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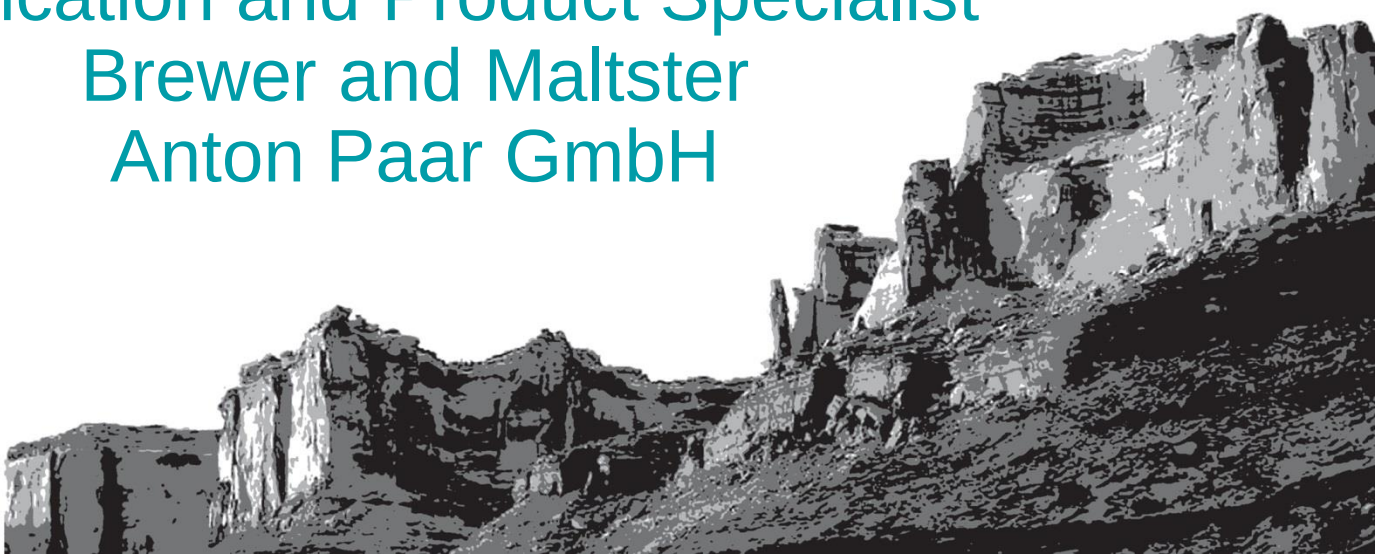
#ElevateBeer

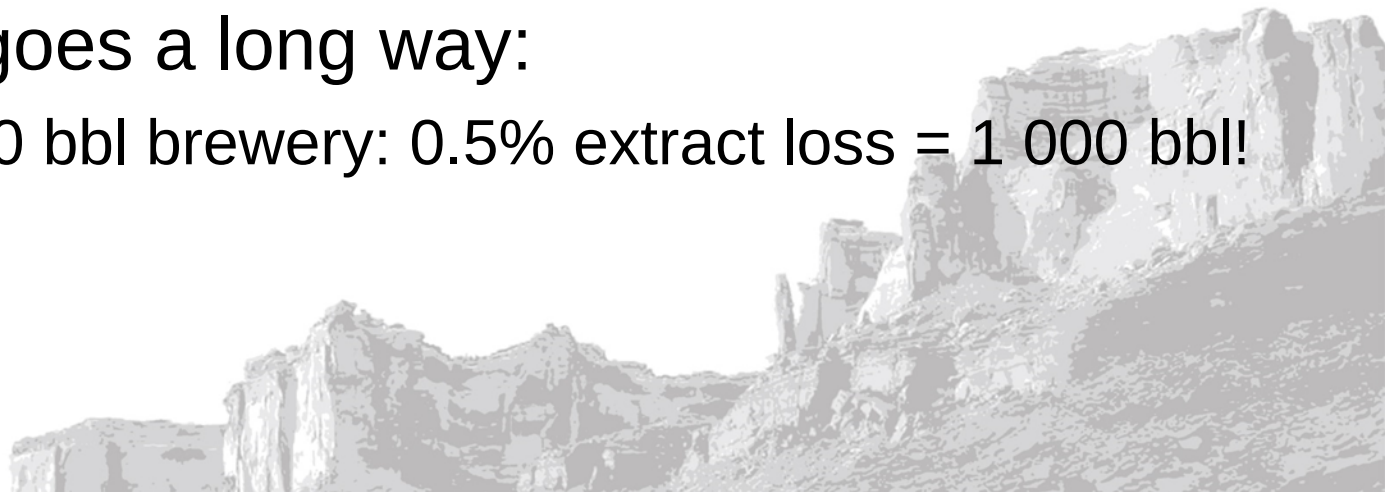
Combining Inline Instrumentation and Data Monitoring to Improve Efficiency

Daniel L. Gore
Application and Product Specialist
Brewer and Maltster
Anton Paar GmbH



Can AP Measure Extract Loss?

