delfortgroup
www.delfortgroup.com

Using Residual Length Data to Estimate the Rate of Self-Extinguishment of Banded Cigarette

ST41

EITZINGER B., RIVAS CANO A.

CORESTA SSPT Sub-Group Meeting
October 4-8, 2015
Jeju Island, South Korea

dunafin

feurstein

op papírna

tervakoski

wattenspapier

wattens vietnam

Motivation

- IP Testing (ISO 12863, ASTM E2187)
    - Time-consuming
    - Low repeatability due to binomial distribution
      e.g. 85% rate of SE; 95% confidence interval = 29-38 cigarettes

- Proposals for Improvement
    - Verron T. et al. (2013): LIP Cigarettes: Proposal for Alternative Sampling Design
      ST47, CORESTA SSPT Meeting, Seville

    - Case P. et al. (2009): Ignition Propensity: Some further information that can be gained from cigarettes that have been subjected to ASTM E2187 testing
      SSPT40, CORESTA SSPT Meeting, Aix-en-Provence

- Target: Improved estimation of the SE rate of banded cigarettes
  using residual length (RL) data

Outline

Cigarette Data and Measurement Results

	Band D* cm/s	SE Rate [%] Mean	SE Rate [%] St. Dev.	Residual Length [mm] Mean	Residual Length [mm] Std. Dev.[1]	Residual Length [mm] Std. Dev.[2]
A	0.04	95.8	2.9	30.8	0.3	11.0
B	0.04	97.5	0.0	32.6	1.3	10.6
C	0.10	83.3	5.2	25.6	3.1	15.6
D	0.10	85.0	2.5	24.5	2.8	15.4
E	0.15	79.2	1.4	23.4	1.8	16.9
F	0.15	80.0	6.6	21.5	3.7	15.5

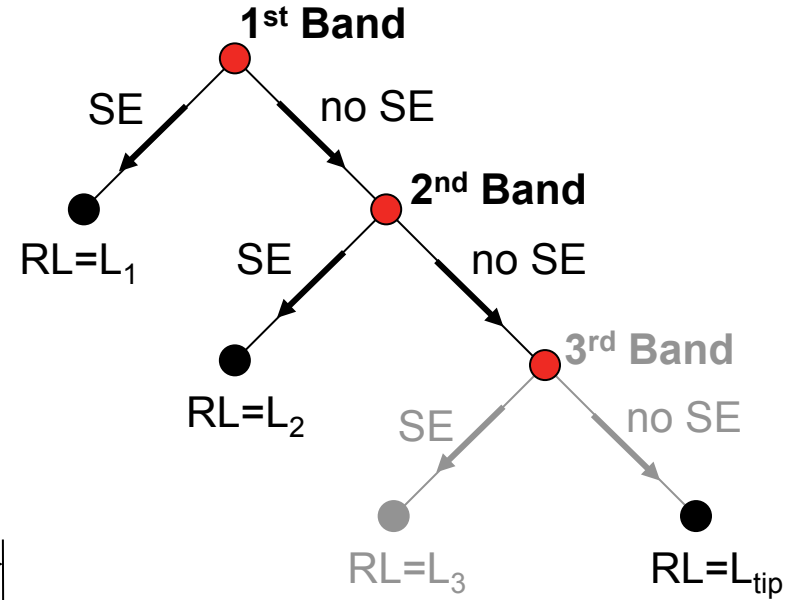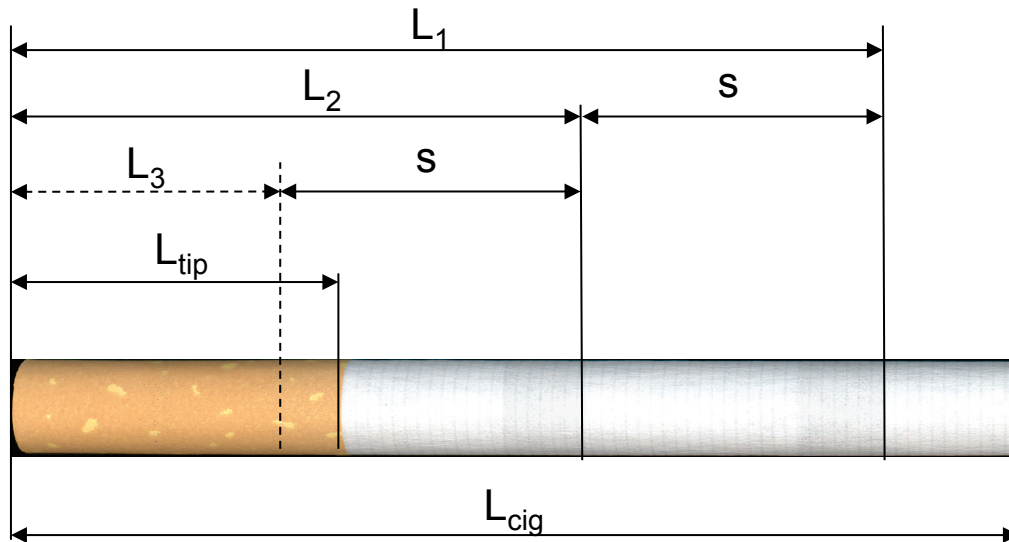- 6 samples, 3 x 40 cigarettes tested = 18 data points

