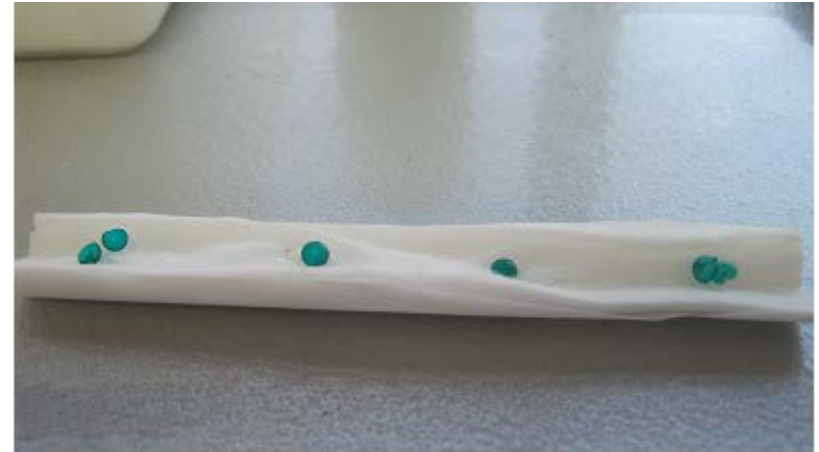
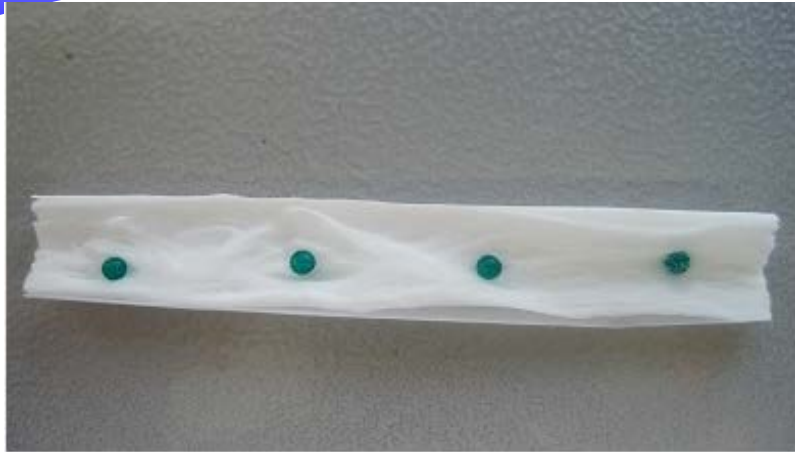


A powerful tool for the verification of the quality of cigarettes and filterrods
- with and without aromatic capsules and segments.

- 1. Advantage of a fast quality verification of cigarettes and filterrods**
- 2. Aspects of the microwave measurement technology**
- 3. Laboratory quality control device MW4420**
- 4. Fast and precise measurement of tobacco rod moisture**
- 5. Fast and precise measurement of tobacco rod density profile:
preventing loose ends of tobacco rod**
- 6. Filterrods and capsules: different filterrod designs with e.g.
menthol capsules - microwave signal**
- 7. Multisegmented filters: edge detection and charcoal
determination**
- 8. High-speed online detection with same microwave sensor:
control of cigarette, capsule quality with ejection**
- 9. Summary and conclusions**

1. Advantage of a fast quality verification of cigarettes and filterrods

Broken Capsules



Filterrod with menthol capsules positioned at their target locations

Opened filtertip with one menthol-capsule



1. Advantage of a fast quality verification of cigarettes and filterrods

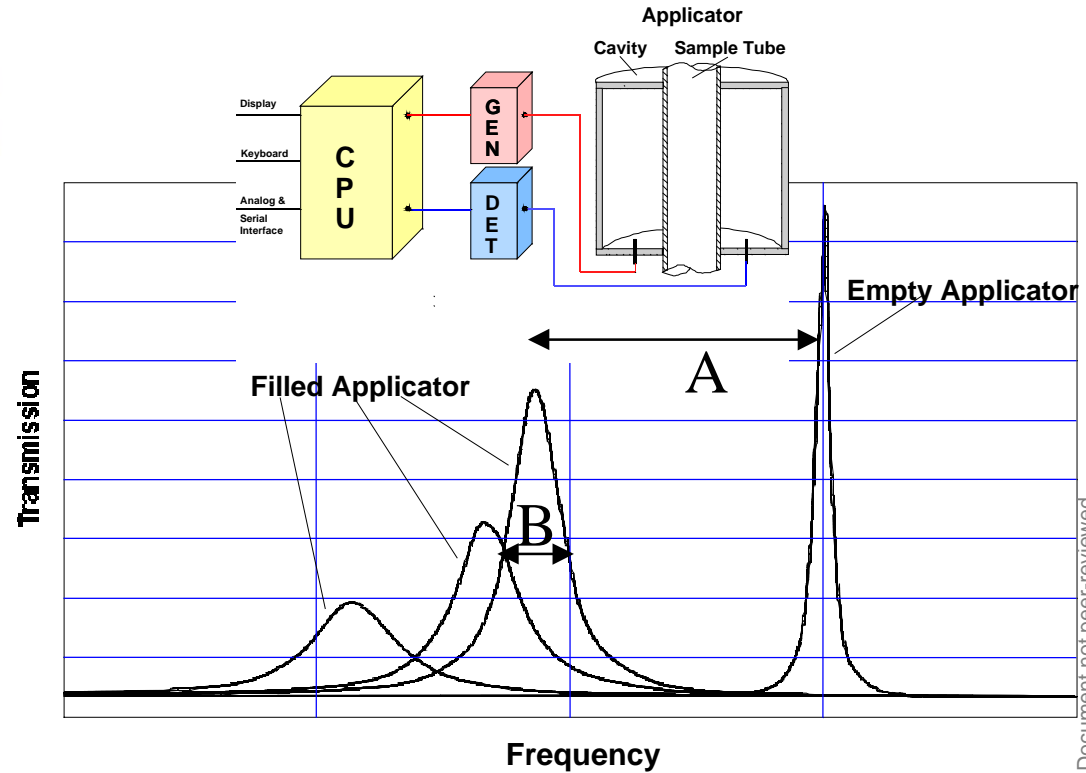
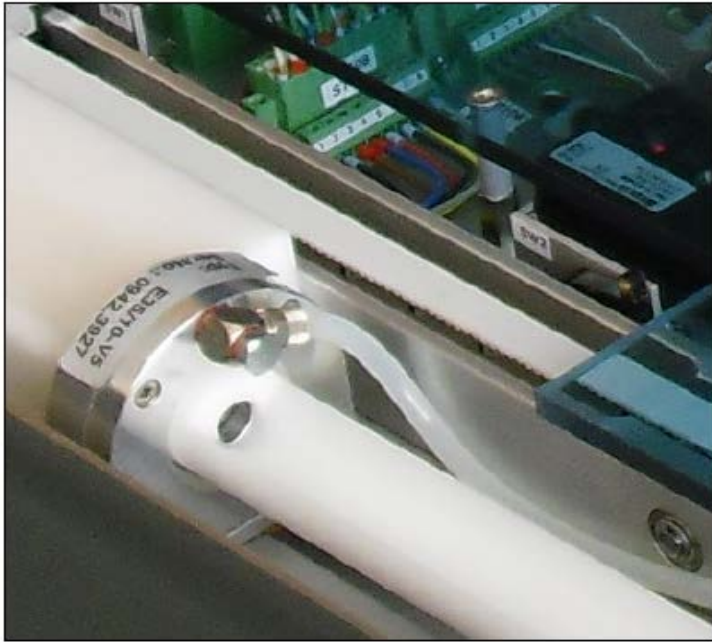
Which Quality-Features can be verified, and instantaneously reported to manufacturing?