- Yes, we can help measure & reduce extract loss
  - Regardless of brewery size
- Increased, industry-wide focus on efficiency
- The reasoning is the same:
  - Conserve resources and raw materials
  - Increase productivity and profitability
- A little bit goes a long way:
  - A 200 000 bbl brewery: 0.5% extract loss = 1 000 bbl!

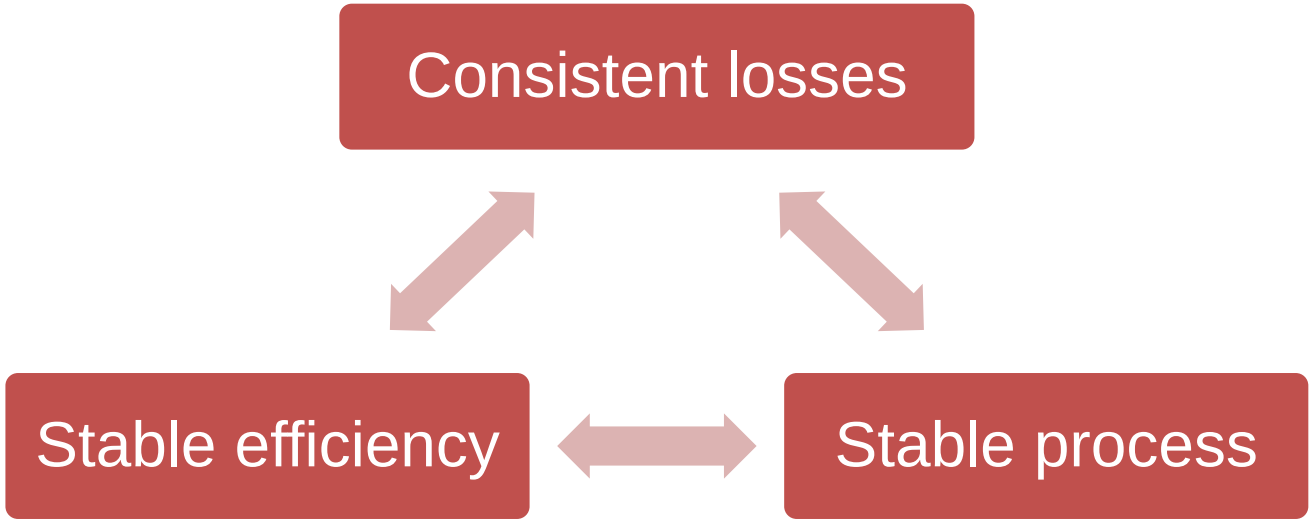


Where to Measure Loss?

- **Grain Bill**
  - Total extract malt
- **Lauter Tun**
  - Total extract to kettle
- **Cold Wort**
  - Total extract to fermenter
- **Filter**
  - Total ext/alc to BBT
- **Packaging**
  - Total ext/alc
  - Total volume

Why? Measurable Benefits!