- Length 84 mm, tipping 25 mm, band width 6 mm, band spacing 18 mm

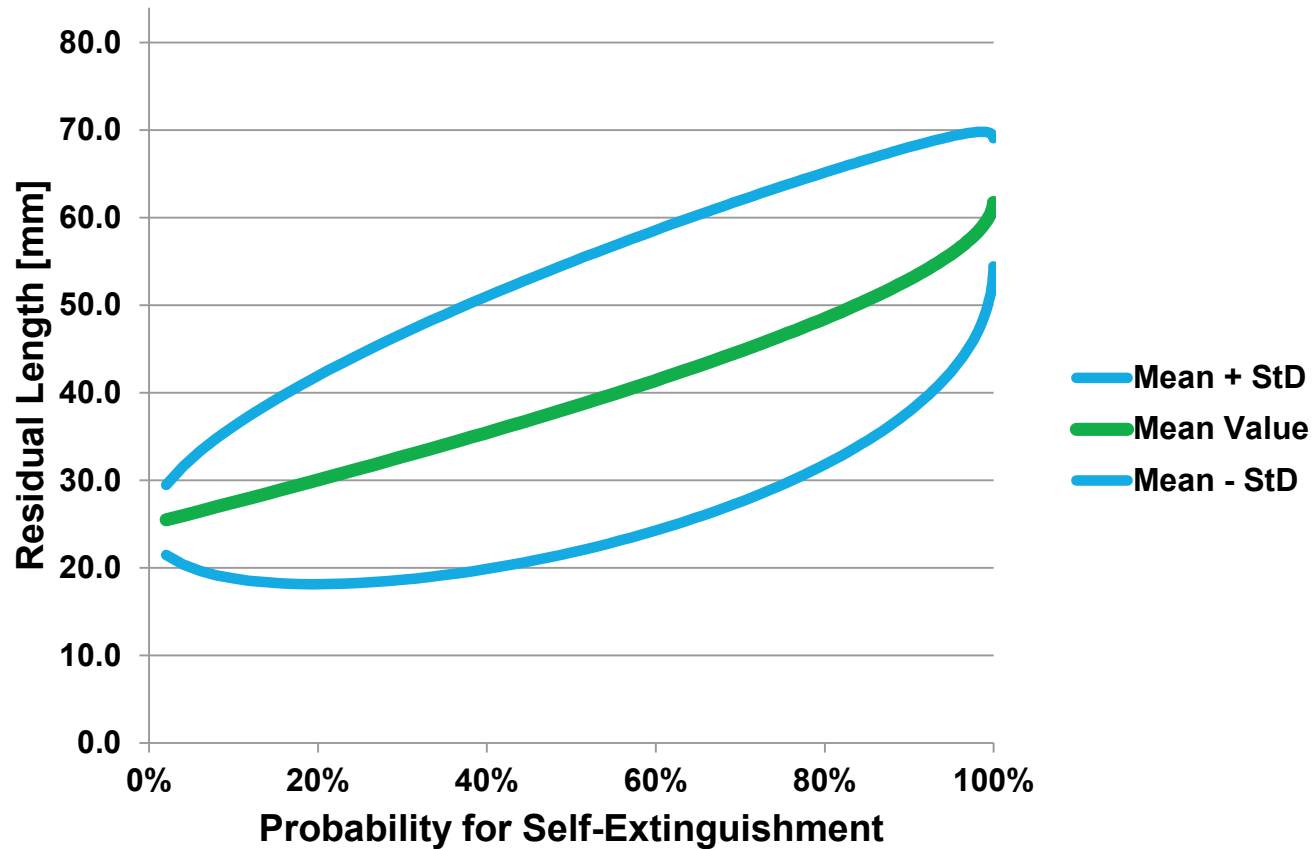[1] of mean RL of 40 cigarettes; [2] of RL of single cigarette

Basic Concept

Assumptions

- No SE between bands
- SE at leading edge of band
- Probability for SE same for each band
- Uniformly distributed band position
- Reduced cigarette length due to lighting effects