- Total and individual tobacco moisture of a cigarette batch, and a single cigarette
- Total and individual tobacco rod-weight of a cigarette batch, and a single cigarette
- Dense-end values (densing-values) within a batch of cigarettes (avoiding loose ends)
- Detection of machine cut position (to prevent incorrect tobacco rod cut position)
- Quality of capsules in filterrods, cigarette-filter tips and multi-segmented filters
 - Correct position of each capsule, relative to its target position
 - Recognising the statistical drift of the mean capsule position
 - Capsule filling in a target range – preventing double capsules and voids
 - Identification of damaged capsules – instant or ex-post detection
- Position of edges of segments in multi segmented filterrods or filtertips in cigarettes
 - White-white and charcoal filters
- Charcoal content and distribution in carbon filtersegments

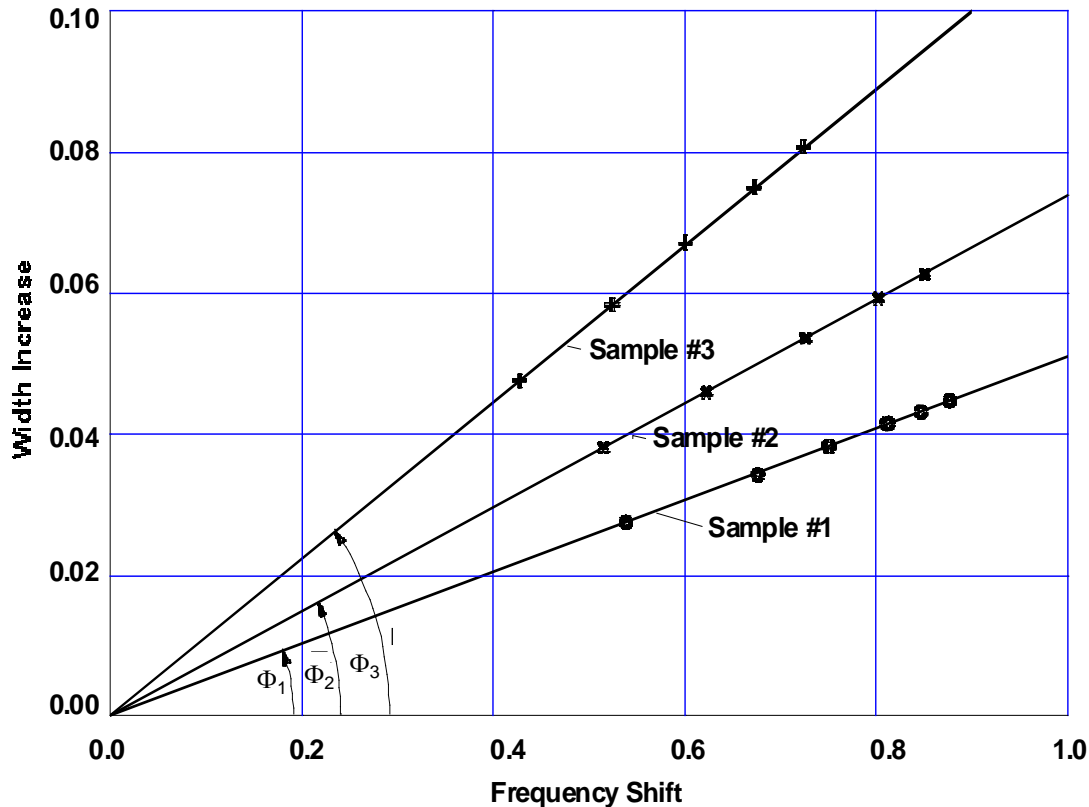
2. Aspects of the microwave measurement technology

Resonator microwave profile for filterrods and cigarettes (3 mm measuring zone)

Resonance effect of filterrods and cigarettes with varying density and moisture in the microwave-field



2. Aspects of the microwave measurement technology



Two independent measuring parameters A and B:

- both are proportional to the mass.
- B/A is independent of mass, and proportional to water content.

A: Shift of resonance frequency caused by dielectric properties, e.g. menthol density.

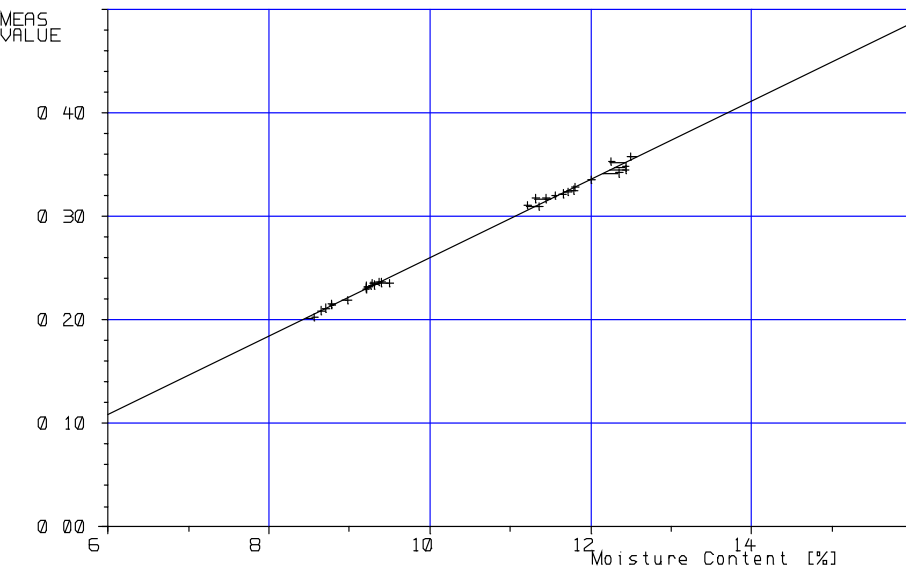
B: Increase of bandwidth caused by small mobile, polar molecules, e.g. water.

Independence of substrate.

2. Aspects of the microwave measurement technology

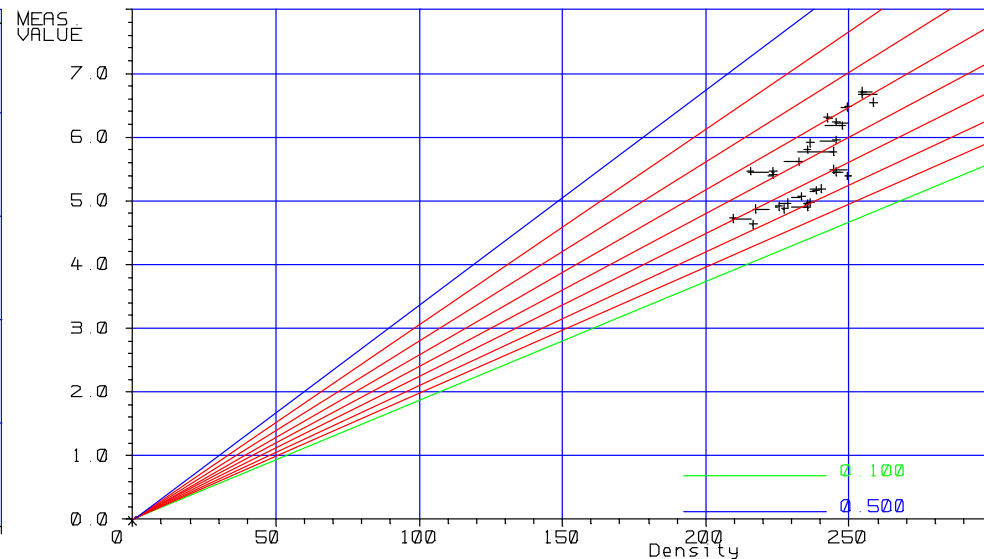
Measurement of two parameters (A, B):

Determination of two physical values (moisture and mass)



Moisture calibration against direct method (e.g. Karl-Fischer):

$$\text{Moisture (\%)} = k_a \cdot B/A + k_b$$



Mass calibration against direct method (e.g. weight scale):

$$\text{Mass (mg)} = k_c \cdot A + k_d \cdot B$$

3. Laboratory quality control device MW4420

Profile verification filterrods, cigarettes and cigars

Diameters: superslim, slim, kingsize, up to 9mm; for cigars with special sensor possible diameter up to 20mm:

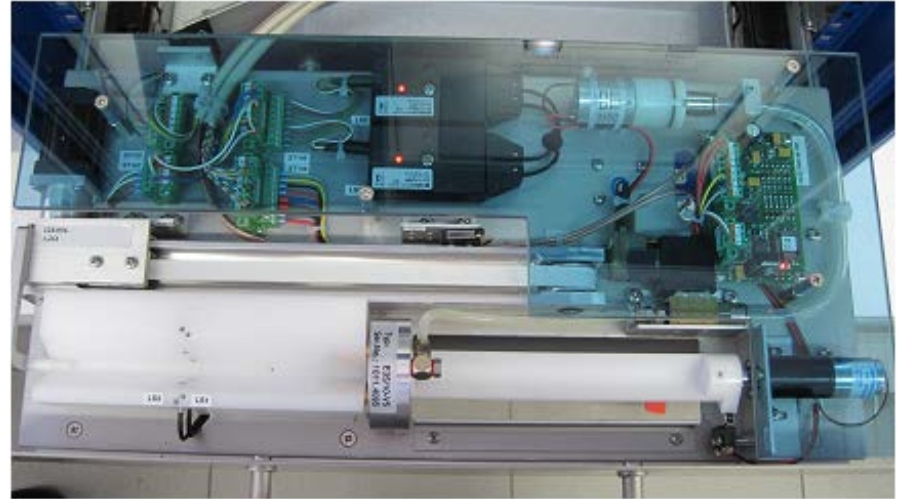
- Mean of tobacco moisture batch and tobacco mass of cigarettes
- Dense-end correction by measurement of cut position and densing values of tobacco rods
- Position and fill of aromatic capsules in cigarettes and filterrods up to 144 mm, ejection of defect rods
- Multisegmented filters with and without charcoal, segment position and charcoal content
- Project phase: foreign-body detection in cigarettes with ejection



3. Laboratory quality control device MW4420

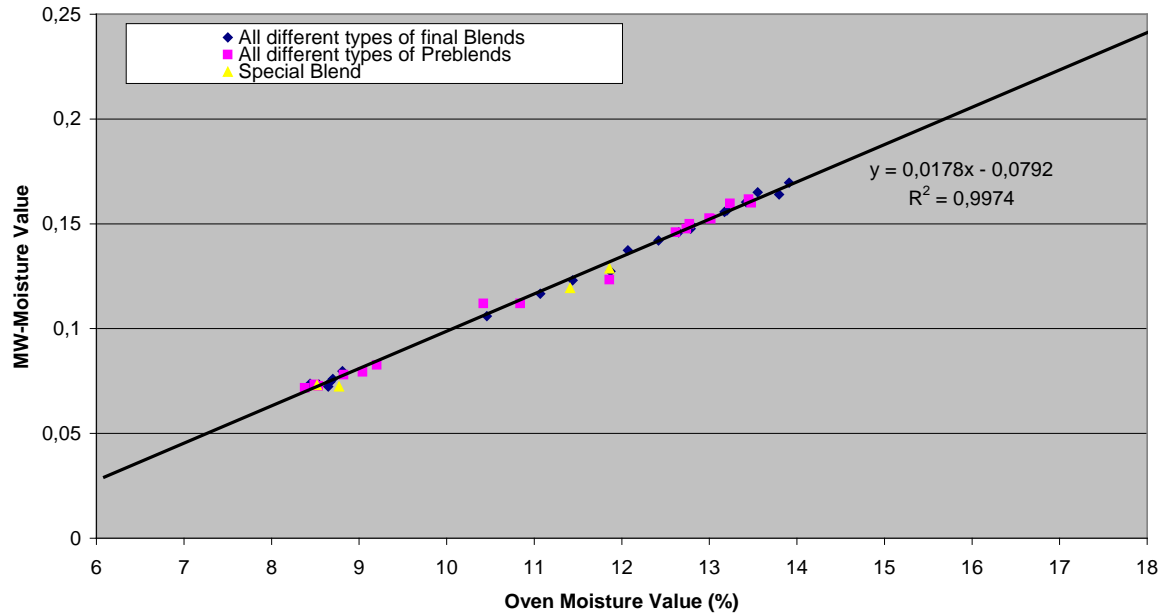
Controlled horizontal travel of cigarettes and filterrods through a 3 mm measuring window of the profile resonator (positioning independent of resonator by step-motor of the pusher)

Ejection of defect filterrods, cigarettes with identified capsule or segment errors (or foreign bodies). Statistics of faulty rods, all data available in Excel-readable format.



4. Fast and precise measurement of tobacco rod moisture

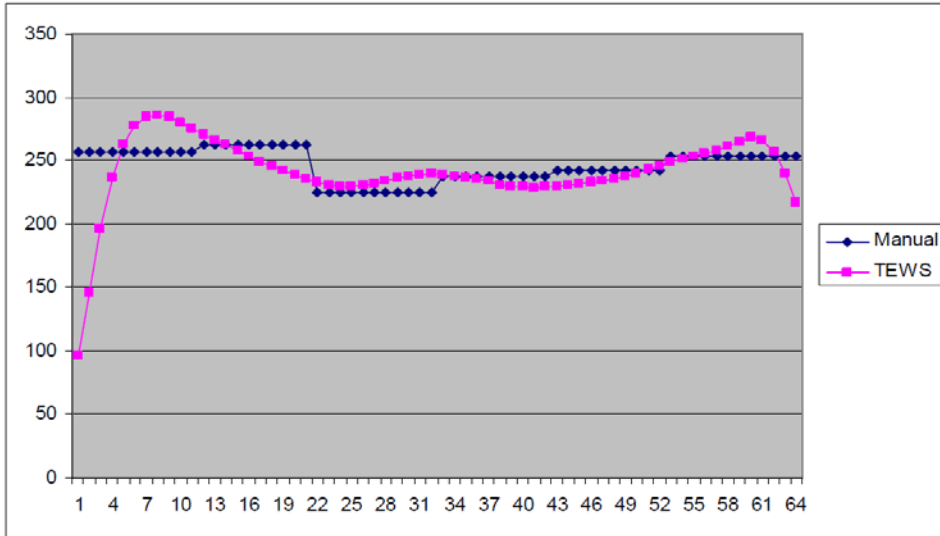
Comparison of Microwave-Moisture-Values and Oven- Reference-Values
of all Blends and Preblends



MW tobacco rod moisture measurement standards can be globally transferred across corporate entities by transferring calibrations across devices, all derived from a single master calibration.

- Only a few product calibrations are required to fit the many various tobacco types/blends
- Calibrations remain unchanged over years, thus assuring low device-to-device differentials
- Project: Development of one single moisture standard method to allow benchmarking of all devices against a single master device

5. Fast and precise Measurement of Tobacco Rod Density Profile



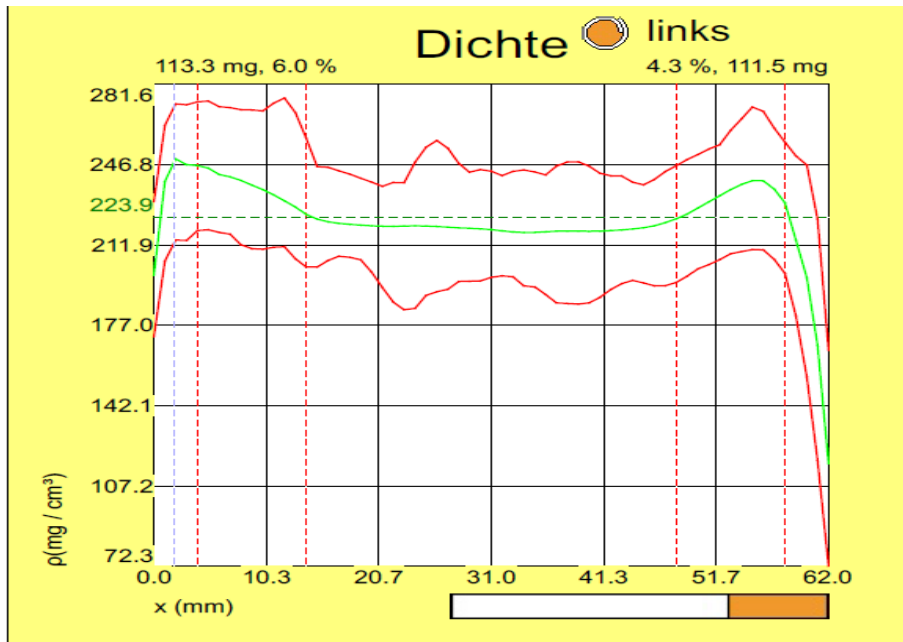
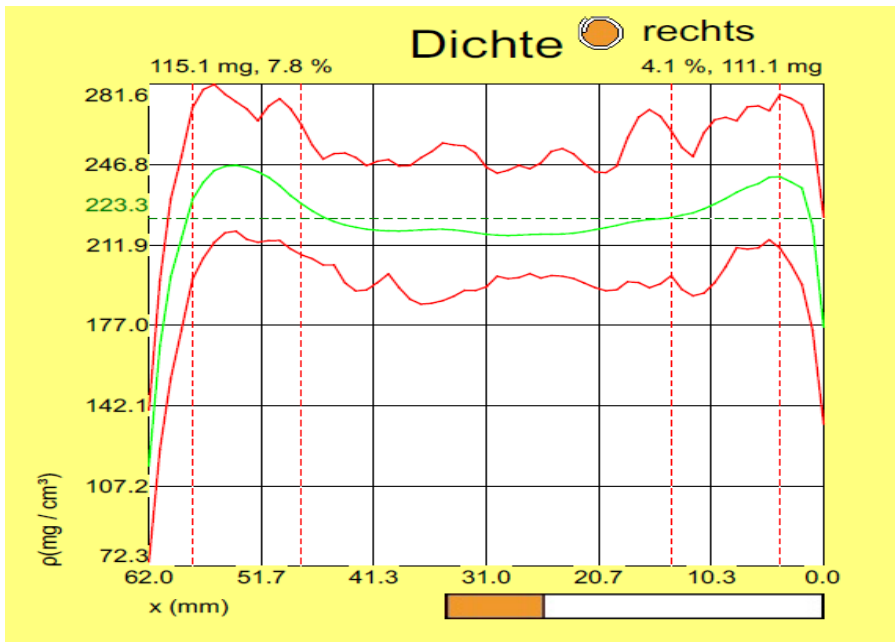
Comparison between TEWS & manual cut

