NZ Government – Industry Primary Growth Partnership (PGP) programme

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Dairy for life

Outline

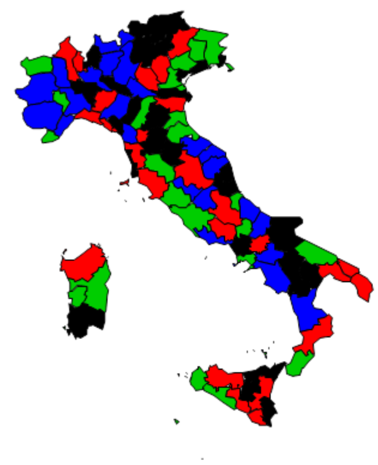
1. PGP programme overview
    - Use of industrial statistics stream of work
2. Background - Sampling Inspection
    - Objective of sampling inspection
    - Structure of inspection process
3. Problems with current inspection methodologies
4. PGP developments for measurement error adjustment
5. Progress and Future Work
6. Conclusions

NZ Trade 2013

Exports $NZ62000M

- Dairy $NZ11500M (19%)
  - 7 million dairy cows
  - exports 95% of dairy products

- Meat $NZ5250M (8.5%)
  - 4 million beef cattle
  - 31 million sheep



- Wood/Timber $NZ3375M (5.5%)

Primary Growth Partnership (PGP) programme

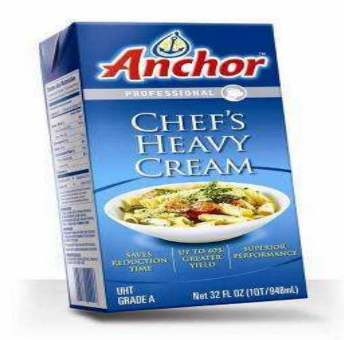
Transformational platforms of research, training, and knowledge transfer pre- and post-farm gate

$170M over 2011-2018

Innovation to Transform the Dairy Value Chain

On Farm and Pastoral Research | Process Control Product Assessment | Food Structure & Nutrition

Farming → Processing & Supply Chain → Ingredients & Dairy Solutions → Consumer Products



Dairy PGP Programme

Optimising the Supply Chain

Initial Projects

1. Best practice in use of industrial statistics

   Supply chain quality assurance, especially product assessment focusing initially on:

   – Measurement Error

   – Compositional Parameters

2. Optimised Process Control

IAM Discussion Paper

Four options were presented:

1. ***Acceptance Sampling***
2. ***Estimation of total uncertainty from both analysis and sampling***
3. ***Representative/Pragmatic Sampling***
4. ***Auto-Control***

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The Aim of Sampling Inspection (ISO 2859)

"The aim of sampling inspection is to see that the customer receives the quality required,

while remembering that financial resources are not unlimited,

and the cost of the product must reflect the cost of inspection as well as the cost of production"

NZ Primary Growth Partnership programme

- Statistical Approach:
  - ISO 2859 recommends sampling based on the theory of probability:

    "Not all the product will be inspected, but the risks involved can be precisely calculated and a plan chosen to allow no more risk than required"

- Publication Strategy
  - Publications in peer reviewed statistical and quality journals
  - Research available in the public domain

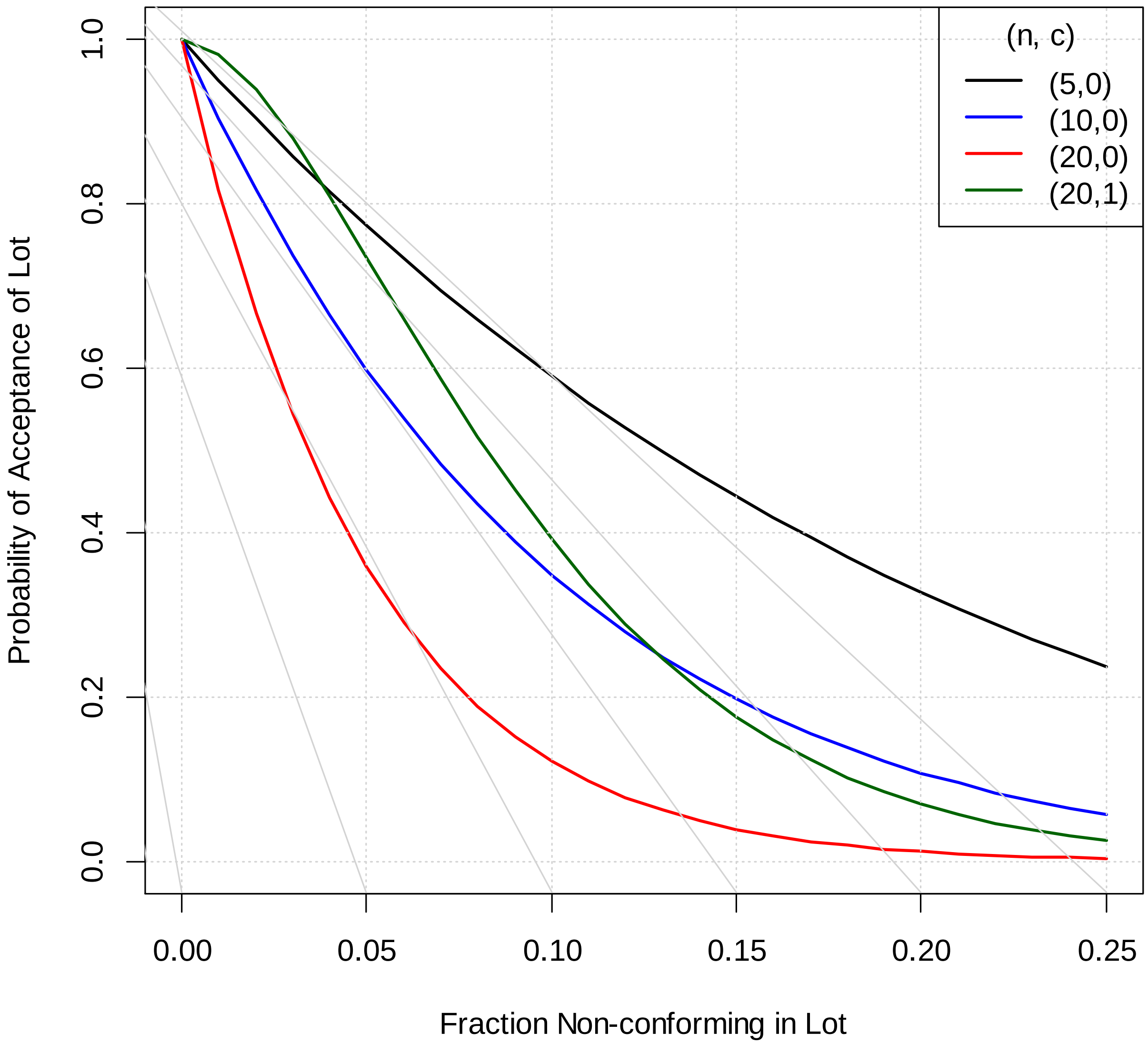
- Simplicity of application
  - Exploited using computer based procedures