1st Band

SE / no SE

RL=L_1

2nd Band

SE / no SE

RL=L_2

3rd Band

SE / no SE

RL=L_3 / RL=L_{tip}

L_1

L_2 | s
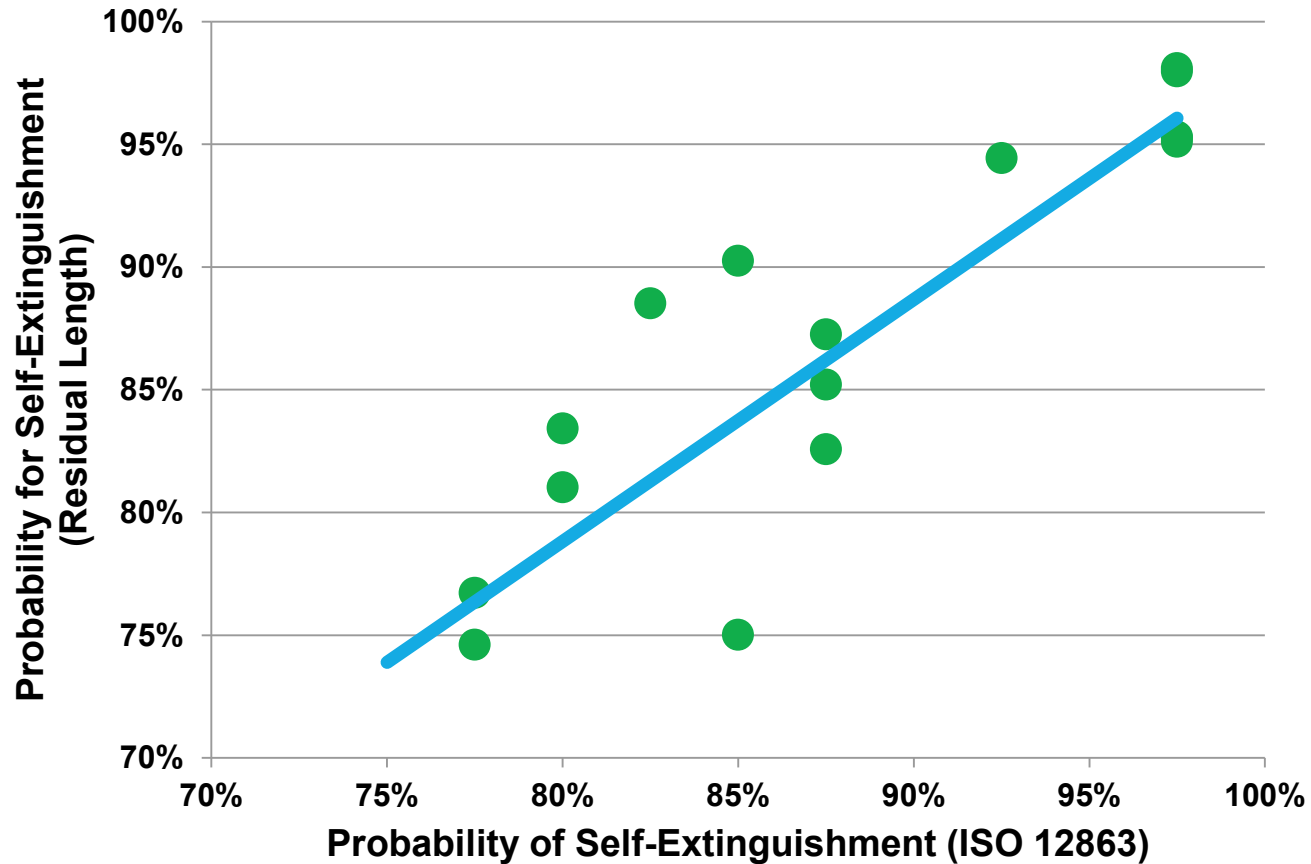
L_3 | s

L_{tip}

L_{cig}

Residual Length vs. SE Rate

(Simulation)

- Higher sensitivity of RL on SE rate at high SE rates.
- RL follows complex, non-continuous distribution.

Results: SE Rate Estimated from RL

Plot: X-axis "Probability of Self-Extinguishment (ISO 12863)" ranging 70% to 100%; Y-axis "Probability for Self-Extinguishment (Residual Length)" ranging 70% to 100%.