Density-Profile

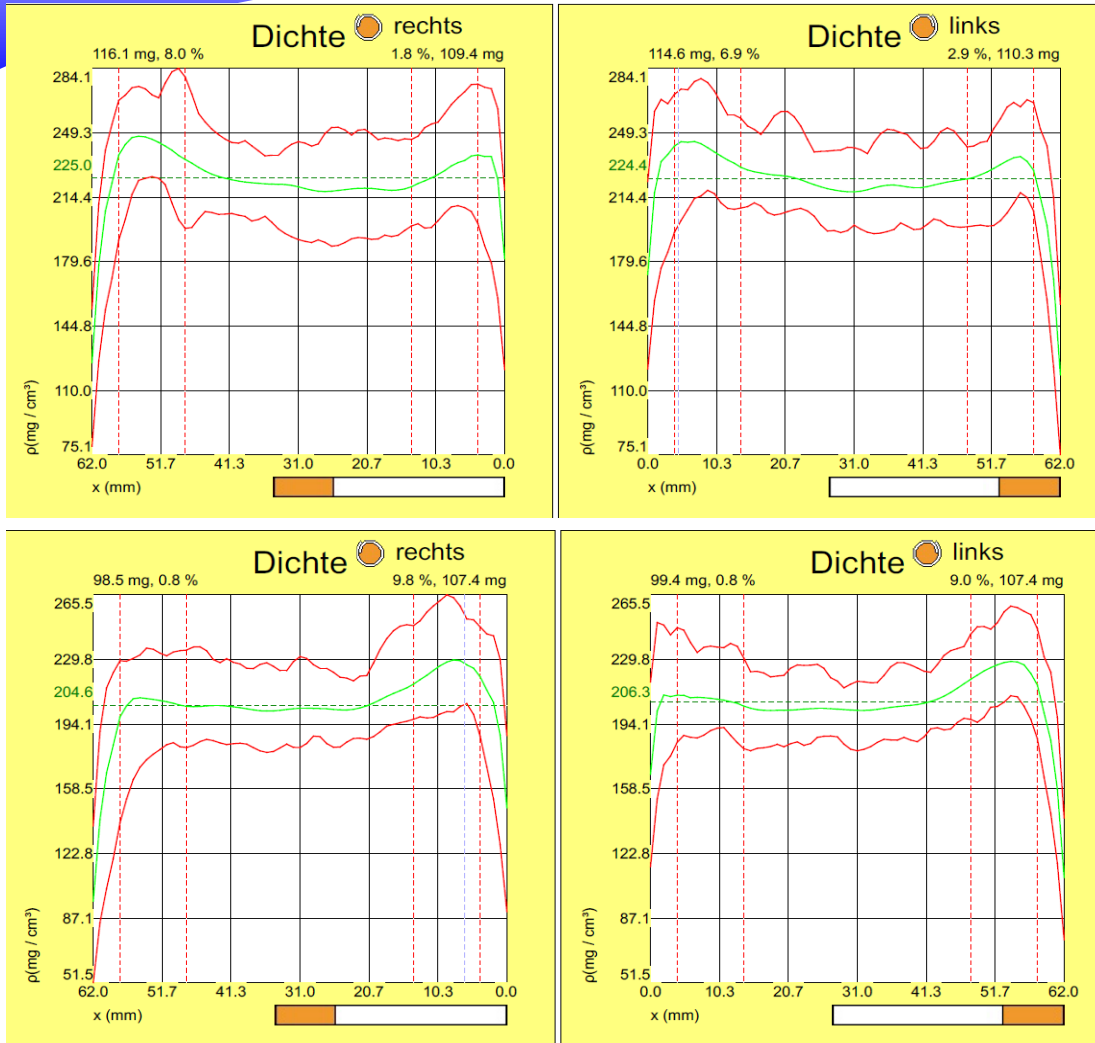
Unit is mg/ccm, proportionate to segment weight

Left-right sorting algorithm allows verification of cut position

User-defined range of segment weight and densing (%)



5. Cut position determination from tobacco rod density profile



Incorrect cut position of cigarettes causes loose ends and tobacco fall out:

* Positive cut position shift (+4.2mm) to the right: loose end at left cigarettes

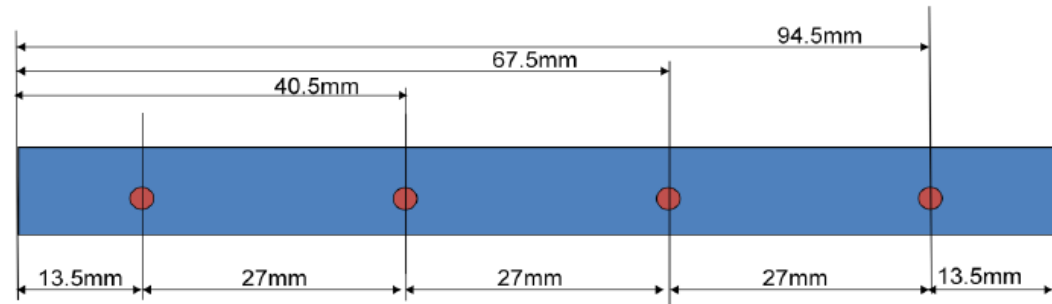
* Negative cut position shift (-6.1 mm) to the left: loose end at right cigarettes

Microwave technology provides warnings to prevent loose ends

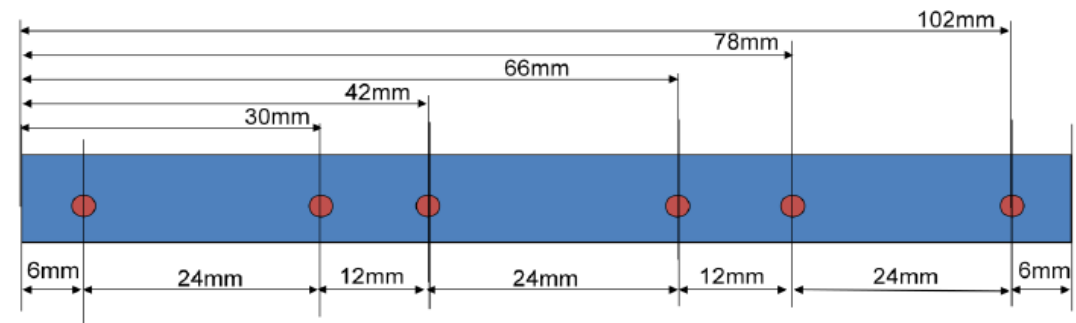
6. Filterrods and capsules: different filterrod designs with e.g. menthol capsules - microwave signal

Capsule Placement Dimensions

108mm rod with 4 capsules



108mm rod with 6 capsules



Various capsule positions are possible, (format-change) :

Symmetrically :

constant capsule-distance 27 mm

Asymmetrically:

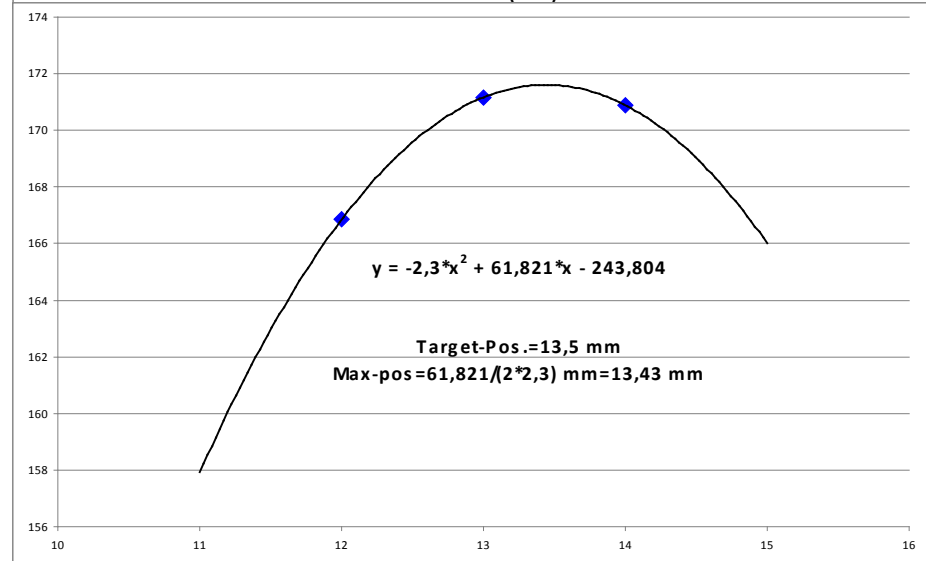
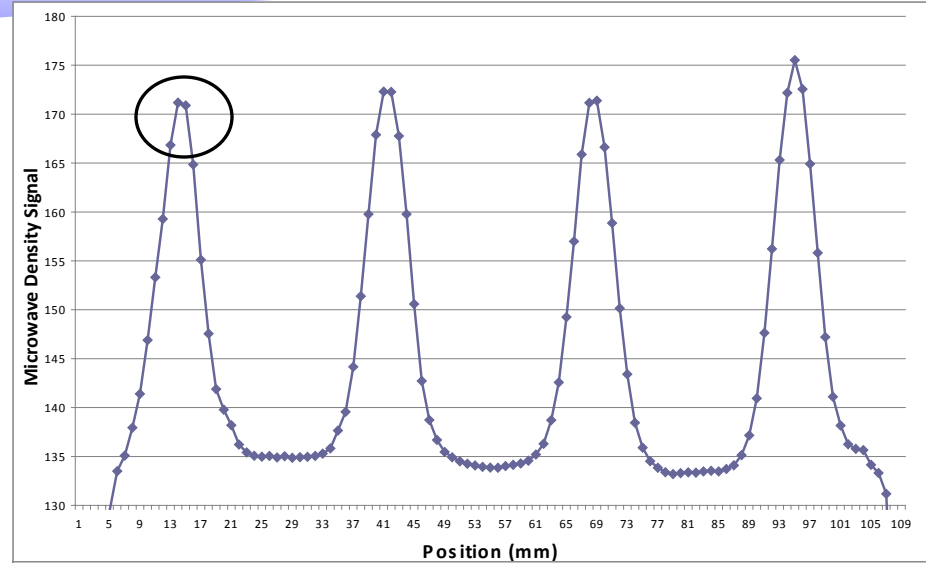
variable capsule-distance 12 / 24 mm

6. Filterrods and capsules: menthol capsules - microwave signal

Microwave density-signal of a 108 mm Filterrod with 4 symmetrically positioned capsules.

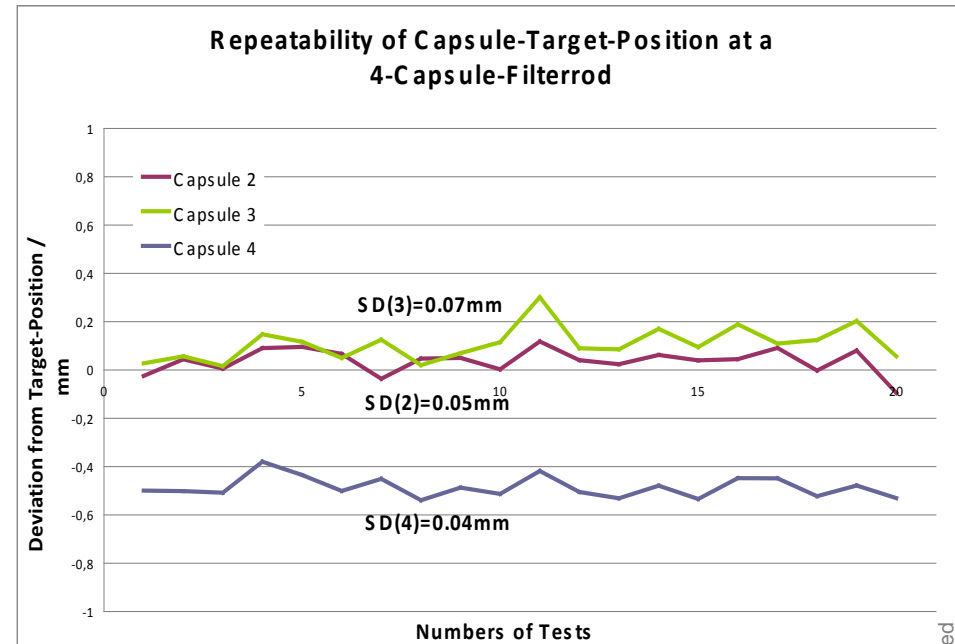
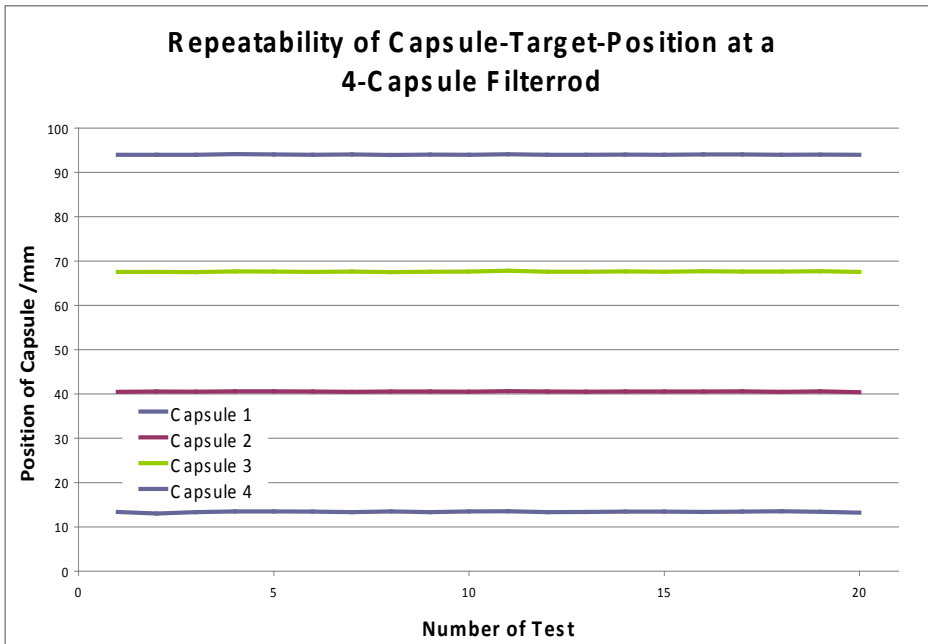
Density maximum equals position of the capsule, and no calibration is required.

Improvement of precision by fitting a parabolic function at its maximum: Precision 0.1 mm.