- Continuous evaluation vital to detect issues early



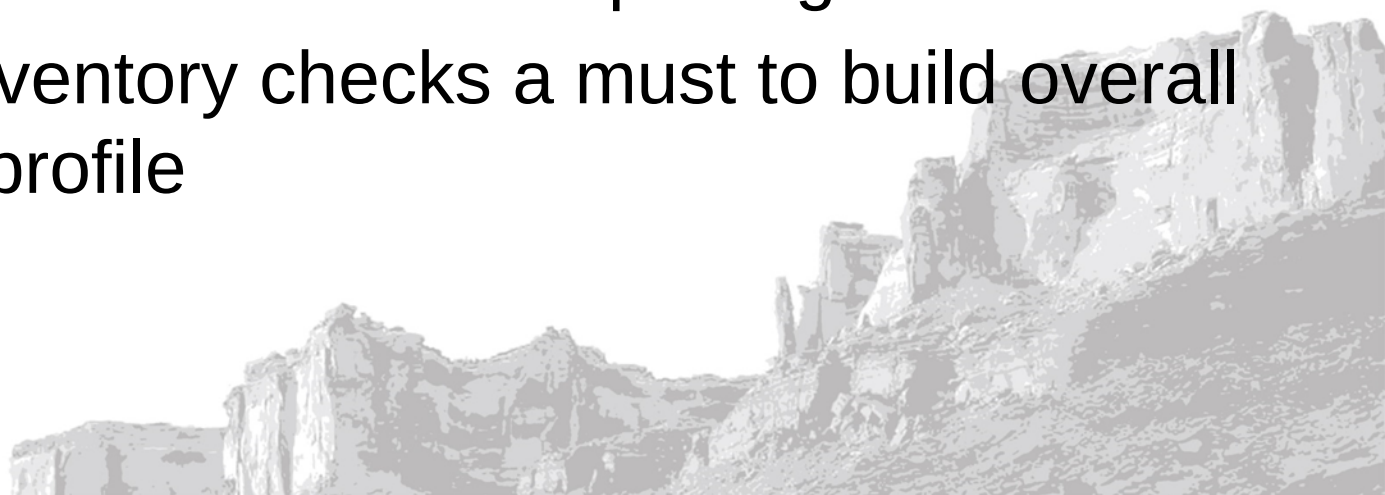
- Sudden changes in performance are a **red flag**
- Reduce loss = increase capacity (and capital)

How? Measurement Management!

- Systems must be robust, accurate, traceable, and easy to calibrate.
- Instrumentation **must** be calibrated regularly to ensure reliable data.
- Proper calibration is more important than the actual measurement!
- Exact calibration delivers exact results!

How? Measurement Management!

- Volume measurement not enough, only part of it
  - No concentration compensation
- Compensate flow with temperature & density
- Measure & evaluate each completed step
- Exceptions create gaps for extract losses
- Automated evaluation and reporting saves time
- Regular inventory checks a must to build overall efficiency profile



Basic Volume Loss

Cast wort vol./month – beer sold vol./month = volume lost

For example:

12 300 bbl – 11 000 bbl = 1 300 bbl or 10.57%

- If loss usually 10.4%, you have a problem!

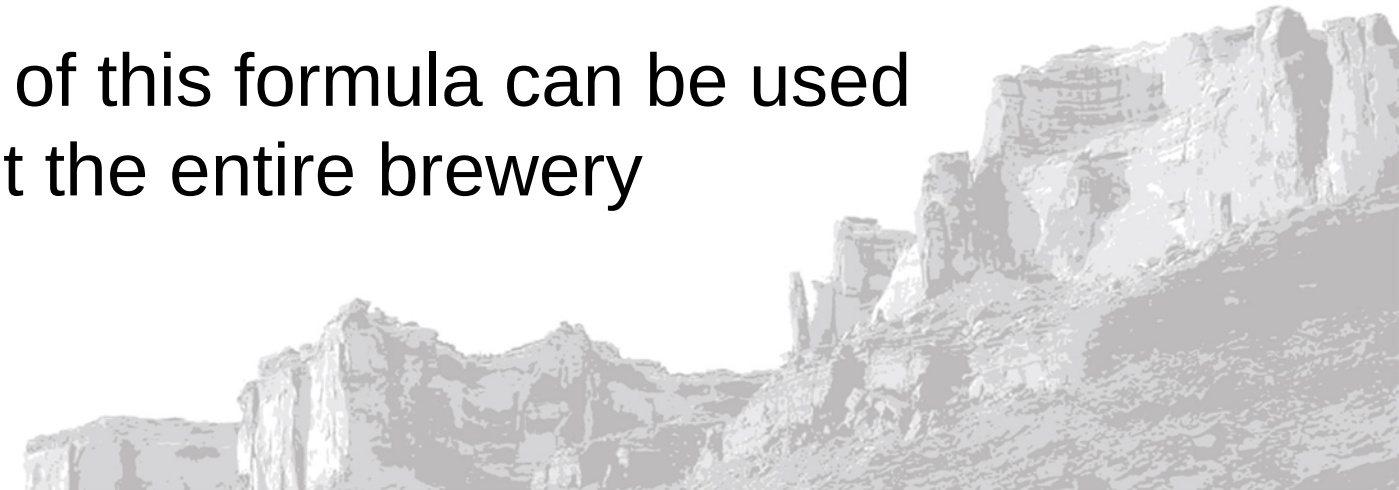
However, this is not the whole picture…

Basic Mass Balance

- Evaluation of extract loss is a basic mass balance based on kg (or lbs) of extract:

$$Y_{BH} = \frac{extract\ mass\ kg\ \times 100\%}{grist\ mass\ kg}$$

- Variations of this formula can be used throughout the entire brewery



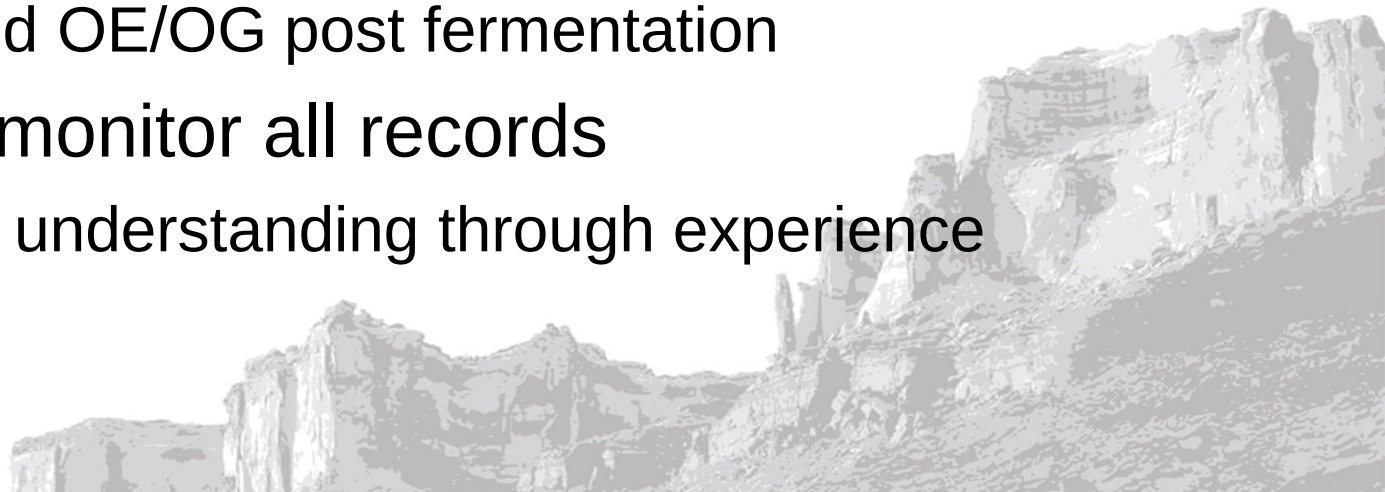
Brewhouse

- First place where efficiency and/or losses are measured
  - Malt/adjunct extract analysis → mass balance start
- Extract fluctuates
  - Batch changes (seasonal, supplier), process control, grist quality, mash program, temperature, time, lauter program, sparge temperature, etc.
- Laboratory checks and validation
  - Residual extract in piping and vessels
    - Extract recovery from last runnings, hot break
    - Whole hops, pellets, & extract have different extract retention

Fermentation

This is where it starts to get complicated…

- Yeast quality, extract composition, O_2 concentration, temperature, attenuation, and more affect extract loss
- Compare:
  - Measured OE/OG before fermentation
  - Calculated OE/OG post fermentation
- Keep and monitor all records
  - Establish understanding through experience