- Good agreement, systematic error ≈ -1.5%
- R^2 = 0.80 is acceptable, needs to be <1 for improvement
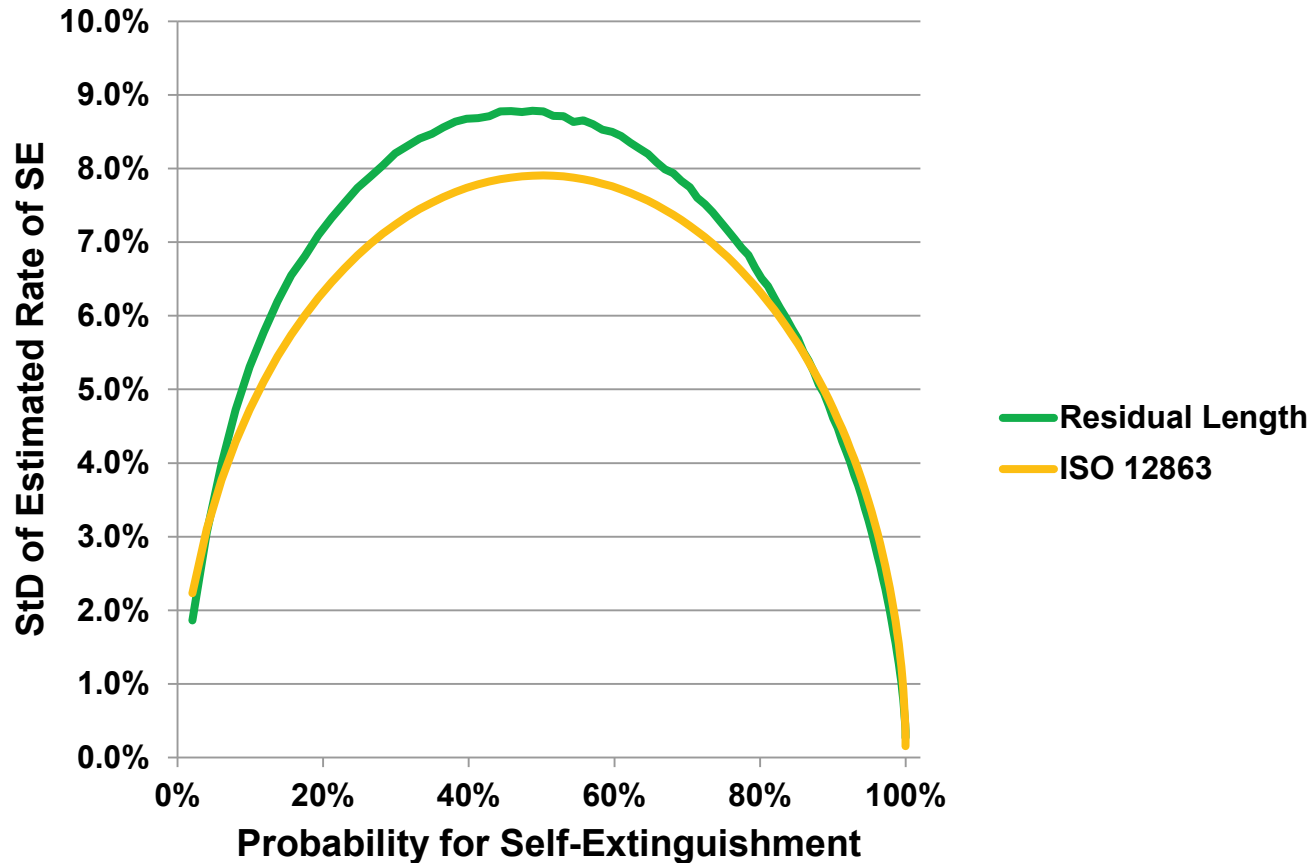
Results: SE Rate Estimated from RL
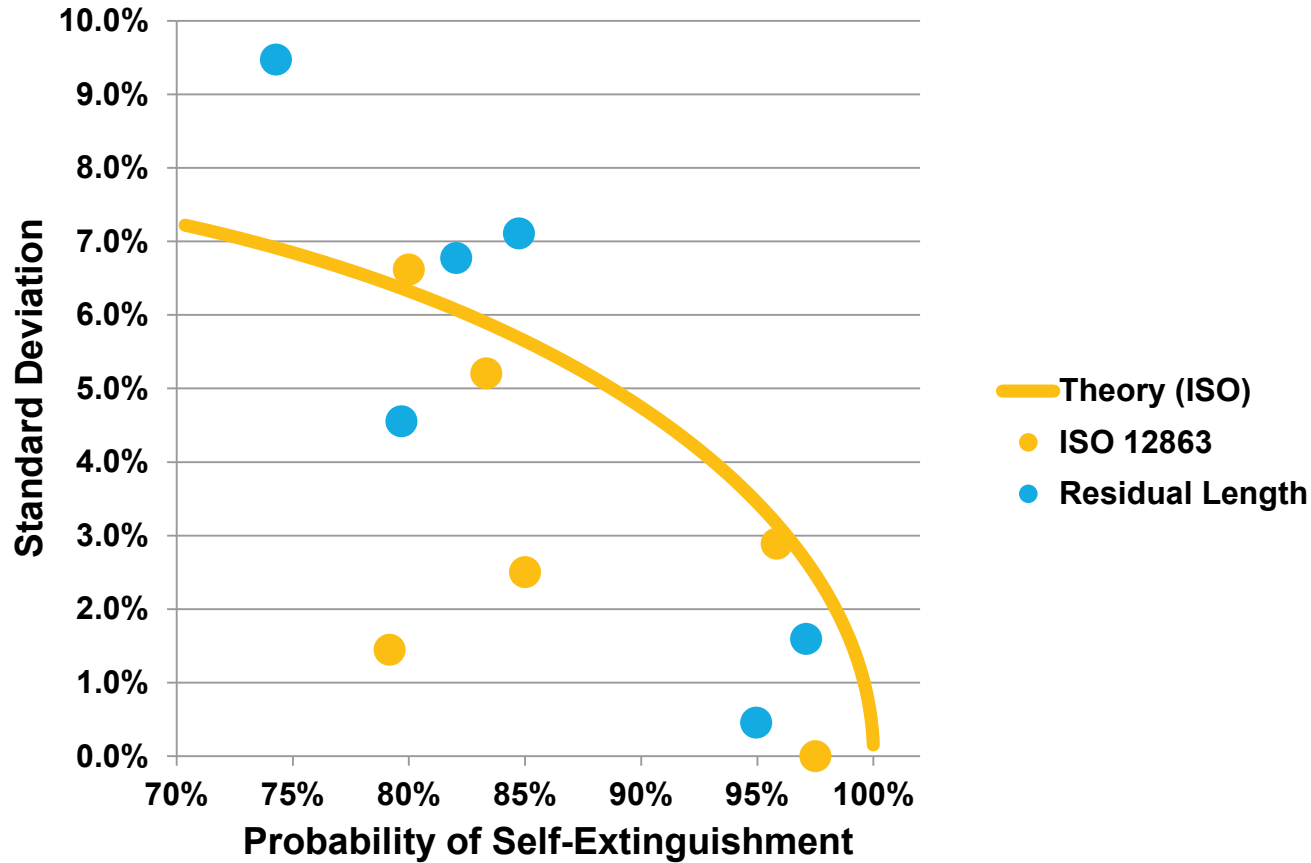
No improvement compared to ISO 12863