6. Filterrods and capsules: menthol capsules - microwave signal

Repeatability Test with one Filterrod, containing 4 Capsules



Left: Absolute position

Right: Relative position to target

Standard deviation of each position value below 0.1 mm

6. Filterrods and capsules – capsule quality and microwave signals

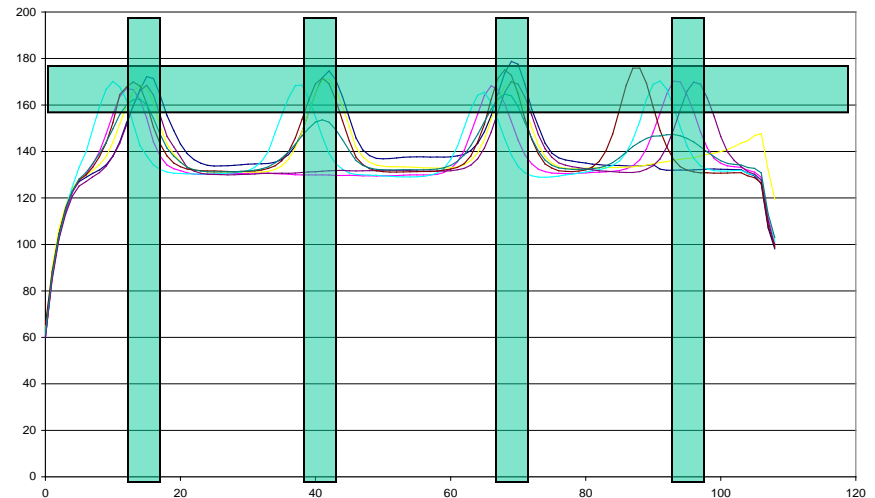
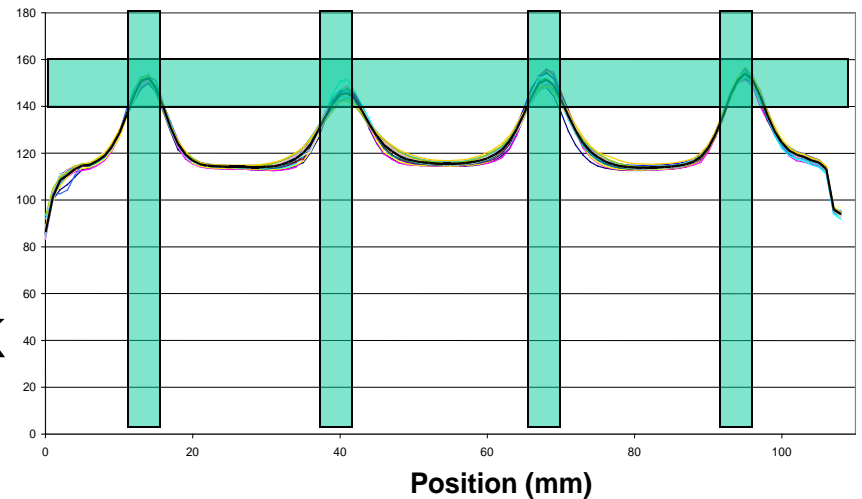
Batch of intact capsules:

- Positions of capsules are OK.
- Mass signals from menthol are OK (to install max. and min. threshold)

Batch of partially defect capsules:

- Some positions are incorrect
- Some capsules are not full
- Some capsules are missing

MW4420 Microwave- Density Signal of Capsules



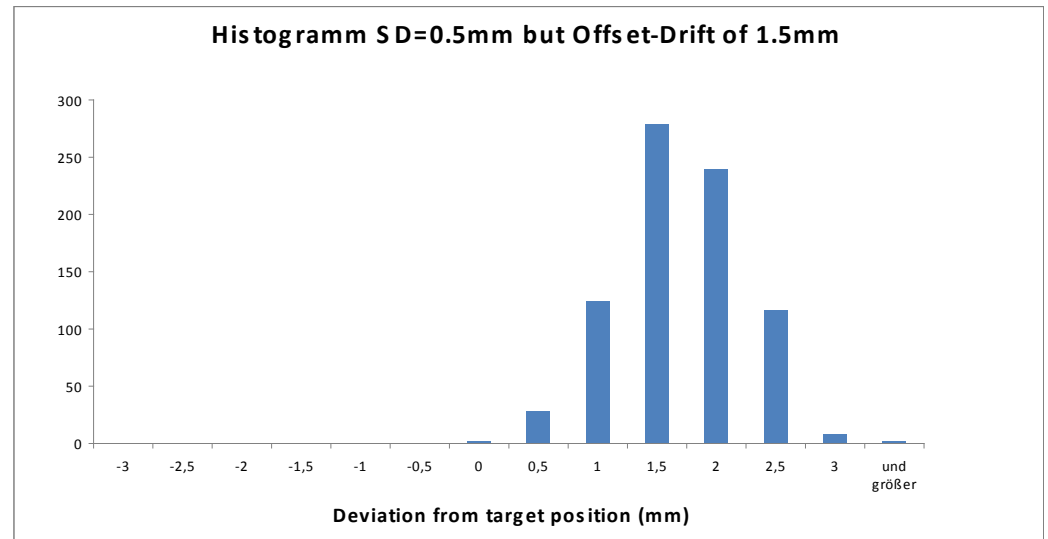
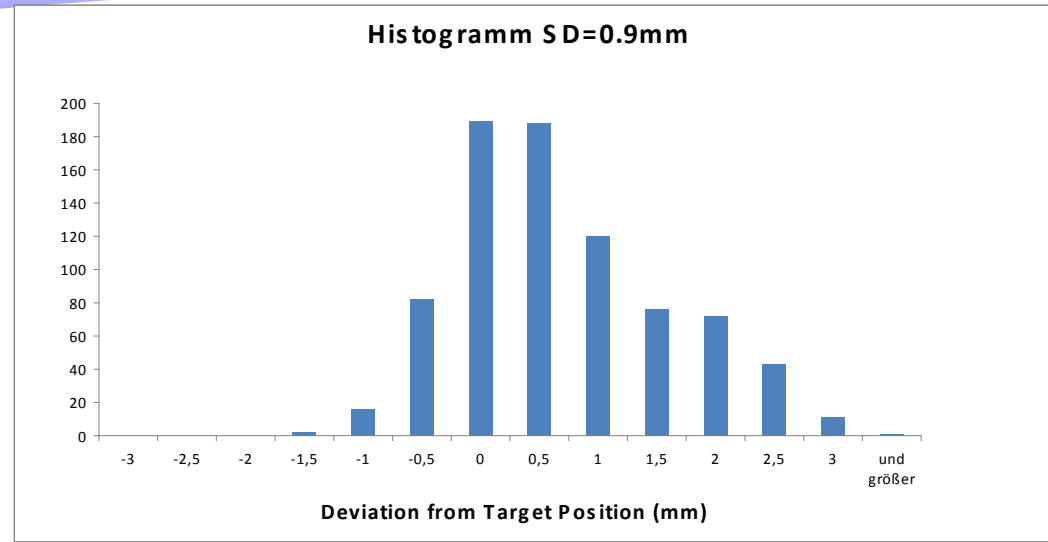
6. Filterrods and capsules: capsule quality – microwave signals

Statistics for filterrods from an accepted production lot.

Efficiency: 99%.

Above: Capsules are in target position.

Below: Capsules with an offset in the position drift within the permitted range - machine correction is required.