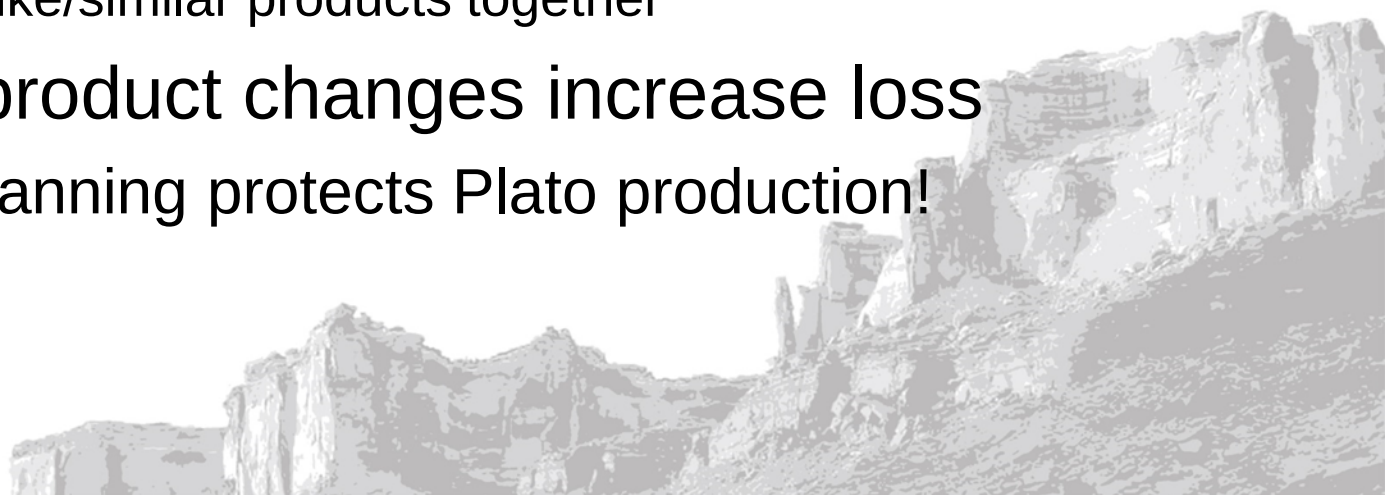
Fermentation

- Balling formula, an amazing thing, but…
  - Fits all products some of the time, some products all of the time, but never all products all the time
- Please see “Balling’s Formula – scrutiny of a brewing dogma” from The Scandinavian School of Brewing* for more details

* Nielsen, Kristiansen, Lassen, Erikstrøm. (2007). Balling’s Formula – scrutiny of a brewing dogma. BRAUWELT INTERNATIONAL, 2007/II, 90-93

Filtration

- Filtration system dependent
  - Candle, sheet, separator, etc., piping volume, brewer's attention to detail, automation
- Tank lees another source of extract loss
  - Similar to beer transfer/phase detection
  - Longer filter runs prevent loss
    - Group like/similar products together
- Frequent product changes increase loss
  - Proper planning protects Plato production!



High Gravity Blending

- HGB, blending possible source of extract loss
  - Accurate inline measurement = accurate process control = extract savings
- Large investment **not** necessary
  - Evaluate/improve/optimize existing systems first
  - Get to know your system!
- Good process data worth the time
  - Find optimization potential
  - Fits well with an HACCP plan

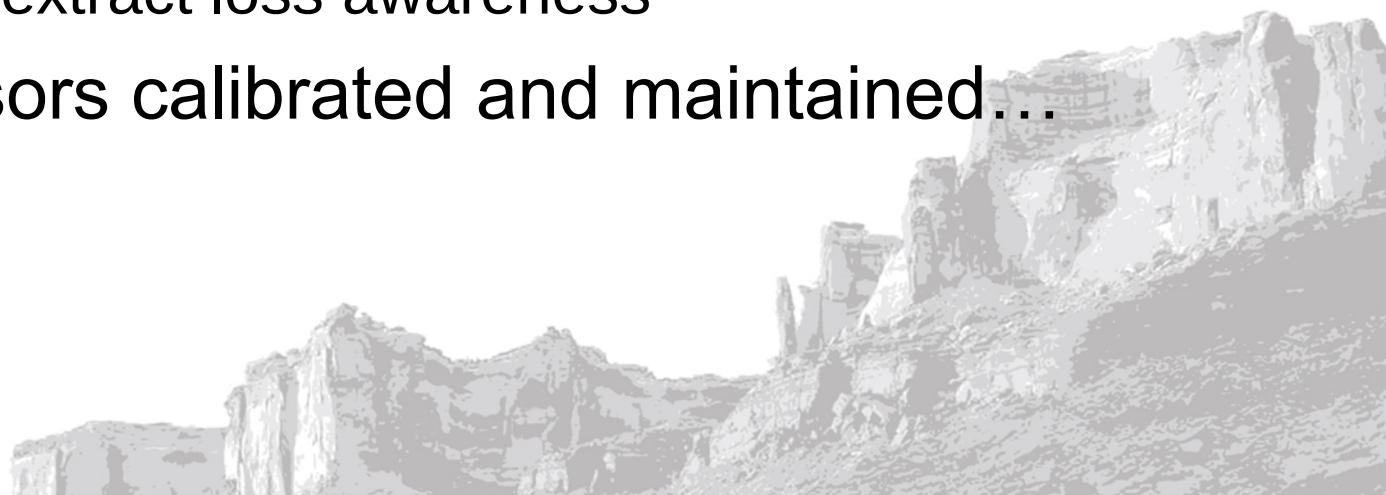
Packaging

- Repeated blending: quantitative brewhouse to bottle batch analysis impossible
- Analysis over time and by brand only option
- Phase detection prevents losses
- Longer filler runs prevent losses
  - Group like/similar products together
- Frequent product changes increase losses

Proper planning protects °Plato production!