Results: SE Rate Estimated from RL

(Simulation)

- Variability of band position 'contaminates' RL data, but does not provide information about SE rate.

Basic Concept

- Use relation between RL and band number
  - Band number is not 'contaminated' by variable band position.
  - Relationship between RL and band number is unambiguous (surjective).

- Measure or calculate fractions of cigarettes that self-extinguished
  - at first band,
  - at second band,
  - at third band (if present),
  - not at all.

- Determine estimate of SE rate such that the measured fraction of cigarettes in each category matches the theoretical fractions.
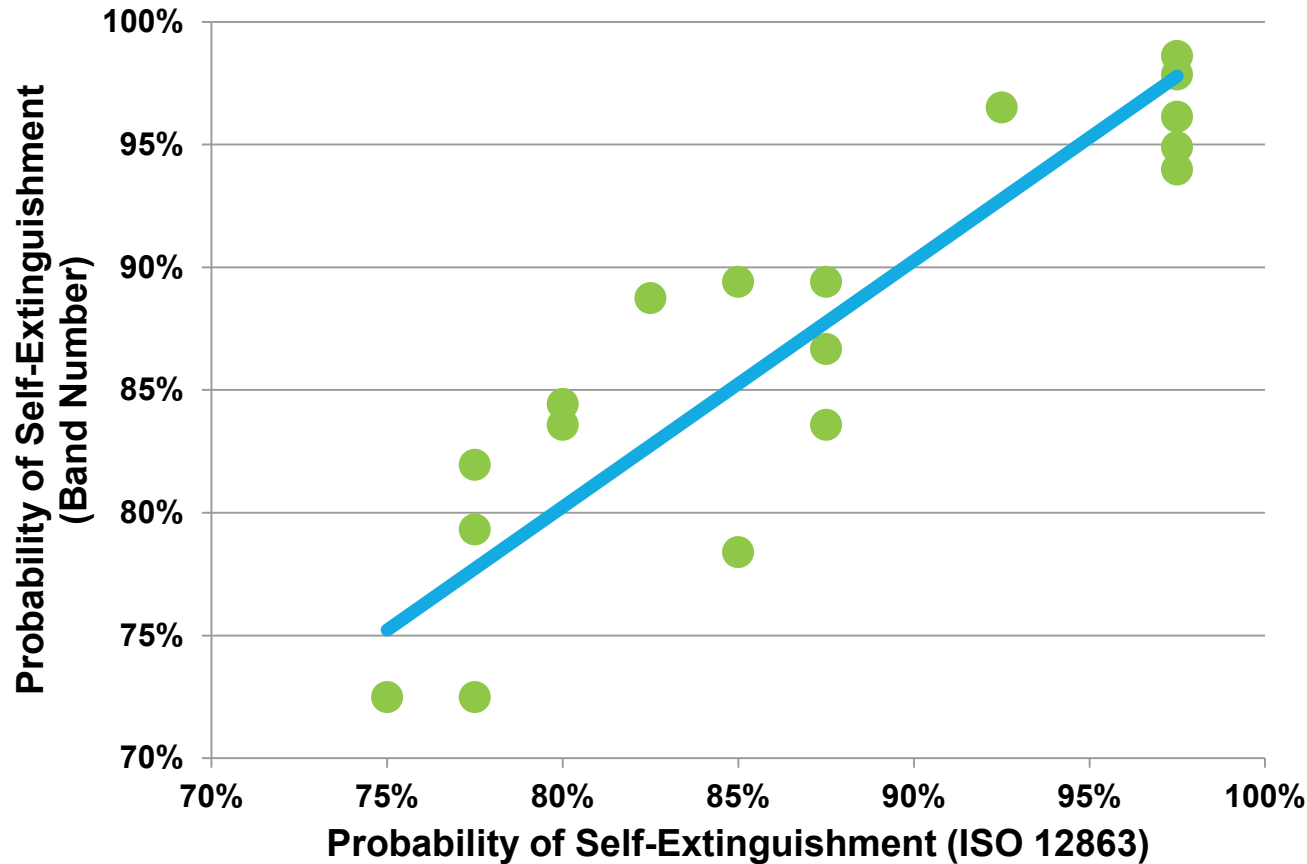
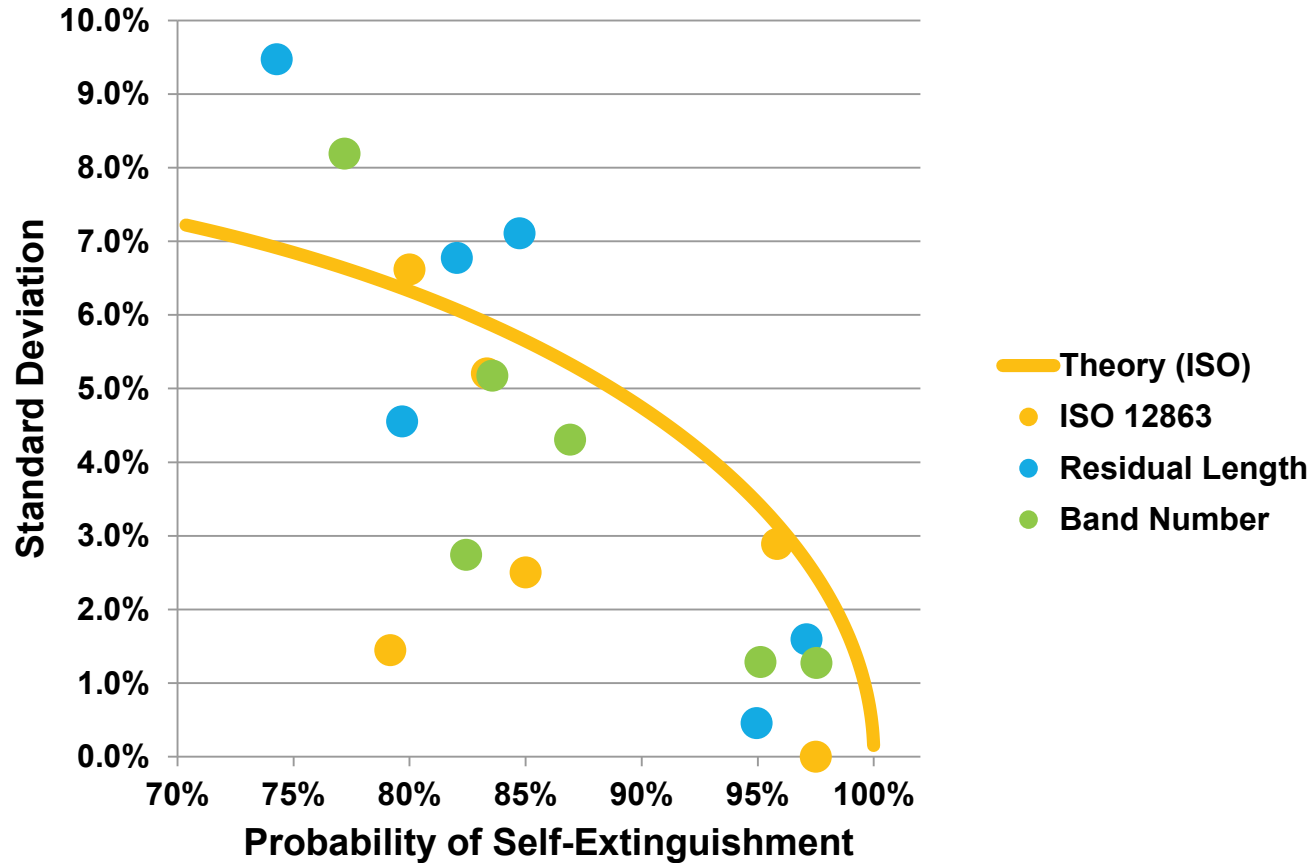# Band Number vs. SE Rate

