Types for Recyclates

With the Help of the Three-range Method in the NIR Range



NIR Measurement of Recyclates

Immediately after the extrusion process in the recycling company, during material feeding at the plastics processor and during the dosing process immediately before the injection molding or extrusion process.



Increasing Use of Recycled Materials

The increased use of recyclates worldwide is of great importance for several reasons:

- **Environmental protection:** The use of recycled materials reduces the need for new raw materials, which in turn reduces the extraction of natural resources and the associated environmental damage.
- **Reducing waste:** Recyclates help to reduce the amount of plastic waste that ends up in landfills or in the environment.
- **Circular economy:** In a circular economy, materials are kept in the economic cycle for as long as possible.
- **Energy saving:** Manufacturing products from recycled materials requires less energy than production from new raw materials.
- **Legal requirements:** In many regions of the world, requirements are set for the use of recyclates with the aim of promoting sustainability and reducing environmental impact.

Plastics Recycling

- Collecting plastic waste
- Reprocessing plastic waste
- Separating and sorting the coarse fraction
- Shredding the coarse fraction
- Cleaning the fine fraction
- Separating and sorting the fine fraction
- Extruding, filtering and regranulating the fine fraction
- NIR control of the recyclate
- Filling and packaging of the recyclate
- Delivery to the plastics processing industry



NIR Measurement of Recyclates during Production

In the past, it was sufficient to produce recyclates that could only be used for inferior products (so-called downcycling), but the plastics processing industry and the legislators are increasingly demanding a recyclate quality that comes close to the properties of virgin plastic. Modern recycling approaches aim to keep high-quality materials in the cycle for as long as possible.

The plastic type of the recyclate is an important quality criterion, as it can serve as an indicator of possible contamination. Deviations from the respective reference value may indicate that the recyclate has not been completely cleaned or that it consists of different types of plastic. The purity of a type of plastic is crucial for many end products.



Inline Recyclate NIR Measurement in a Recycling Plant

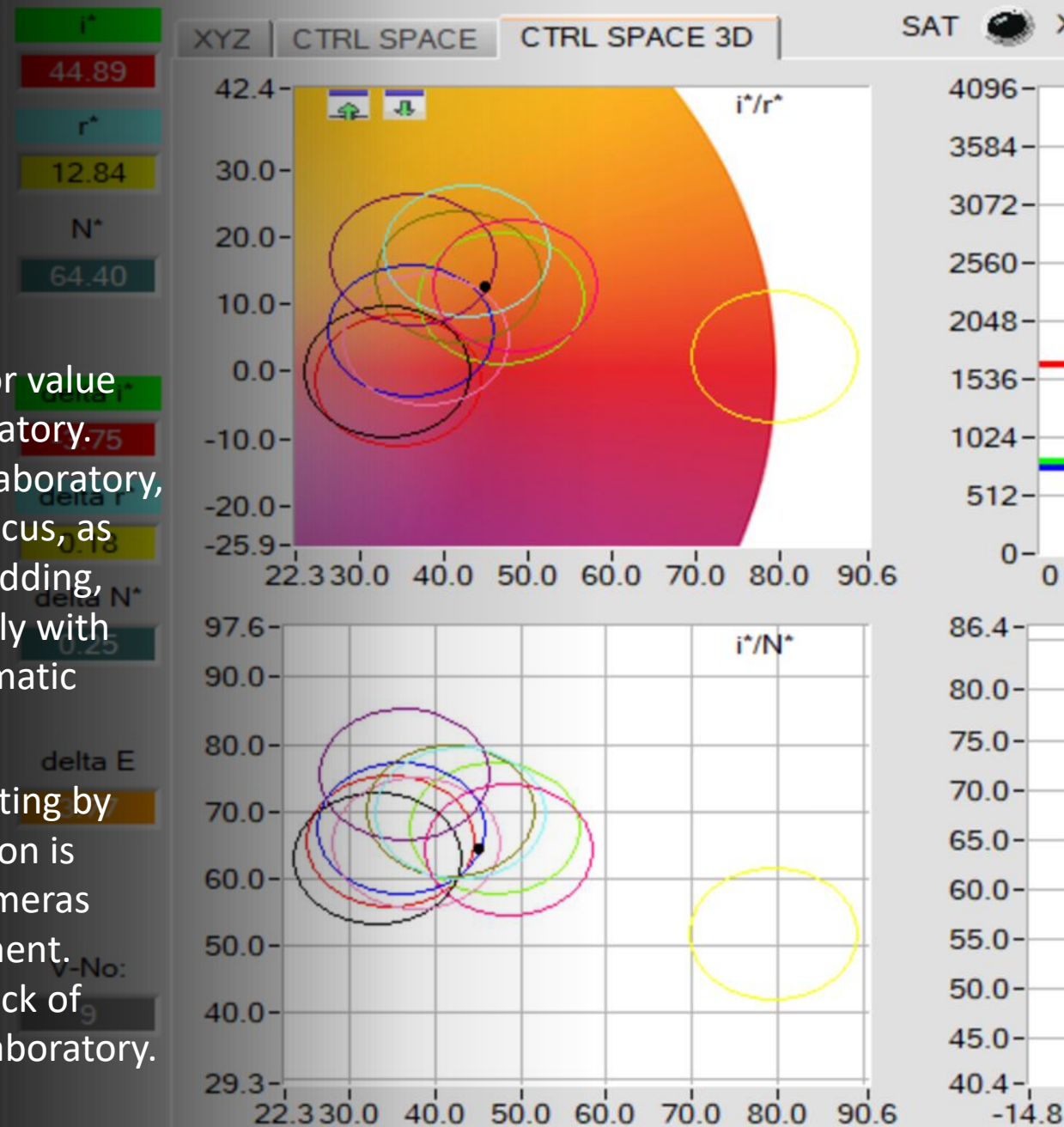
The first way which the Nⁱr value of recyclates can be measured is immediately after the extrusion process. The NIR sensor system is directed at the recyclate flow conveyed on a vibrating chute. Thanks to the robust design of the sensor system, reliable measurements can be made even at high recyclate temperatures.