Acceptance Sampling Plans

- Acceptance Sampling Plans are simple to apply:
  - e.g. Inspection by Attributes plans:

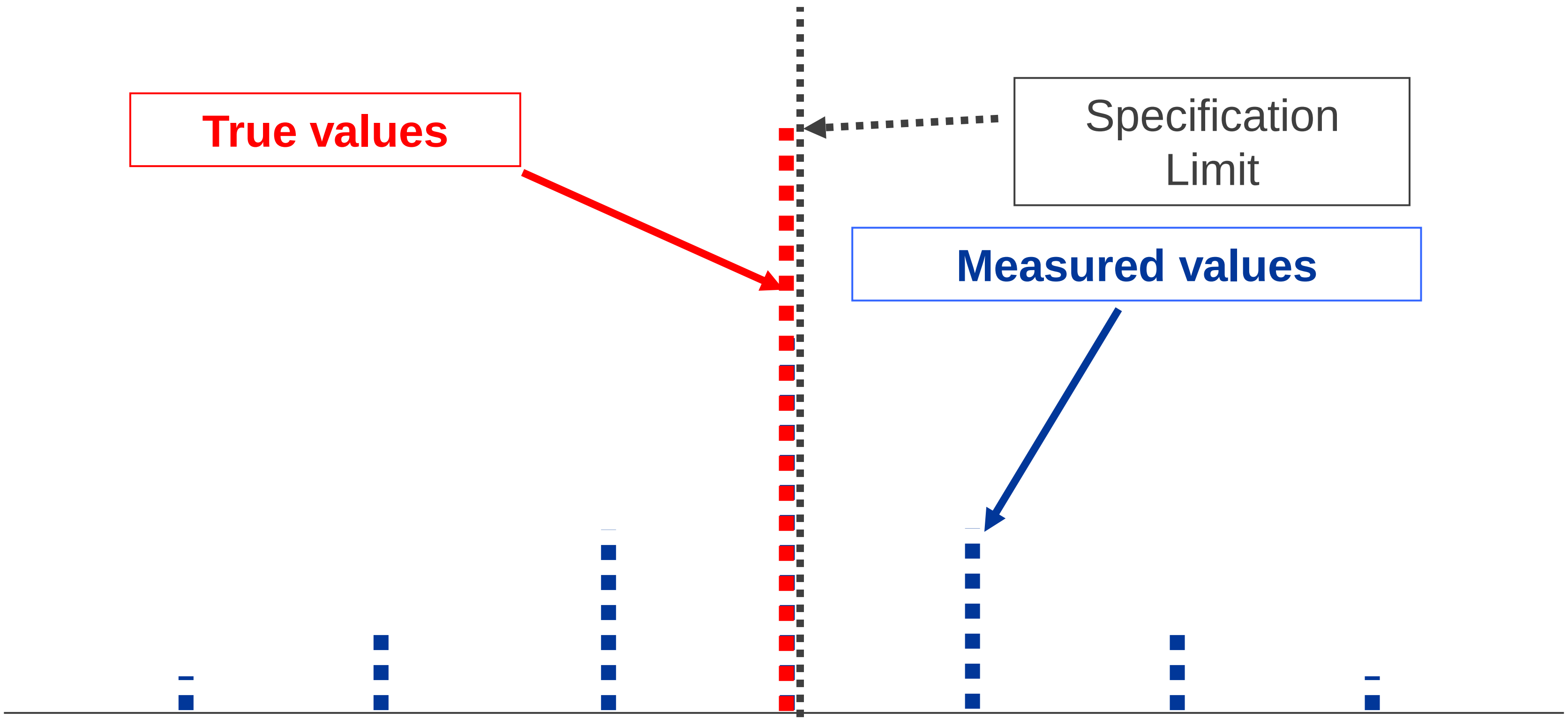
1. Take “n” samples from the lot under inspection
2. Test those samples
3. Accept the lot provided no more than “c” of these samples are “defective”

Values of “n” and “c” chosen to control the risks of accepting poor quality product, typically by specifying the Acceptance Quality Level.


(n, c)
(5,0)
(10,0)
(20,0)
(20,1)
Probability of Acceptance of Lot
Fraction Non-conforming in Lot
0.0
0.2
0.4
0.6
0.8
1.0
0.00
0.05
0.10
0.15
0.20
0.25

Current Standards

- Current Standards do not allow for measurement error, which can have an appreciable effect on product acceptance
  - ‘pure’ measurement error has more effect on the producer, causing increased rejection of good product



Current Standards

- Sampling Plans are indexed by lot size (number of items in the lot)
  - ISO 2859, ISO 3951 and CAC GL-50 assume lots consist of discrete items
  - Not applicable to lots of bulk materials

- Inspection by Variables plans assume normal distributions
  - Assumption of Normality is often inappropriate or unjustified
  - Normality tests are ineffective with small sample sizes
  - Incorrect assumption of Normality can lead to increased failure of good product
  - “Model Uncertainty”