Phase Detection

- Don’t forget the piping…
  - Push product by volume/time inaccurate
  - Measurement is better and automatable
    - Conductivity, color, extract, alcohol
    - Losses possible before/after each batch
- Don’t forget the wastewater…
  - Increase extract loss awareness
- Keep sensors calibrated and maintained…



Good Brewing Practices

- See the MBAA's "Minimum Good Brewing Practices for the U.S. Brewing Industry"

  http://www.mbaa.com/brewresources/foodsafety/haccp/Pages/GBPs.aspx

So what can Anton Paar do?

Well, we …

- measure product in-line and in the lab
  - Extract, alcohol, CO_2, O_2, color, turbidity, etc.
- can incorporate other, existing inputs
  - Flow, conductivity, etc.
- can combine them into a useable format
- show, record and analyze process data
- calculate Process Capability & Quality Index

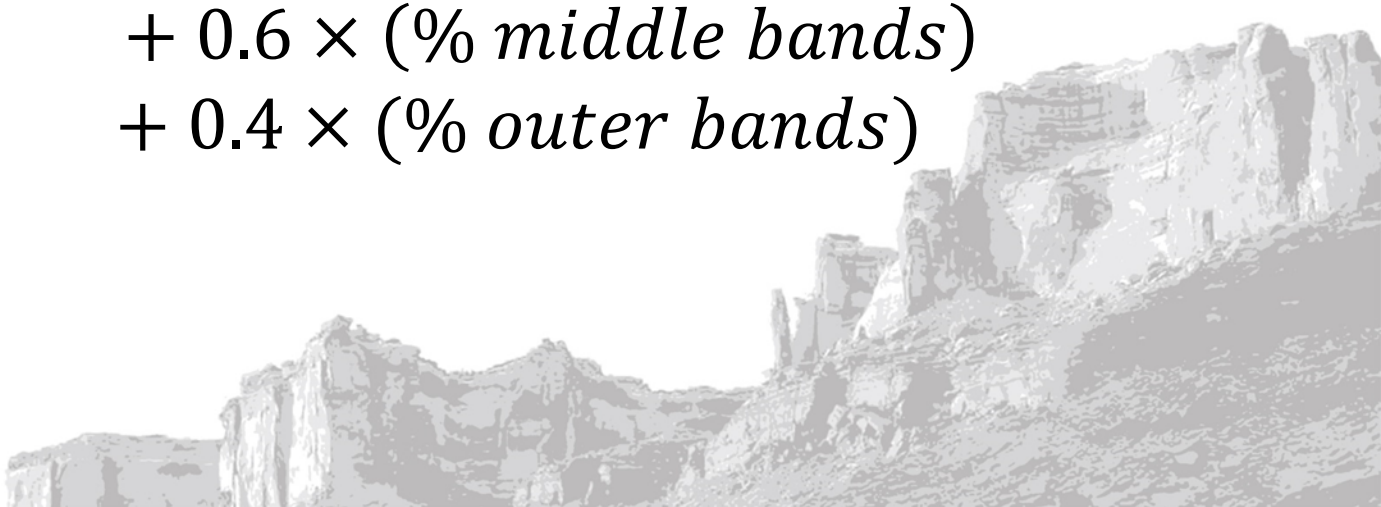
So …

What is the Quality Index?