Measurement Accuracy and Comparability of N^* and r^* Values

In many recycling plants, only the $L^*a^*b^*$ color value of a recyclate is usually measured in the laboratory. The examination of the type of plastic in the laboratory, on the other hand, has so far been less of a focus, as they rely on pre-sorting and sorting after shredding, washing and drying the plastic material, usually with hyperspectral cameras and subsequent pneumatic separation.

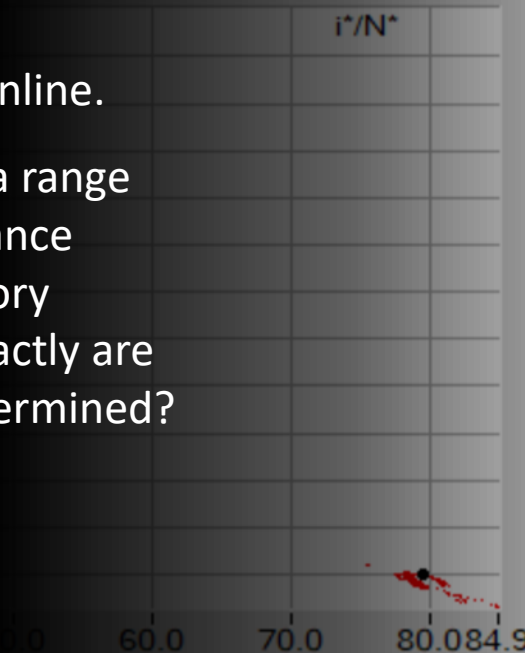
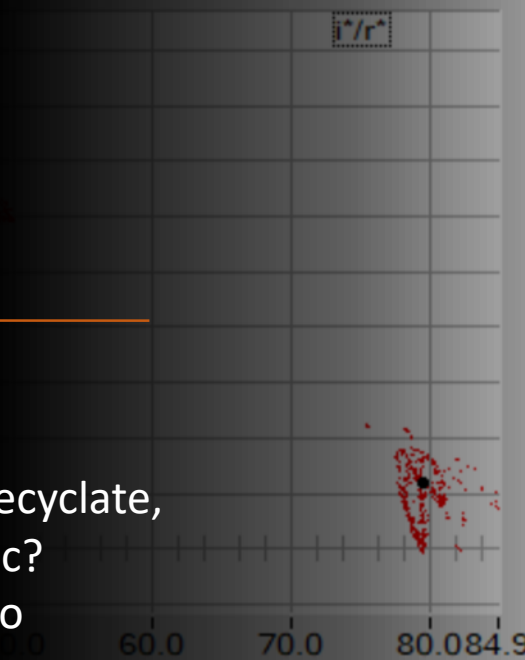
However, a similar process is also used for sorting by color. Pre-sorting and sorting of the fine fraction is also carried out there using line scan color cameras and compressed air nozzles in a line arrangement. But despite this effort, an additional color check of the respective recyclate is carried out in the laboratory.



Determination of the $N^*i^*r^*$ Values

Why is this step, which makes sense in terms of the color quality of the recyclate, not also applied to the type of plastic? The reason for this is probably due to the limited range of inexpensive NIR measuring instruments that can be used both in the laboratory and inline.

The SPECTRO-T-3 series now offers a range of attractively priced, high-performance measuring systems for both laboratory and inline applications. But what exactly are $N^*i^*r^*$ values and how they are determined?