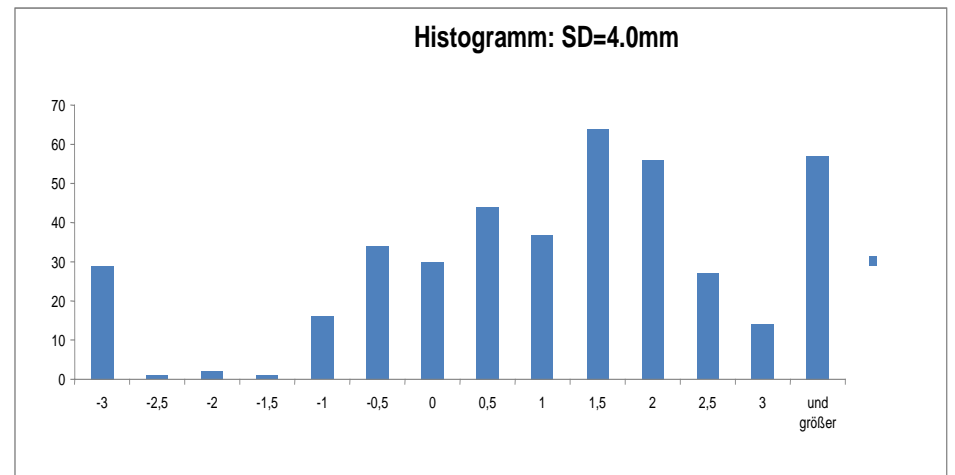
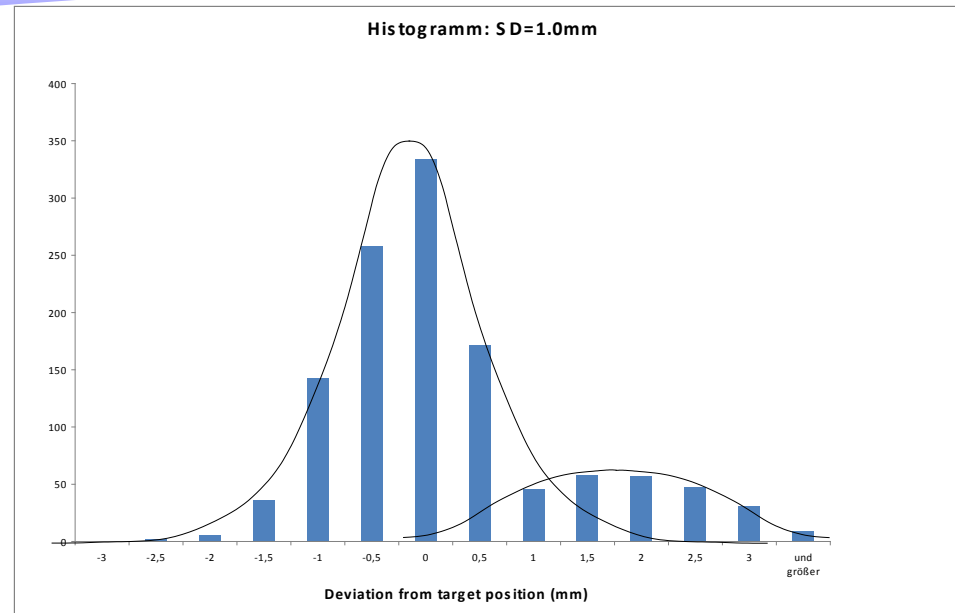


6. Filterrods and capsules: capsule quality – microwave signals

Statistics of a batch of filterrods made during a problem prone manufacturing run:

Upper: Capsules with double population of capsule distribution - lower efficiency of 97% (SD = 1.0 mm)

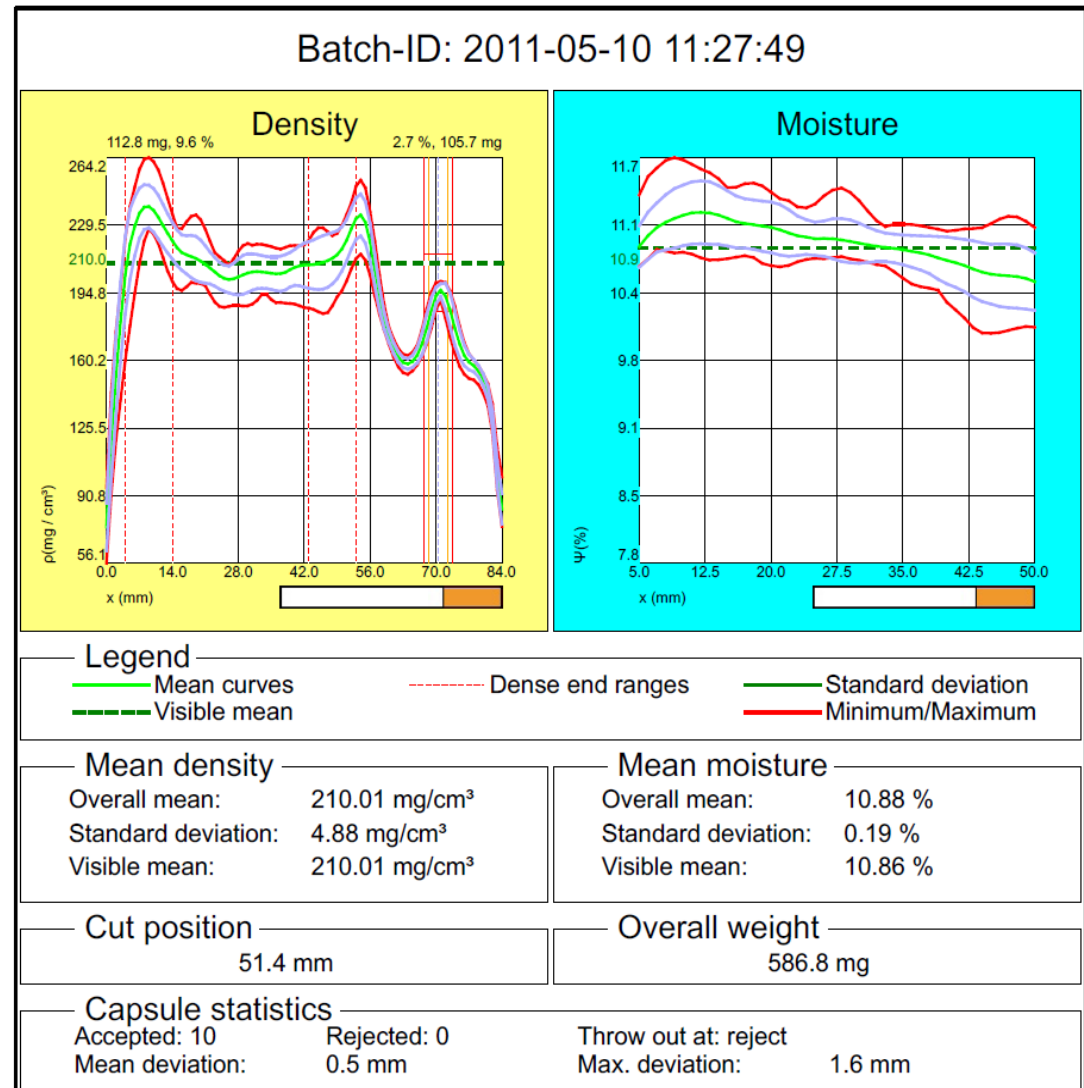
Below: Capsules with low efficiency of 79%. (SD = 4.0 mm)



6. Filterrods and capsules: capsule quality – microwave signals

Quality verification of finished cigarettes, containing one capsule:

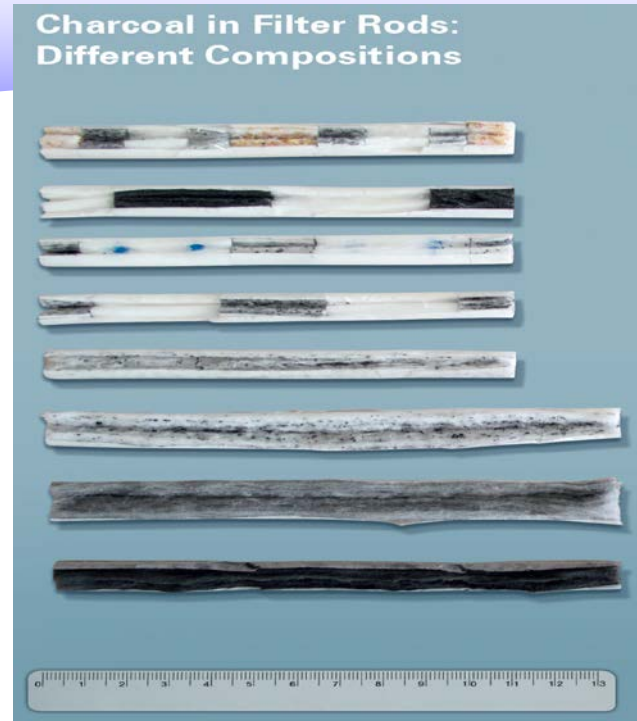
- Measurement of mean density and moisture of the tobacco rod.
- Quality verification of position and amplitude signal of the flavor capsule in the filter segment.