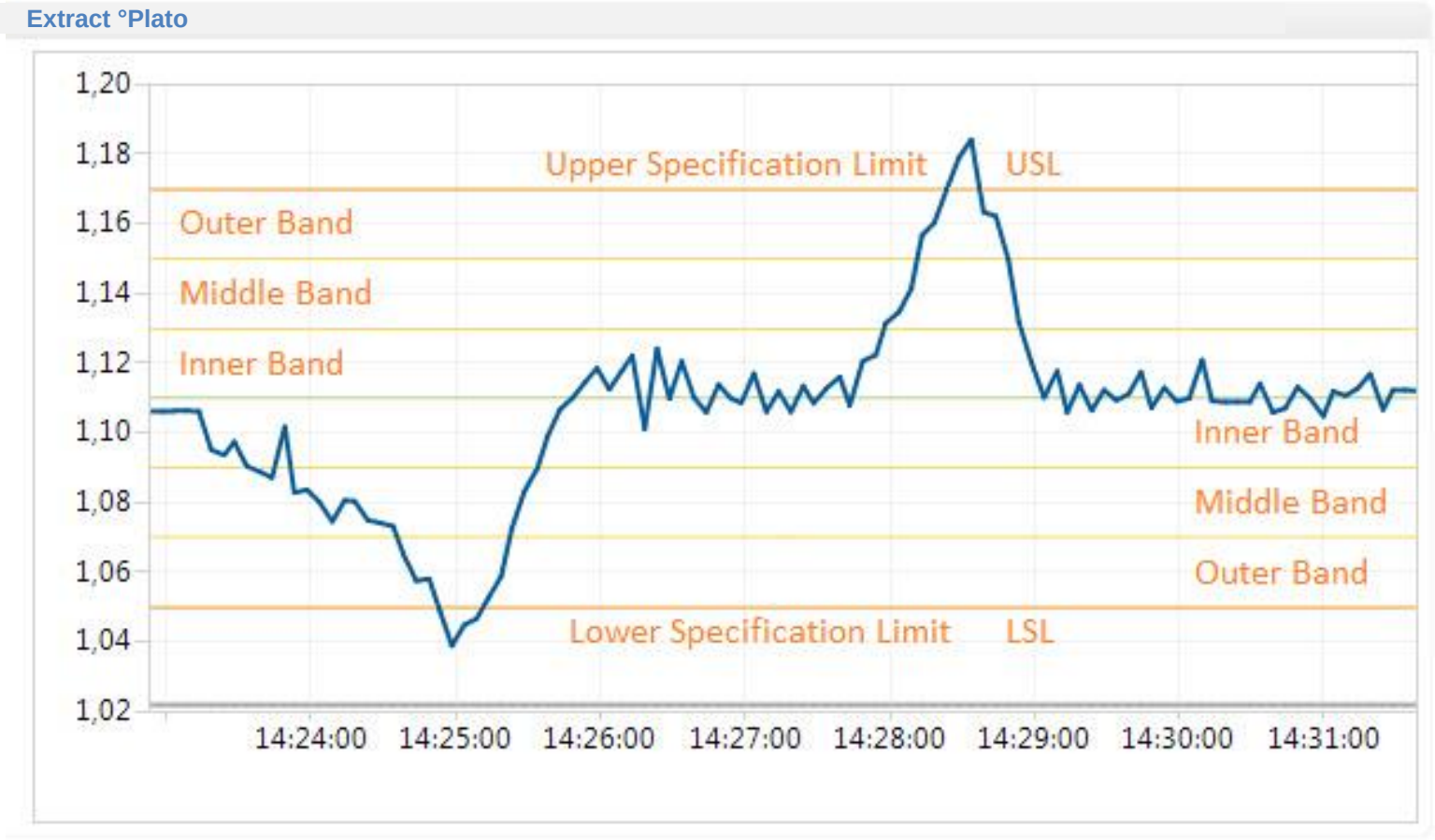
The statistical distribution of weighted data covering six equal ranges across a specified range which is defined by the:

- Lower specification limit (LSL)
- Upper specification limit (USL)

$$QI\ \% = 1.0 \times (\%\ inner\ bands) + 0.6 \times (\%\ middle\ bands) + 0.4 \times (\%\ outer\ bands)$$