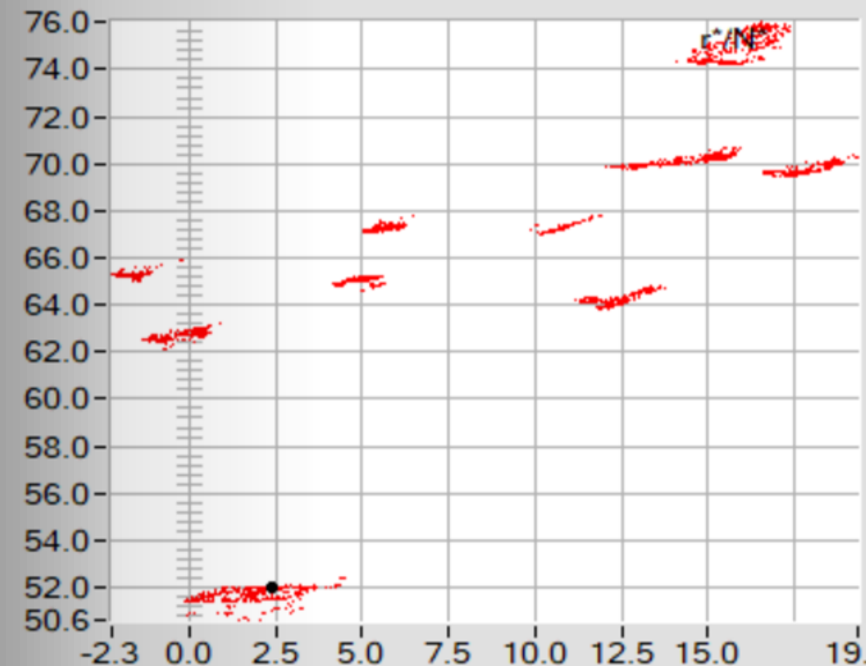
CLOSE

START STOP

COUNTER 5454 RESET

i^*	r^*	N^*
79.50	2.37	52.02

TEACH TO TABLE

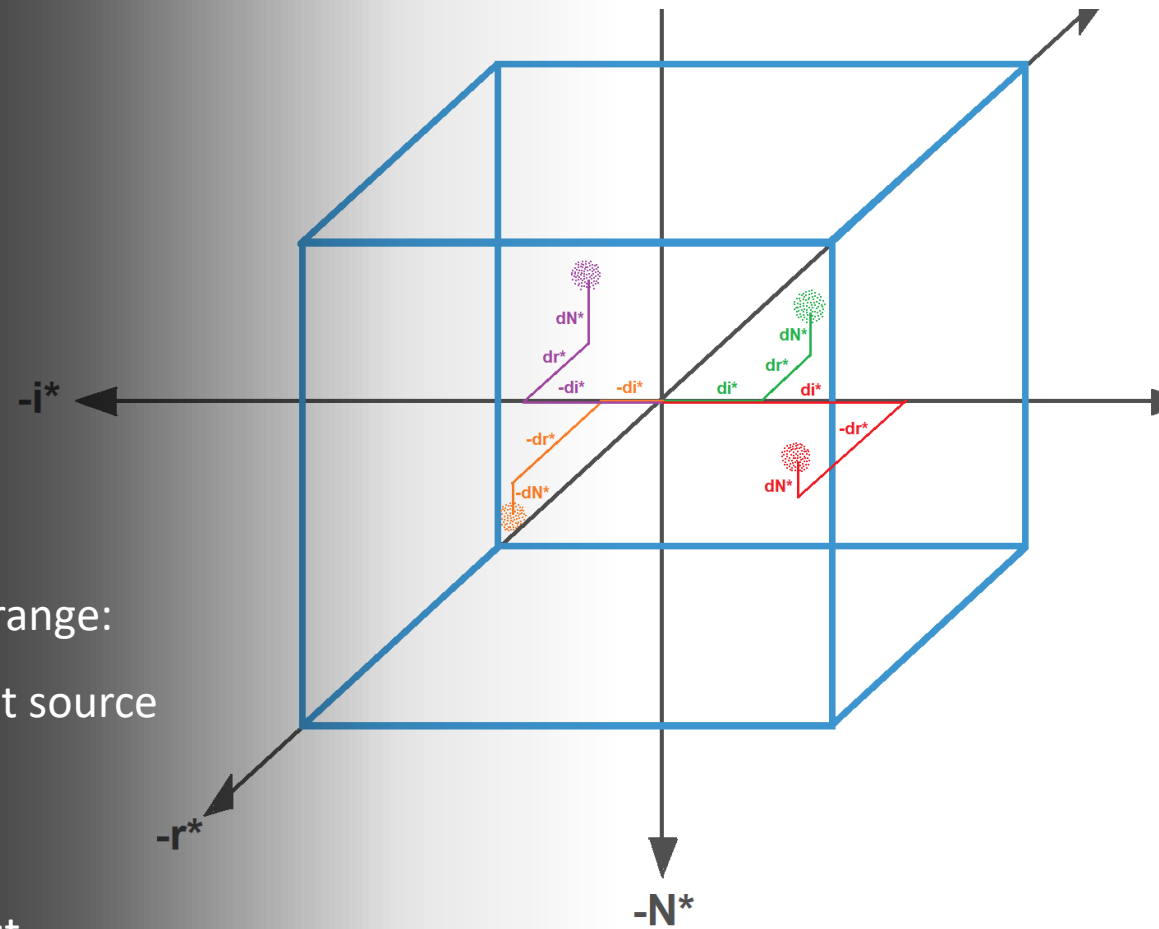


Definition of the $N^*i^*r^*$ Value

To determine the color, there are basically two measurement methods in the visible wavelength range:

- Use of a spectrometer and a suitable white light source
- Use of an RGB detector in conjunction with a D65-like, modulatable white light source.