(Simulation)
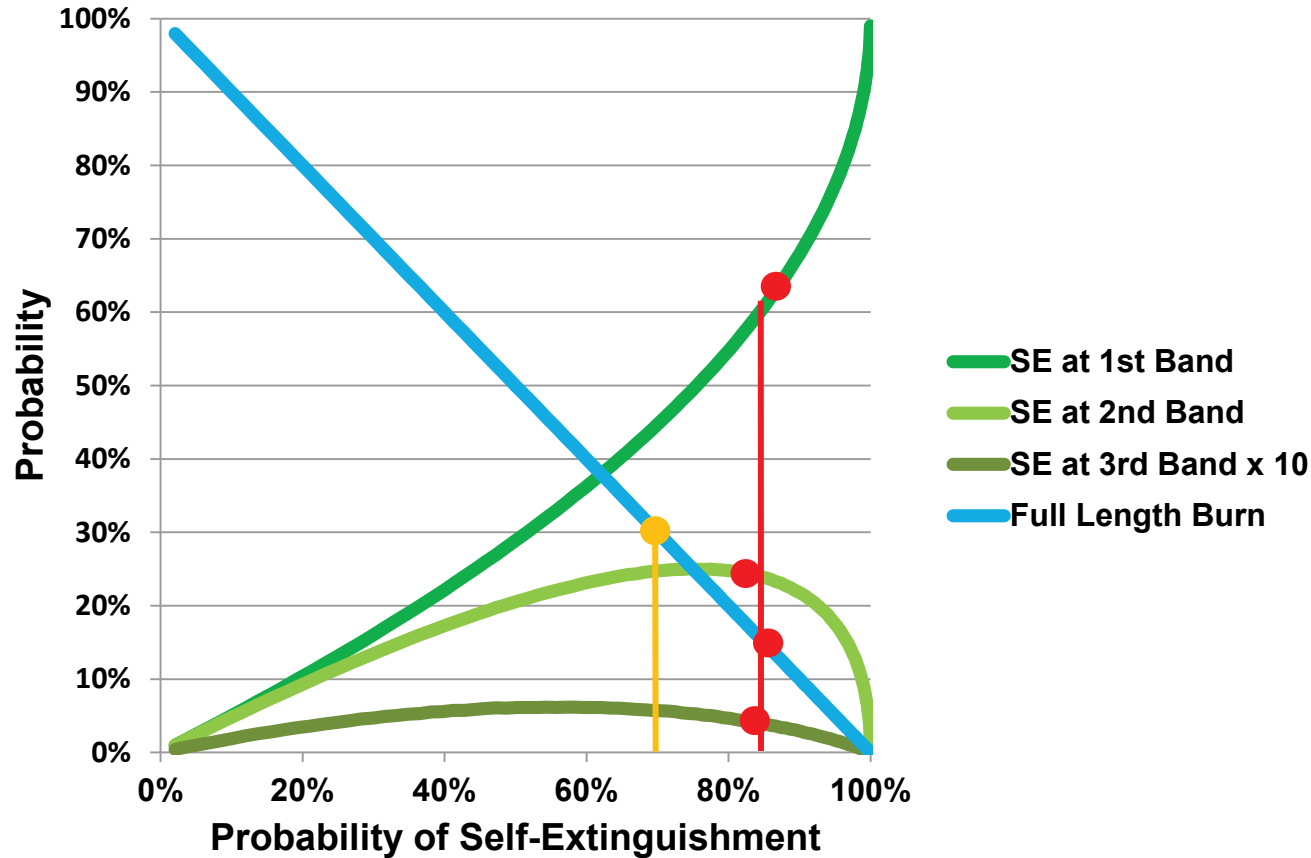
As more information is used, when the SE rate is estimated from the band number, a more precise estimate may be expected.