IAM Discussion Paper

1. *Acceptance Sampling*
2. ***Estimation of total uncertainty from both analysis and sampling***
3. *Representative/Pragmatic Sampling*
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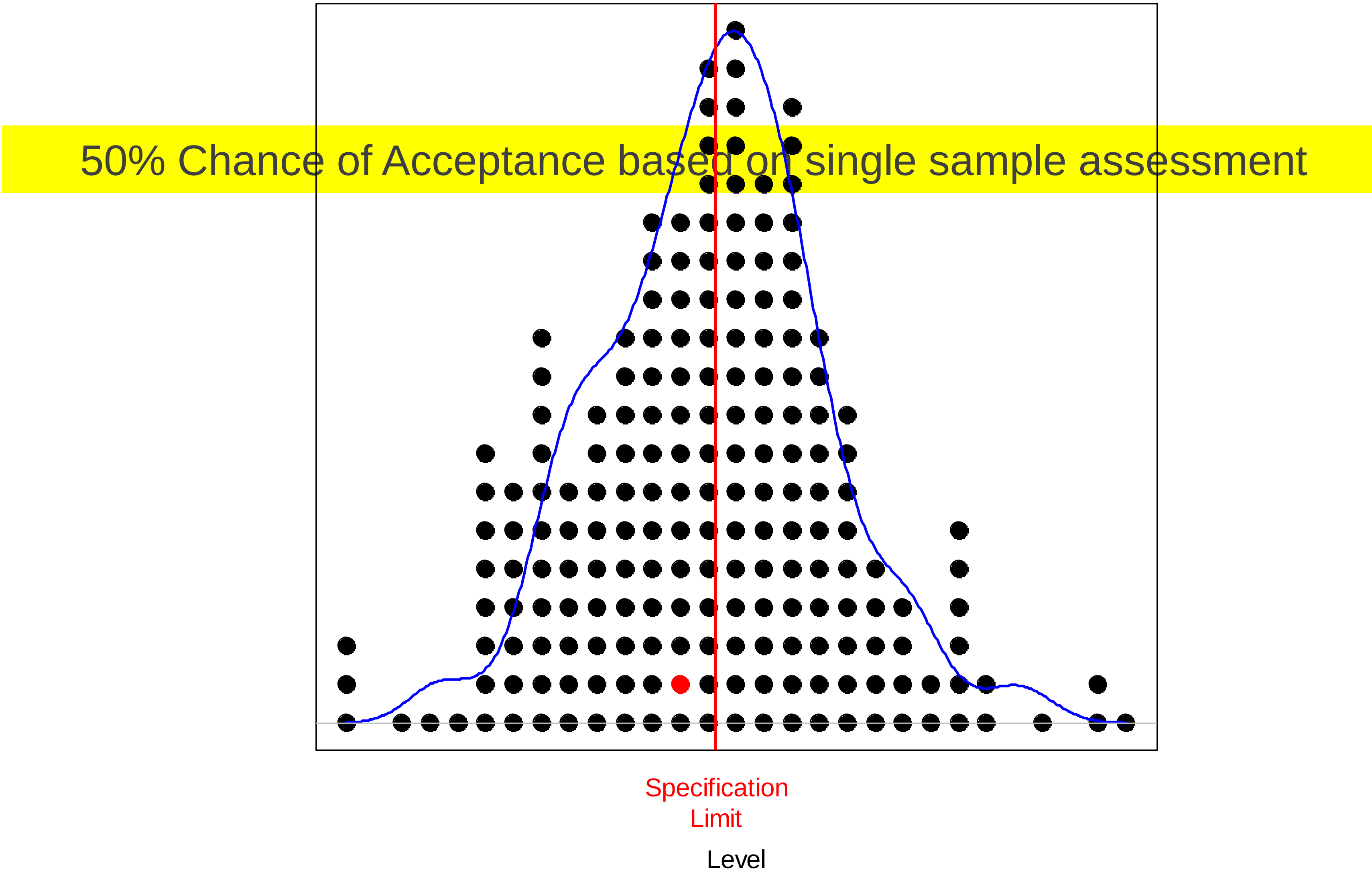
Measurement/Sampling Uncertainty Approach

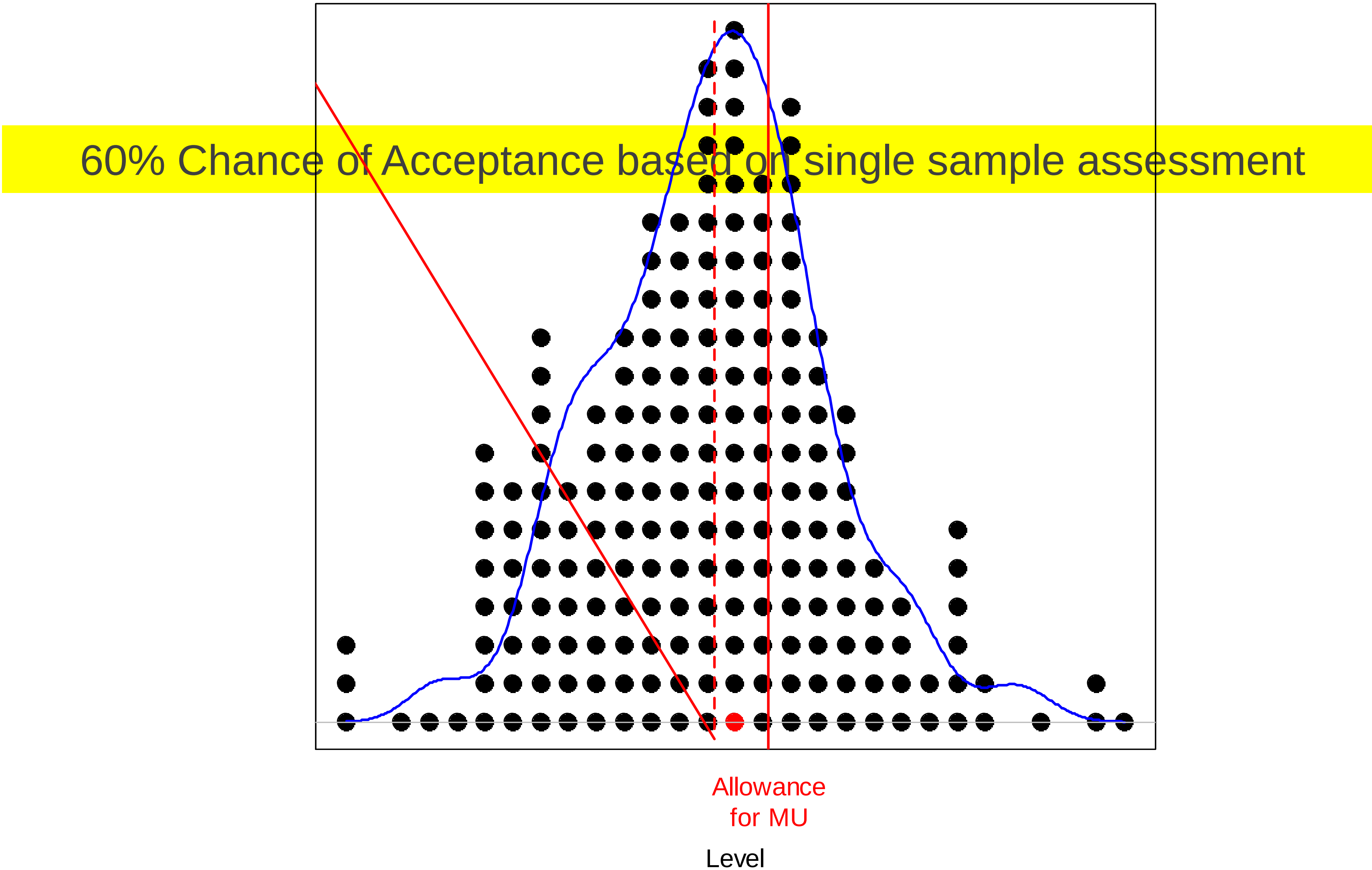
We see this approach as having limited value:

- Conservative allowances for measurement and sampling uncertainty detract from consumer protection

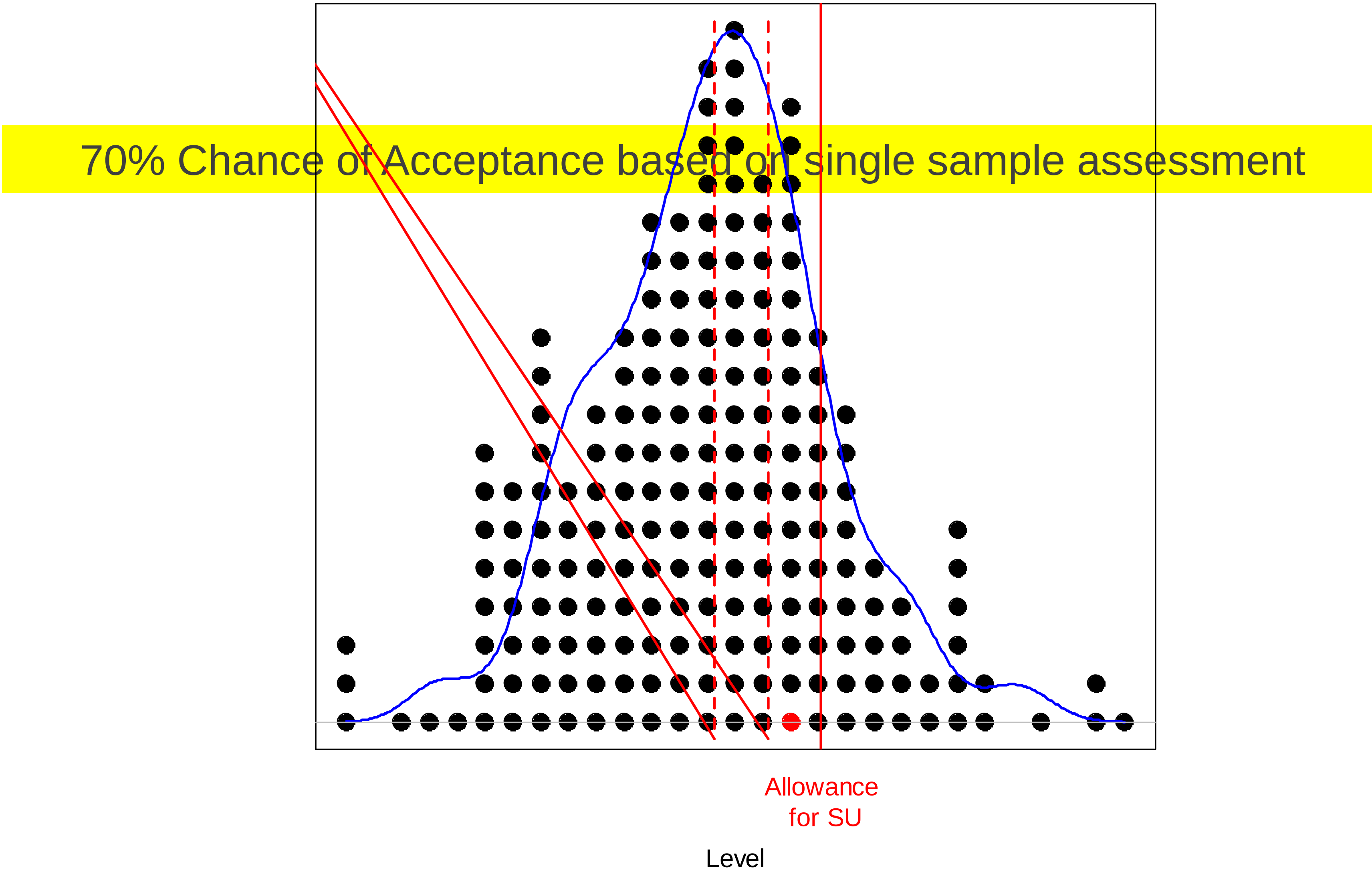
Inspection of Lot with 50% out of specification