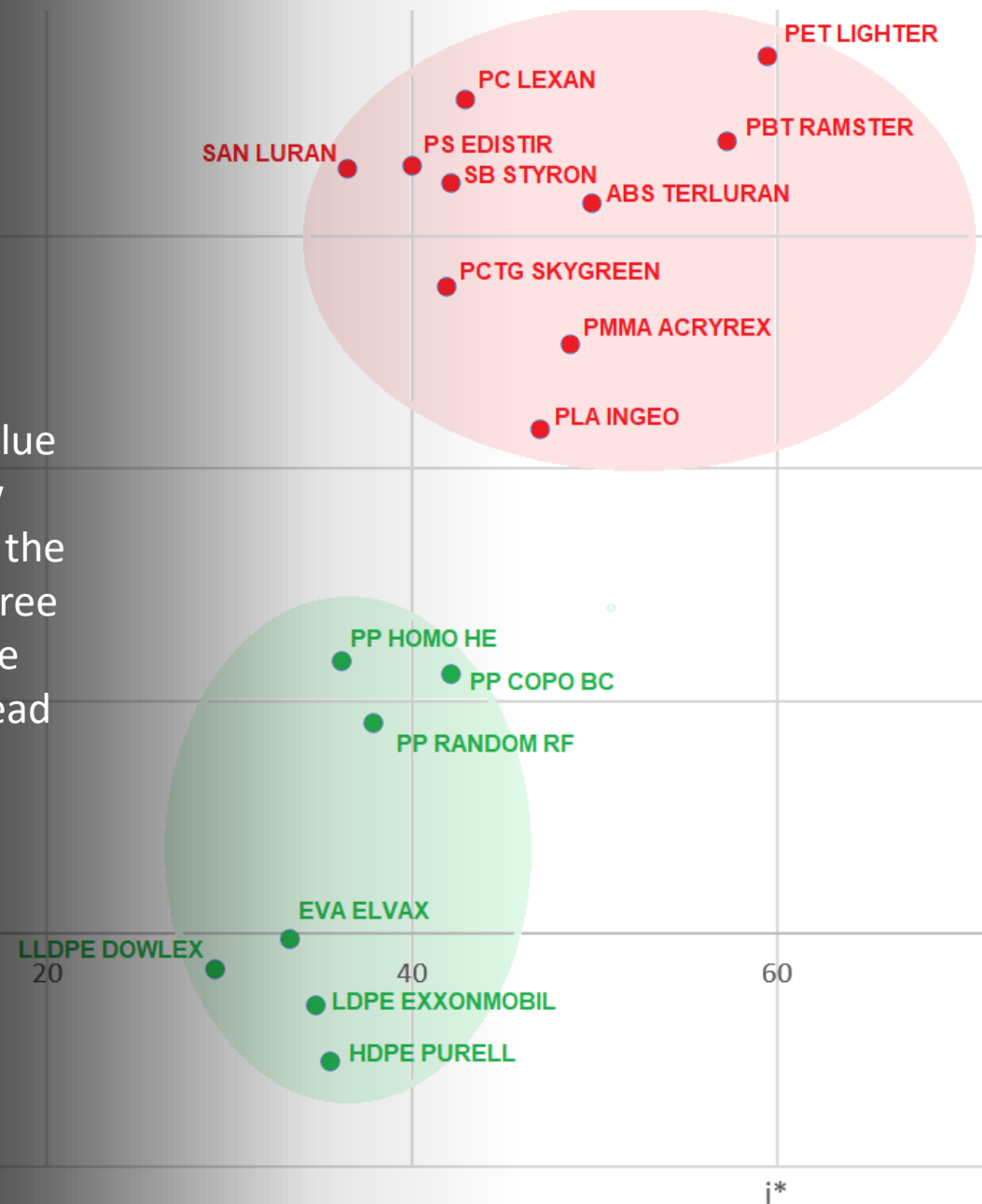
In both methods, the XYZ initial raw values are first determined for the further calculation of the $L^*a^*b^*$ value. The $L^*a^*b^*$ color space, also known as CIELAB, was standardized by the Commission Internationale de l'Éclairage (CIE) in 1976. A major advantage of the $L^*a^*b^*$ color space is the perceptual equidistance. This means that equal distances in the $L^*a^*b^*$ color space are also perceived as equal color distances when viewed by the human eye.



The Three-range Method in the NIR Range

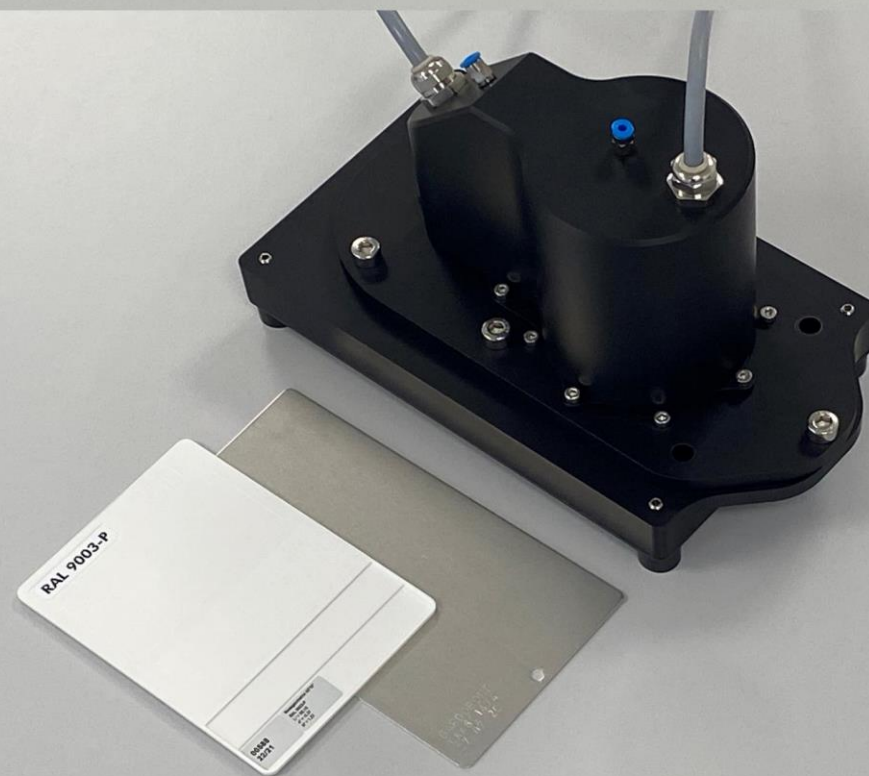
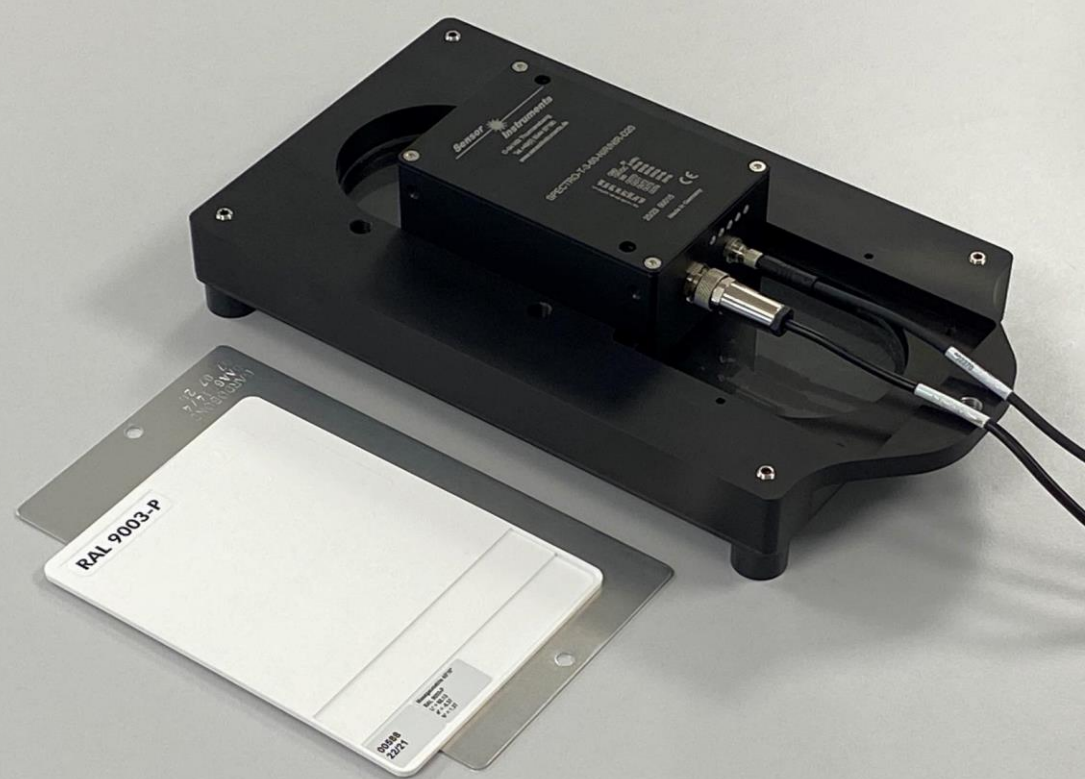
Based on the findings made with the $L^*a^*b^*$ color value in the visible wavelength range, this method has now also been consistently applied in the NIR range using the three-range method. The measurement data from three wavelength ranges in the NIR (NIR-L, NIR-C, NIR-R) are used as XYZ values and $N^*i^*r^*$ is now calculated instead of $L^*a^*b^*$.