Results: SE Rate Estimated from Band Number

- Good agreement, very small systematic error (slope = 1.003)
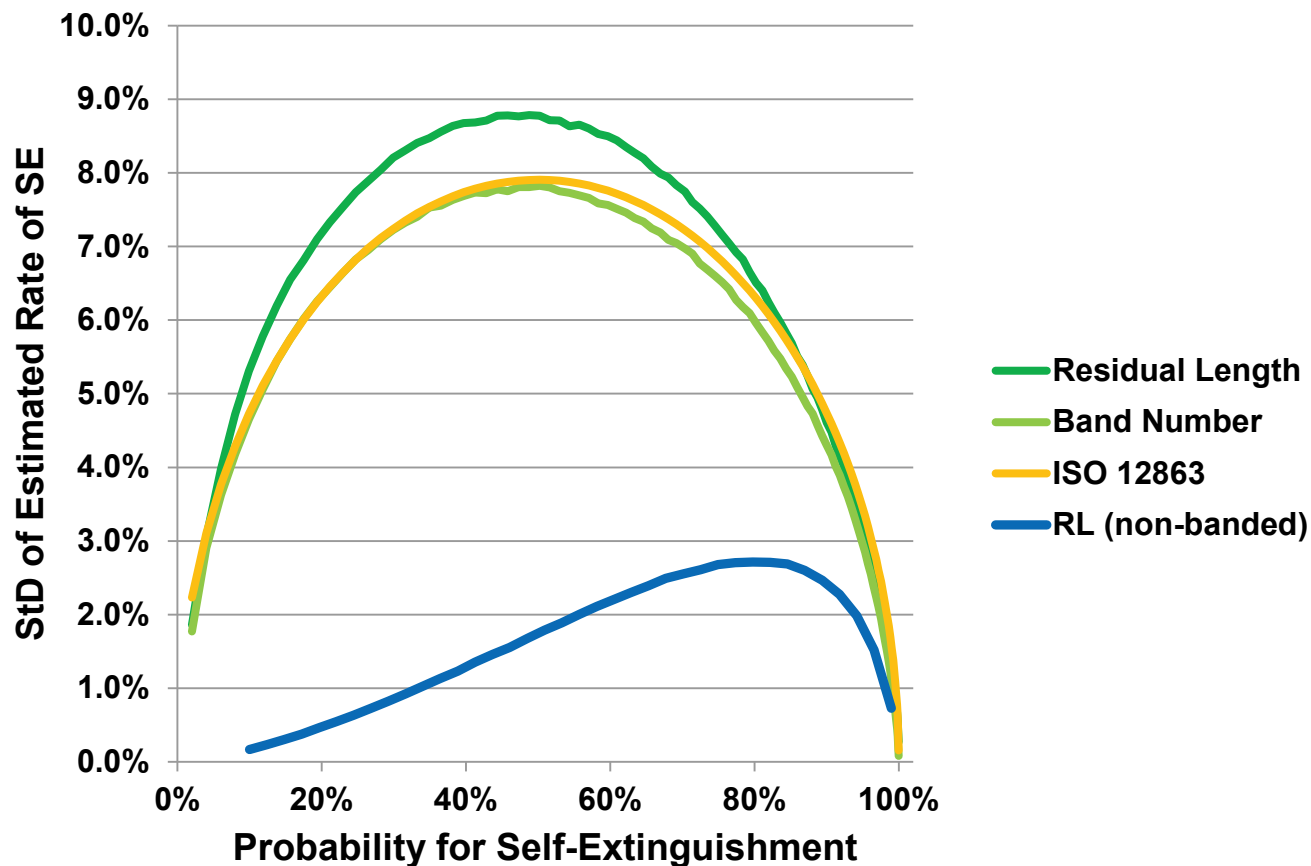- R^2 = 0.79 is acceptable, needs to be <1 for improvement

Results: SE Rate Estimated from Band Number

Almost equivalent to ISO 12863, probably slight improvement in standard deviation, better than estimate from RL.

Results: SE Rate Estimated from Band Number

(Simulation)

Simulation confirms limited improvement compared to estimate based on ISO 12863.

Summary and Conclusions

- Using residual length data for banded LIP cigarettes to estimate the rate of self-extinguishment …
  - … provides the same mean SE rate as an estimate by ISO 12863,
  - … shows higher or comparable standard deviation.

- Residual length data on banded cigarettes is 'contaminated' by the variability of the band position. This deteriorates the estimate.

- The band number can be uniquely determined from RL data. The band number does not contain variability from the band position.

- Using the band number to estimate the rate of self-extinguishment …
  - … provides the same mean SE rate as an estimate by ISO 12863,
  - … shows slightly lower standard deviation by about 5-10%.

- Residual length data and the band number contains little additional information about the SE rate and has limited potential to improve the estimate of the SE rate beyond ISO 12863.

Acknowledgement

I would like to thank Ana Rivas Cano of Japan Tobacco International for providing the experimental data.

Thank you!