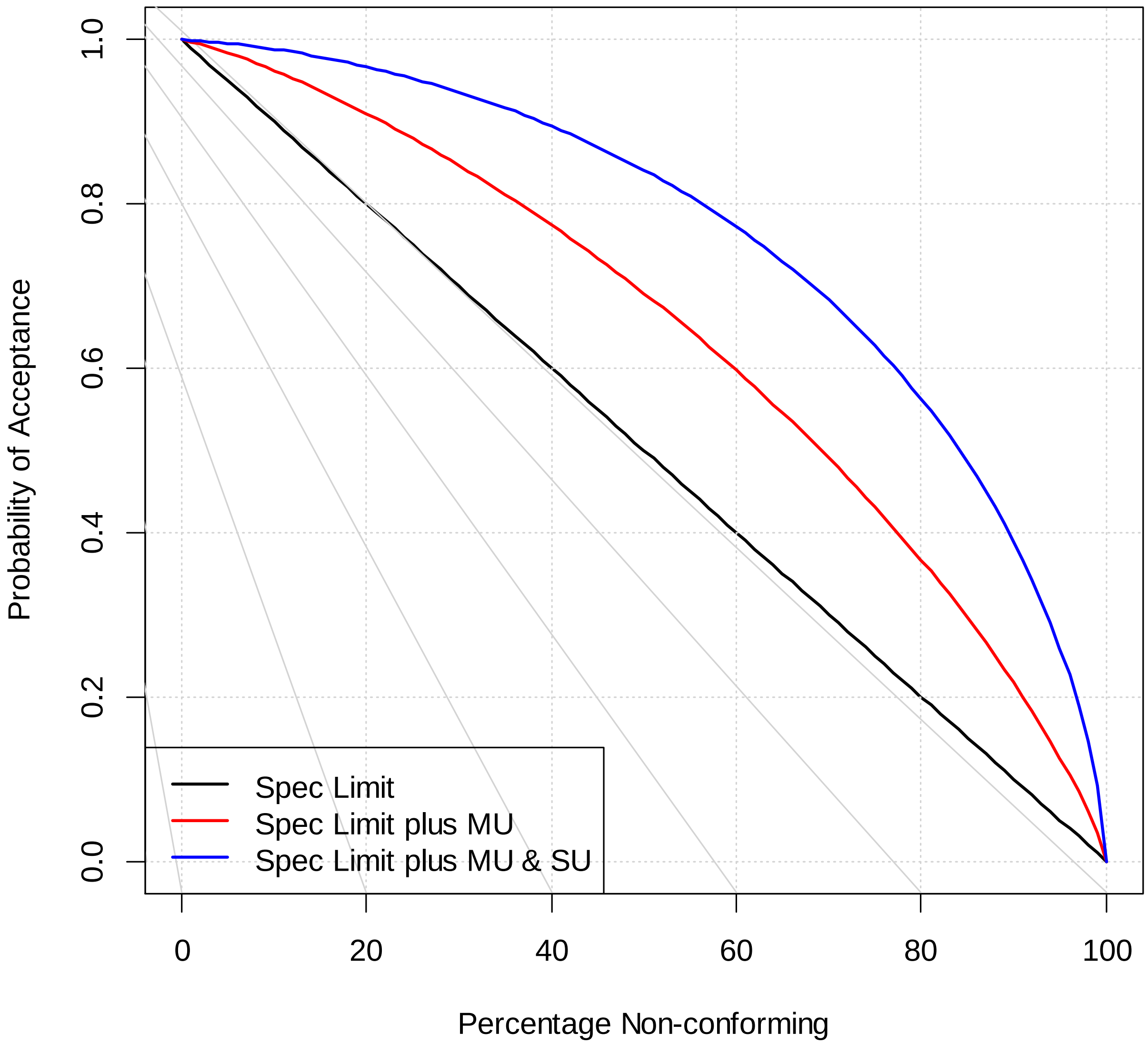
Inspection of Lot with 50% out of specification



Inspection of Lot with 50% out of specification



Operating Characteristics



Conclusions

- Proposed procedure seems ineffective for ensuring that consumers receive product of good quality
- It rewards bad measurement and more variable processes
- It appears derived from the "conformity assessment" literature:
  - Conformity assessment applies to conformity of the item/sample inspected
    - "does the sample comply?"

      See ISO10576 Guidelines for the evaluation of conformity with specified requirements
  - "Sampling Inspection" relates to conformance of the lot overall
    - "does the lot comply?"
- Effective single result assessments can be obtained about average levels (e.g. aflatoxins) using composite samples
  - Methods to deal with measurement error need to be developed

…why not use sampling procedures that are dictated by statistical theory, with the advantages of less cost, and with meaningful, calculable tolerances?

- W.E. Deming

IAM Discussion Paper

1. **_Acceptance Sampling_**
2. **_Estimation of total uncertainty from both analysis and sampling_**
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NZ Primary Growth Partnership Programme

- Several papers submitted for publication

- Two methods developed for grading net of measurement error:
  1. ‘Deconvolution’ method
  – computer-assisted approach

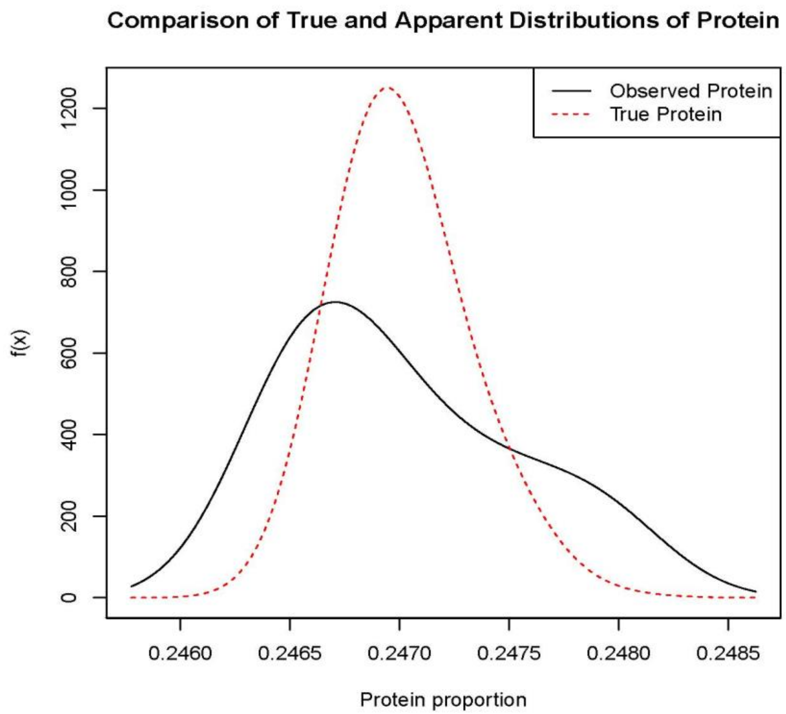
  2. Fractional Non-Conformance method
     – can be implemented in Excel

  General principle:
  – ‘Subtract’ measurement error to perform assessment on ‘net basis’