Numerous investigations on a large number of different virgin material granulates and recyclates in the $N^*i^*r^*$ space provided the basis for this three-range method transferred from the VIS range to the NIR range.



Calibration in the N*i*r* Space

Using the DOCAL Windows® software, calibration in the N*i*r* space is extremely simple. As in the VIS range (RAL color cards), various plastic cards with a defined N*i*r* value are also available here. An aluminum card is used for the white balance, as this provides a neutral reflection of the NIR light used. However, plastic cards with a defined N*i*r* value are also available, which define the reference points during on-site calibration.



Display and Recording of the NIR Values Determined Inline

The DOCAL Windows® software is used to display the $N_{i,r}$ values numerically and graphically, as well as their deviation $dN_{i,r}$ from the target value. At the same time, the data is stored in a file on the panel PC and the data can also be transmitted via fieldbus (ProfiNet) or Ethernet.



Calibration of the Inline NIR Sensor On Site

Calibration of the inline color sensor does not require the system to be dismantled. An aluminum card (included in the scope of delivery) only needs to be placed in front of the sensor at the prescribed distance for the white balance. Calibration (UCAL) to the respective product is carried out using recycled material and the measurement data from the laboratory. After a one-off calibration to the respective recyclate type, the calibration data can be easily imported from the respective file.