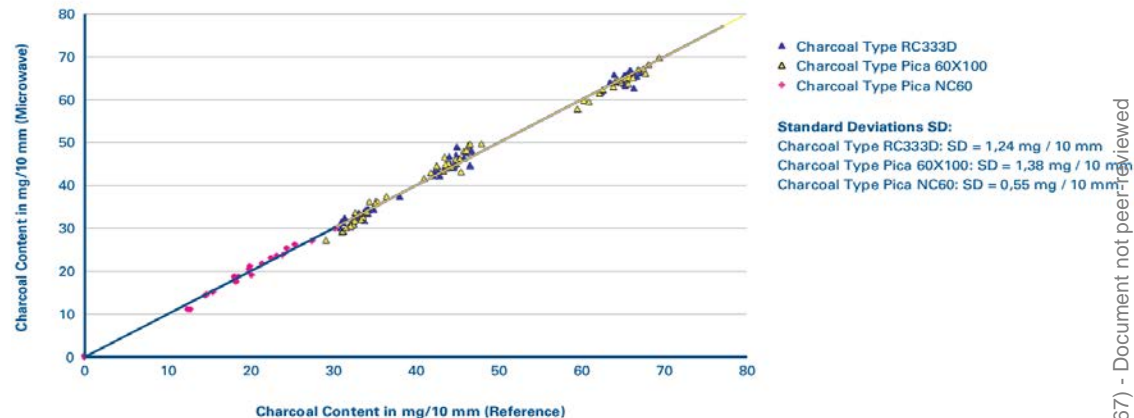
7. Multisegmented filters: edge detection and charcoal determination

Quality check of filterrods, containing charcoal:

- Detection of edges in multisegmented filters
- Detection of charcoal content within one single segment - independently of charcoal particle size



Precision of the Microwave Charcoal Measurement



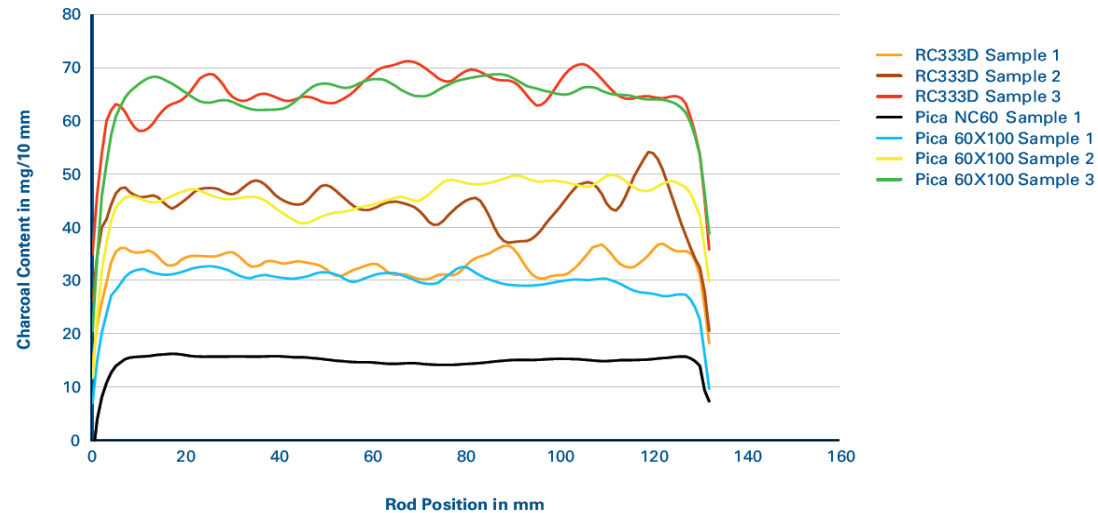
7. Multisegmented filters: edge detection and charcoal determination

Quality verification of filterrods, containing charcoal:

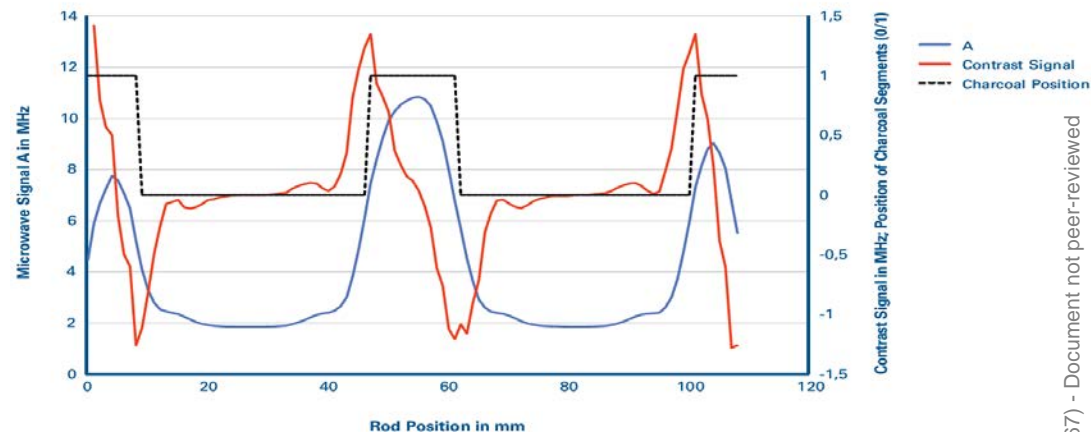
Determination of mean value of charcoal mass and distribution (homogeneity as CV-value), total amount in a single segment.

Identification of edges using a dedicated edge detection function (first derivative of the microwave density function)

Profile Measurement of Charcoal in Filter Rods



Measurement of Charcoal Position in Filter Rods



8. High-speed online detection with same microwave sensor: control of cigarette, capsule quality with ejection

In Co-operation between

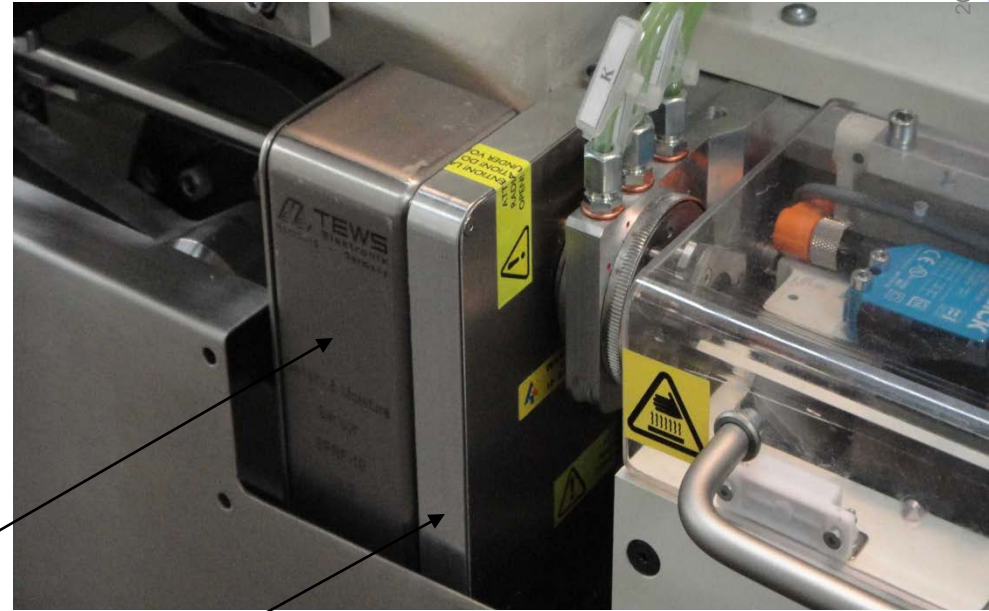
TEWS and **AIGER**

Developed was the detection of menthol capsules in a filter maker:

Microwave Sensor

(60 mm) for tight space - fits into each maker. Measuring time is 0.05msec

Special **3 Lasers-Sensor**, for an improved quality control for a large variety of filters, to detect gaps in multi-segmented filters, longitudinal grooves in Monofilters. Measuring time is 0.004msec



9. Summary and Conclusions

- Microwave resonator technology is a powerful tool to verify the quality of cigarettes and filterrods. It can be used for its single or multiple quality features. Moisture, tobacco weight and cut position identification (to avoid loose end), and tobacco fall-out, are well known and tested. Each device is precalibrated, and calibrations are time-independent. Calibrations are thus device-independent and can be applied as company-wide standards.
- New is the quality verification of filterrods containing aromatic capsules and the quality-verification of multisegmented filters or filter tips of cigarettes (charcoal segments or white-white filters).
 - Measurement of the position of each capsule and the detection of the content of each capsule; ejection of incorrect positions and filling.
 - Measurement edge positions in multi-segmented filters or filter tips of cigarettes; measurement of charcoal content and segment distribution.
- A calibration is not necessary for the position detection.
- This technology is completely transferable to in-line quality verification and machine control.
- All measuring data are available as Excel-readable files via Ethernet or USB.