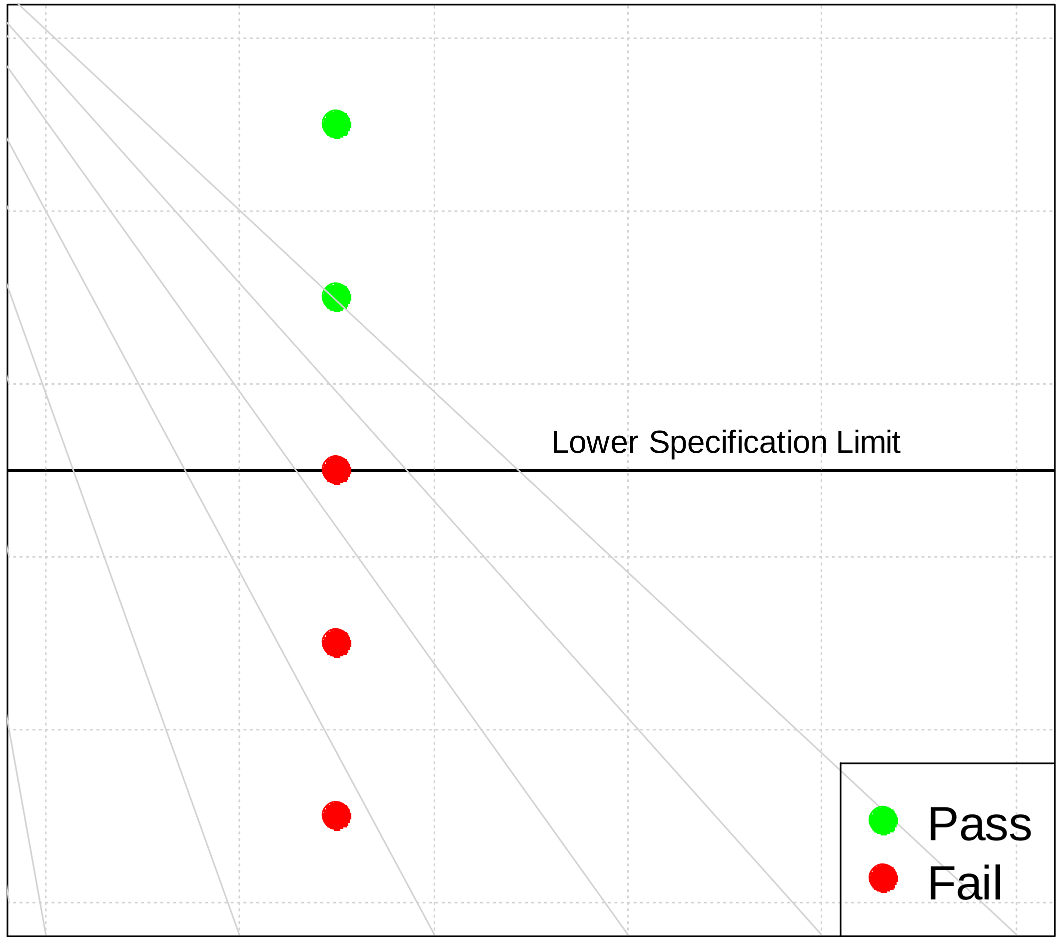
Deconvolution Method

- Measurement error distribution (known) is ‘subtracted’ from overall distribution of results to obtain the ‘true’ distribution

- The true distribution then used to assess proportion non-conforming followed by acceptance decision for the product