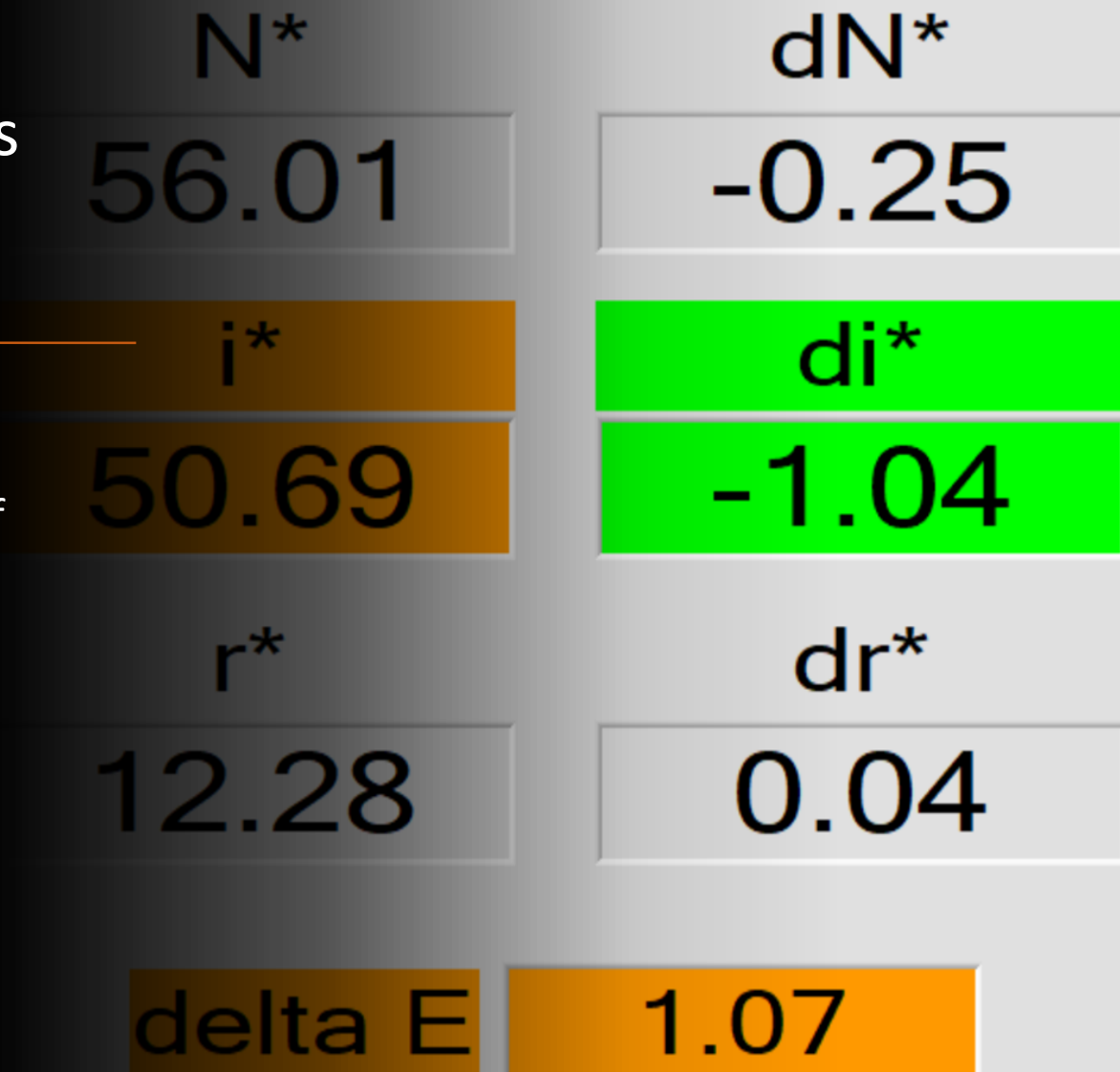
Determining the Recyclate Nⁱr^{*} Values Using a Mobile NIR Measurement System

The mobile NIR measurement system can be used to obtain Nⁱr^{*} measurement data more quickly than in the laboratory, even without an installed NIR sensor system. A recyclate sample can be taken on site from production and fed into the mobile unit (hopper capacity: 11 liters). The mobile NIR measurement system is calibrated in the same way as the inline unit.



Display of $N^*i^*r^*$ Values Using DOCAL Software

Software that enables both simple calibration and convenient display of the $N^*i^*r^*$ measurement values in both numerical and graphical form. Furthermore, the tolerances of a reference sample can be individually defined and called up as required.



Determination of the Recyclate Nⁱr^{*} Values in the Laboratory

The Nⁱr^{*} value of a recyclate sample can also be determined with high accuracy (dE 0.3) using the NIR laboratory device. The high measuring accuracy is achieved by measuring the recyclate flow and continuously averaging the measured values. This eliminates the influence of the random position of the individual pellets in the light spot of the measuring device.



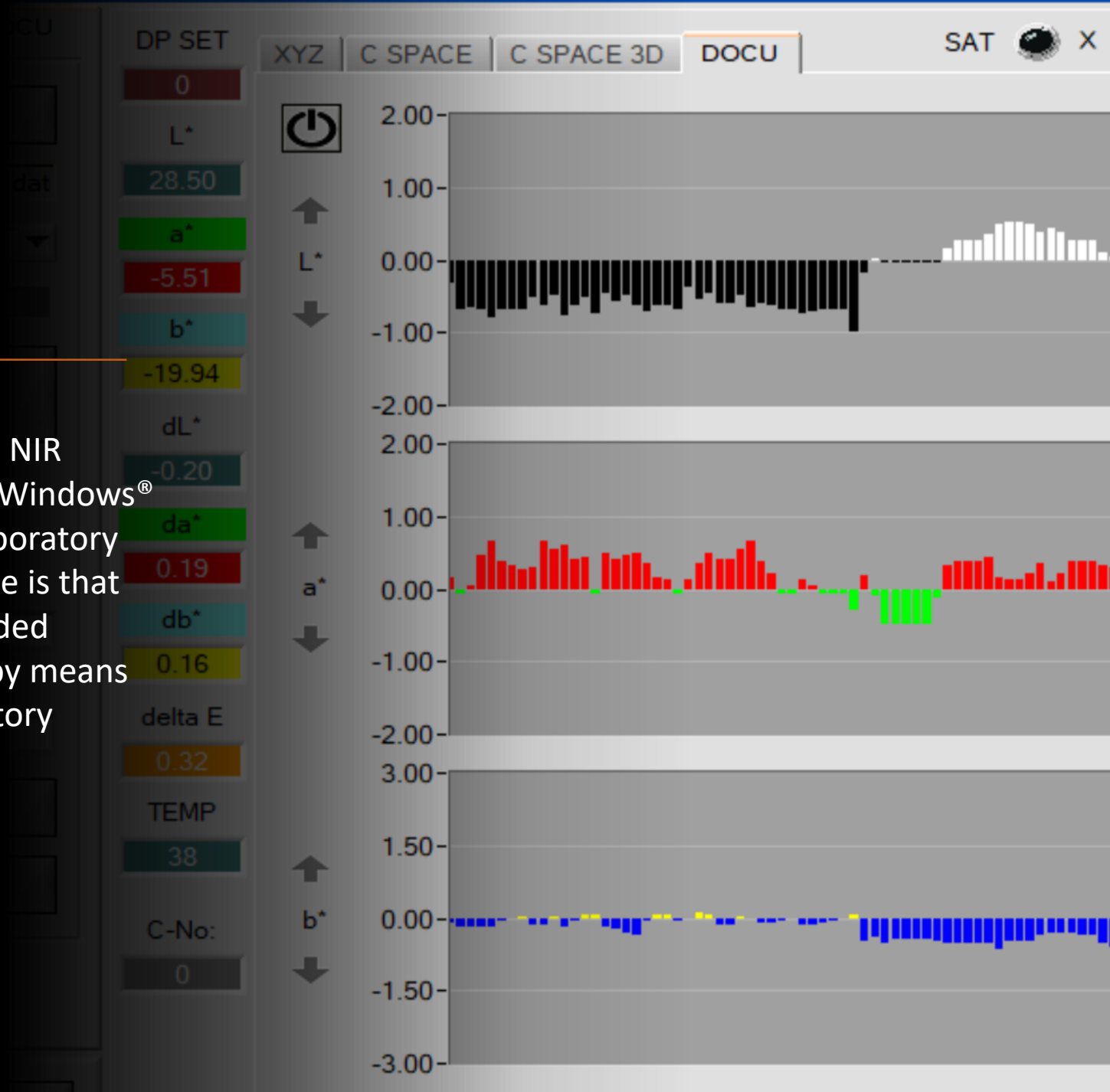
Compact Laboratory System for Measuring the N*i*r Value of Recyclates

A very compact and inexpensive NIR measurement system (MST series) was created using a measuring table top and an optomechanical rail. The recyclate samples are filled into the supplied trays and moved laterally under the light spot in a figure-of-eight movement. This also achieves an accuracy comparable to inline measurement.



DOCAL Software for Laboratory Equipment

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



Plastics Processing

- **Storage of recyclates 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 a 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 granules.
- **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.

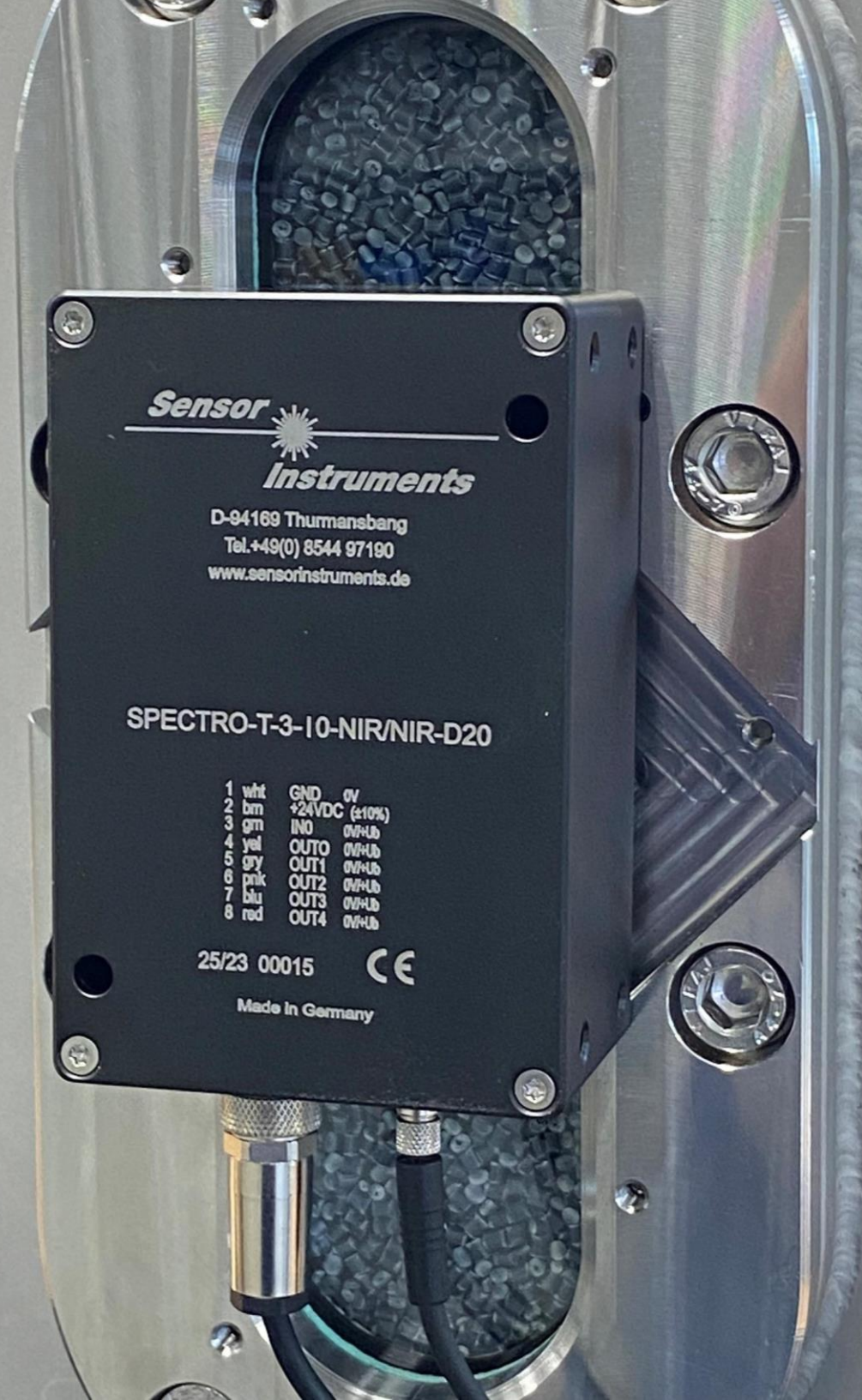


N*i*r* Measurement of Recyclates in the Plastics Processing Industry

Due to the increasing use of recyclates in the processing industry, it is advisable to carry out an incoming inspection in order to prevent any fluctuations in the quality of the recycled material.