Assumption of no test error - absolute pass/fail



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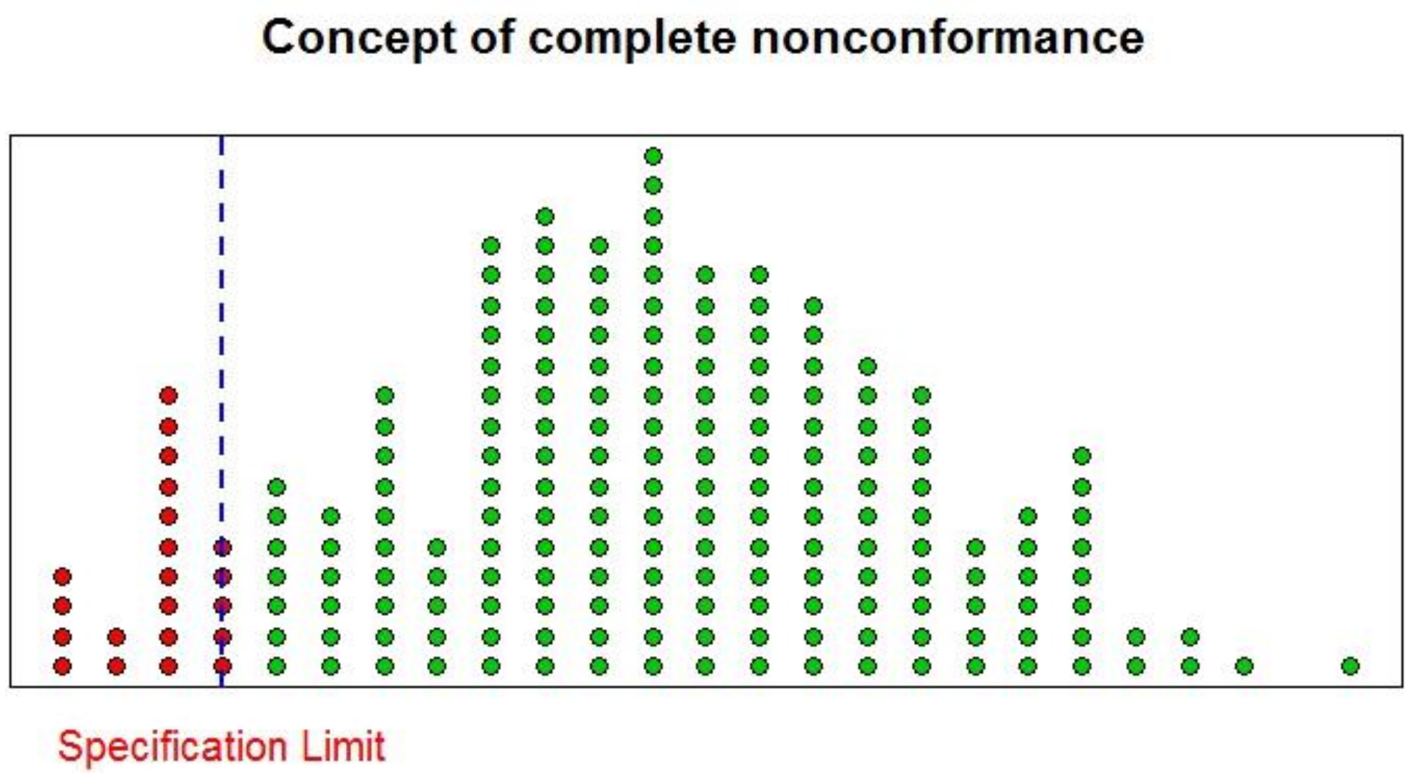
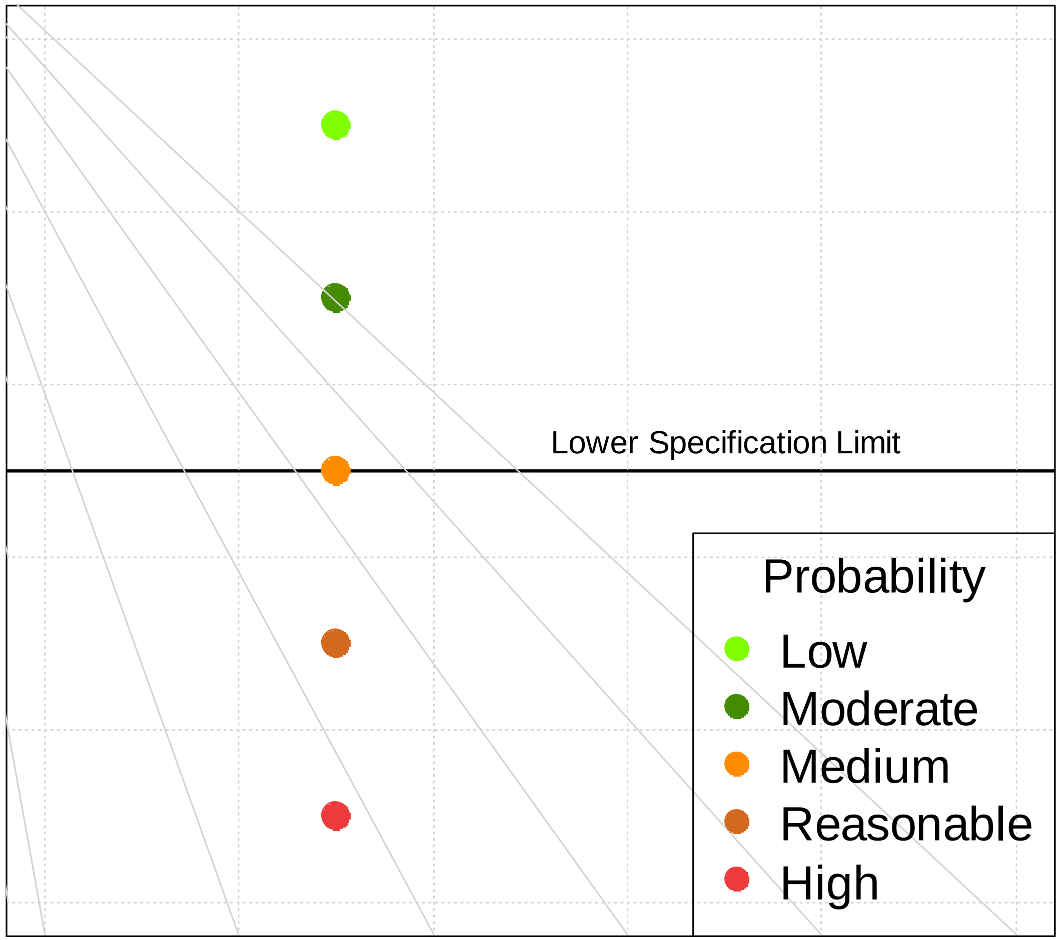
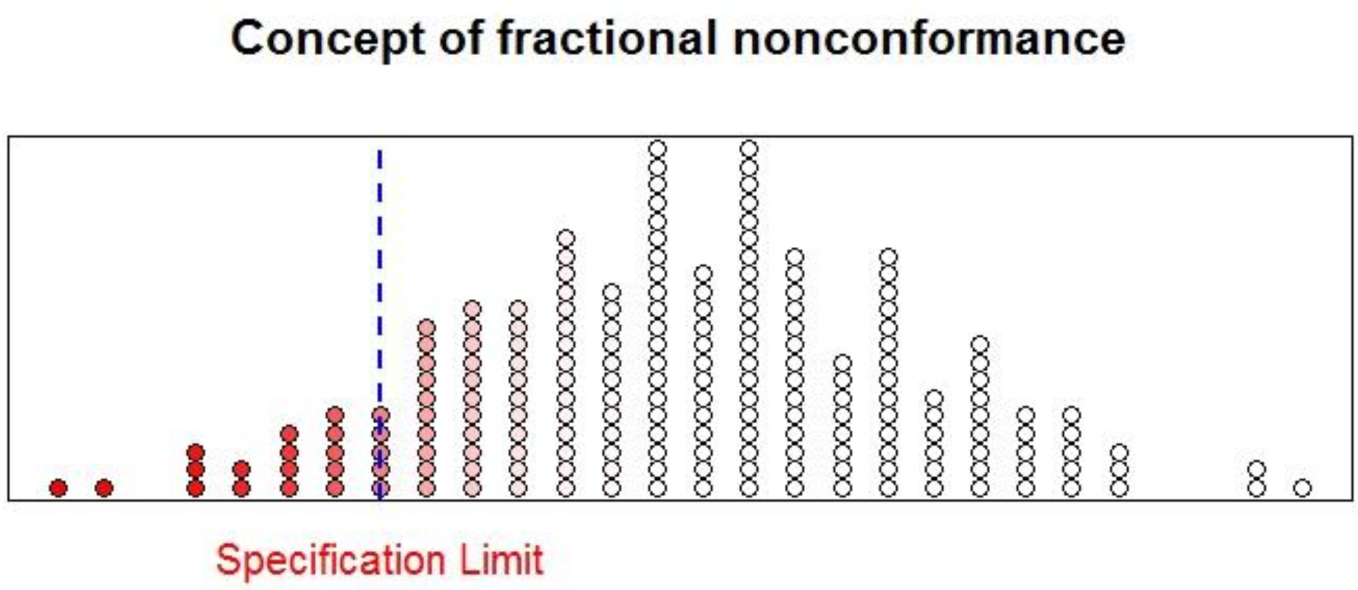


Fractional Non-conformance
- uses probabilities that samples comply with limit



Fractional Non-Conformance Method



- Shading reflects the probabilities that the <u>samples</u> do not comply with the limit, allowing for measurement error and bias
- These probabilities can be used to assess product compliance to the limit

Future Work

1. Fractional nonconformance acceptance plans:
   - Online (possibly automatic) lot assessment
   - Levels of process guard-banding
   - Statistical process control

2. Improved (discriminatory) plans and monitoring strategies for safety assurance including:
   - presence/absence and other types of responses and single result tests
   - measurement error adjustment

3. Deconvolution methods for large scale correlated real time data

Conclusions

- Total uncertainty approach does not seem effective
  – MU appears relevant to ‘conformity assessment’ (does the sample comply?) but not to sampling inspection (does the lot comply?)