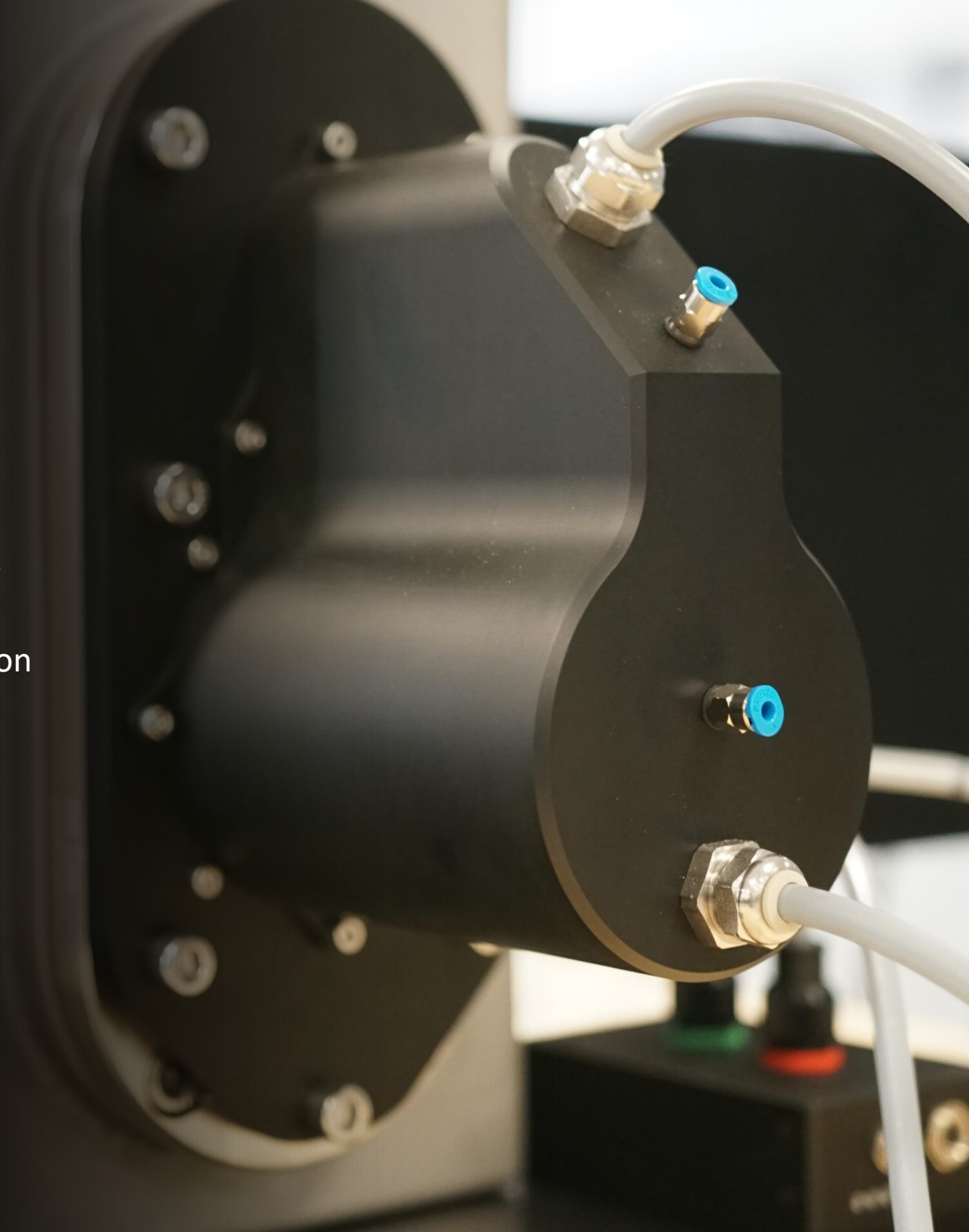
The plastic type of the recyclate can be checked at various points in the process:

- At the silo
- At the material feed container
- At the dosing unit



Recyclate Nⁱr^{*} Measurement at the Silo

A sight glass is placed at a suitable location on the granulate silo and a suitable NIR sensor (0°/45° or d/0° method) is then installed. The Nⁱr^{*} values are also evaluated using the DOCAL Windows[®] software.



Recyclate NIR Testing during Material Feeding

A recyclate NIR check can also be carried out at the material feed container. The system operator is informed about the N*i*r* quality of the recyclate used at an early stage. Furthermore, N*i*r* measurement data can be transmitted to the quality assurance department in real time.



Nⁱr^{*} Measurement of Recyclates at the Gravimetric Dosing Unit

The dosing unit offers another option for measuring the Nⁱr^{*} value of the recyclate. The NIR system can be installed after attaching an appropriate sight glass. Nⁱr^{*} evaluation is carried out using DOCAL Windows[®] software.




Clarity about the Recyclate

Detect the Plastic Types

NIR differentiation of plastic pellets and flakes

Our specialists are happy to tell you more about it

 +49 (0)8544 9719-0

 info@sensorinstruments.de

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