- Statistical approach to sampling inspection is preferred
  – Risks of incorrectly accepting and rejecting product can be controlled as required
  – Provides a means to ensure that procedures are fair to producers
  – Existing ISO and other standards contain useful material
  – Several technical/statistical problems still need to be solved
    - Non-repeatability type measurement error

Main Publications

- Wu, H. & Govindaraju, K. (2013). Computer-aided Variables Sampling Inspection Plans for Compositional Proportions and Measurement Error Adjustment. Revised version sent to Computers & Industrial Engineering.
- Govindaraju, K. Wu, H. & Kissling, R. (2013).Quality Assurance for Compositional Proportions and Risk Assessment. Communicated to Risk Analysis.
- Govindaraju, K. & Kissling R. (2013). A Tightened Single Sampling Variables Plan. Sent to Applied Stochastic Models in Business and Industry. Accepted subject to minor revision.
- Govindaraju, K. & Jones, G. (2013). Fractional Acceptance Numbers for Lot Quality Assurance and Control Charting. Proceeding of Workshop on Intelligent Statistical Quality Control in Sydney, August 20 - 23, 2013. Revised version sent for inclusion in Springer's book Intelligent Statistical Quality Control, 2014.

Some references

- Hahn, G. (1982). Removing measurement error in assessing conformance to specifications. Journal of Quality
- Willink, R (2013) Measurement Uncertainty and Probability. Cambridge University Press

Any questions?

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ADDITIONAL SLIDES

Plans can this be a graphic (flow chart ???)

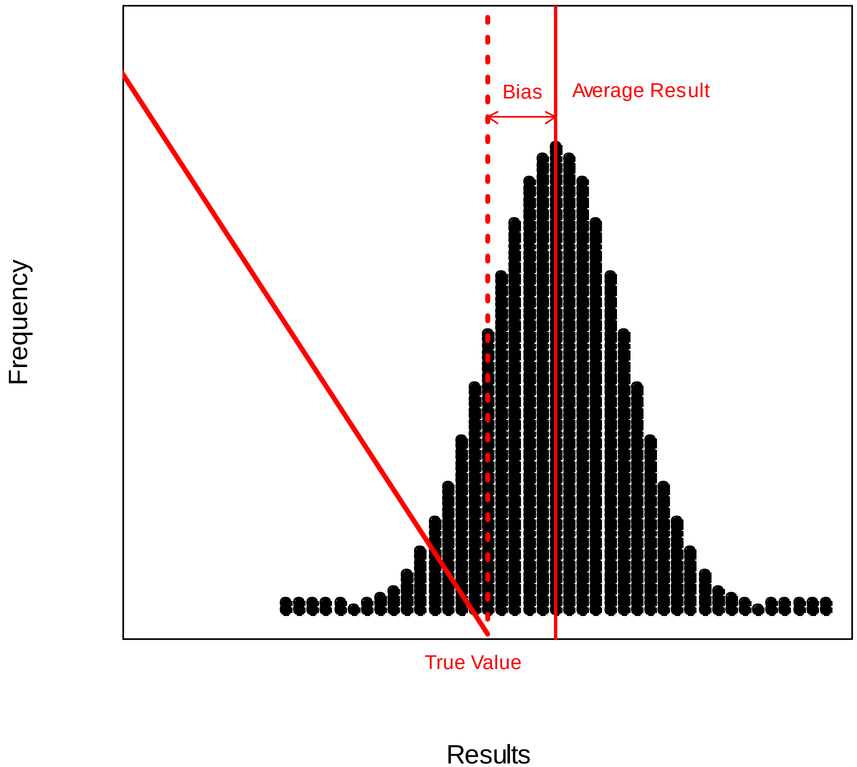
- Inspection by Attributes (ISO 2859)
  - Take "n" samples from the lot under inspection
  - Accept the lot provided no more than "c" of these samples are "defective"
  - Values of n and c chosen to control the risks of accepting poor quality product
- Inspection by Variables (ISO 3951)
  - Take "n" samples from the lot under inspection
  - Calculate the average and standard deviation of the results
  - Accept the lot provided "average + k* standard deviations" is less than the upper specification limit
  - Values of n and k chosen to control the risks of accepting poor quality product
- Inspection of Bulk Materials (ISO 10725)
  - For control of the average level

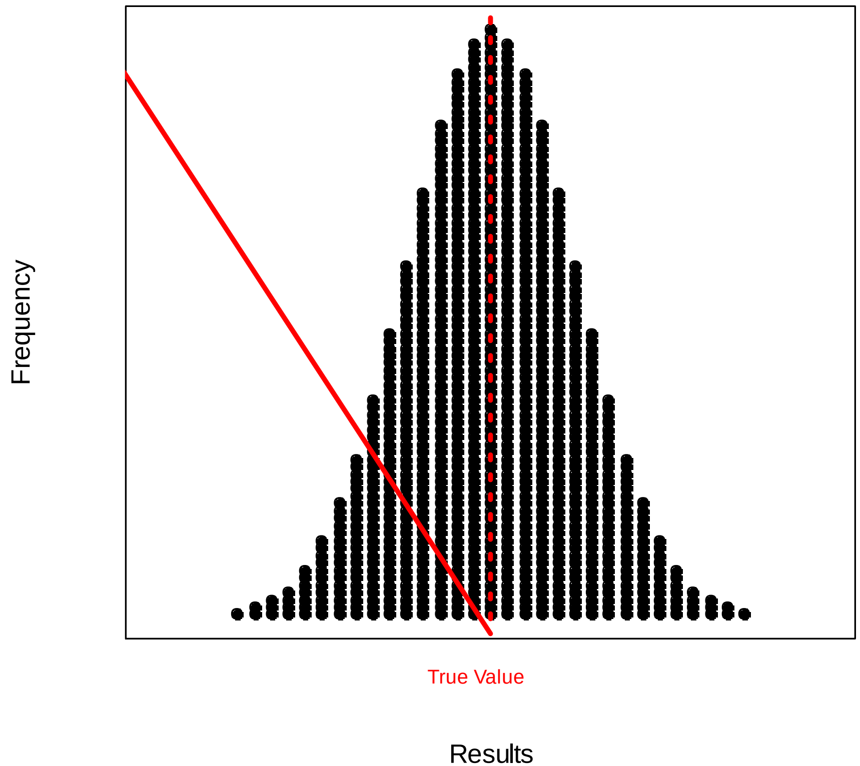
Measurand

A physical quantity whose value, x, is of interest and for which some well-defined set of physical steps produce a measurement, y, a number intended to represent the measurand.

– Vardeman et al, An Introduction to Statistical Issues and Methods in Metrology for Physical Science and Engineering. JQT 46, No. 1, Jan 2014.

Measurement Error presume is making an allowance for ME)





Uncertainty of Estimated Standard Deviations