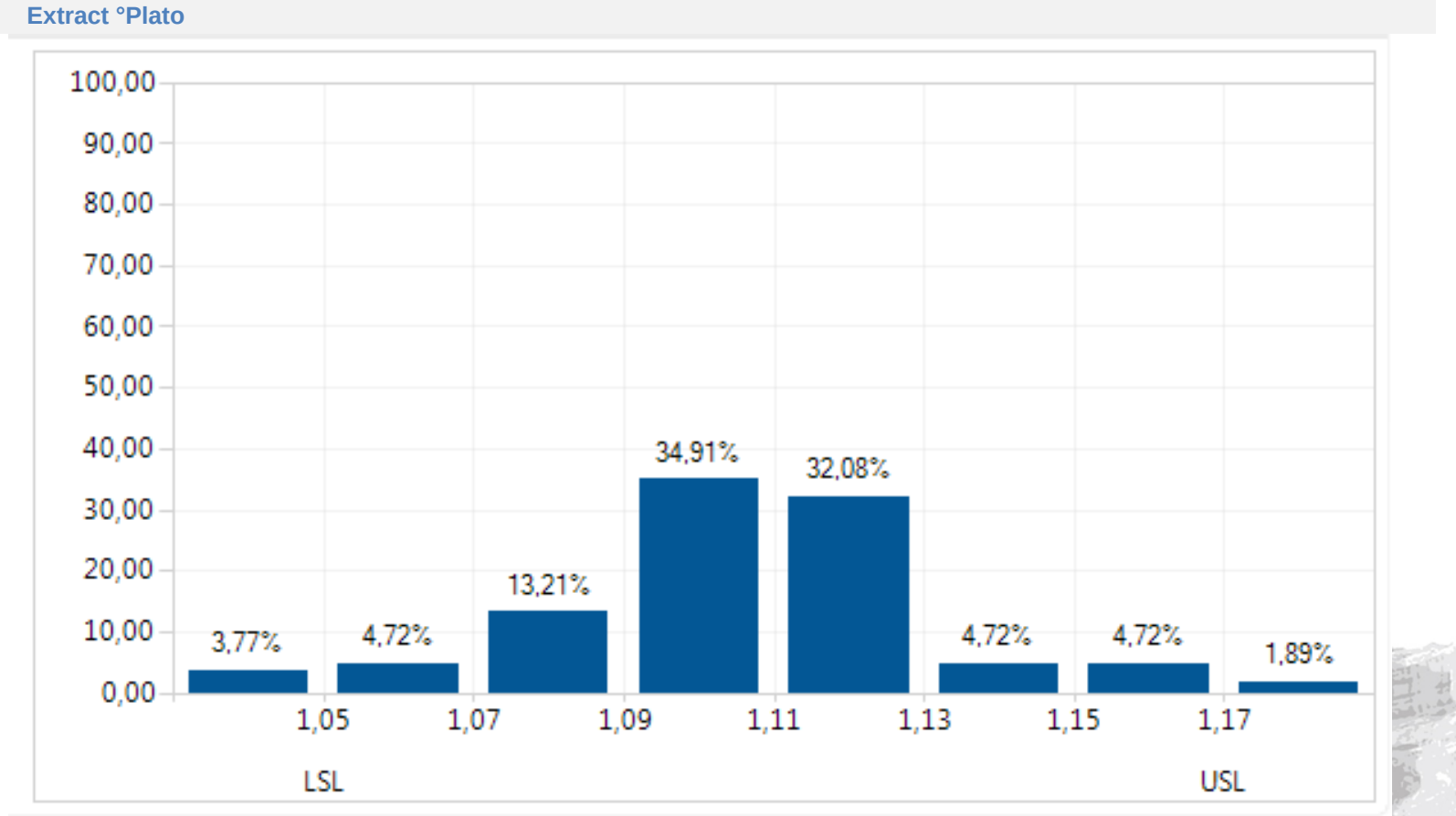


Defined LSL, USL



Trend chart with defined LSL and USL

QI Histogram Displaying 6 Bands



Extract Losses? Where?

Raw Material Monitoring

Wort Monitoring | Lauter Tun & Mash Filter

Wort Monitoring | Kettle

Wort Monitoring | Whirlpool

Extract Losses? Where?

Beer Monitoring | Filtration

Beer Monitoring | Storage (BBT)

Beer Monitoring | Pre-Filler and Final Package

Wort Monitoring | Aeration | Wort Cooler

Fermentation Monitoring | Fermentation Tank

Expanded Functionality

Expanded Anton Paar software functions:

- Combine existing sensors in a complete system
  - Flow meter + extract/alcohol sensor = total mass
- Flow meter input allows calculation of:
  - Volume
  - Total Volume
  - Total Mass
  - Total Extract Mass
  - Total Extract Volume
  - Extract weighted average
  - Total Alcohol Mass
  - Total Alcohol Volume
  - Alcohol weighted average

Conclusion

- Extract loss is everywhere… Go find it!
- Become more familiar with your process.
- Get to know and understand installed systems.
- Consistent & stable is good, sudden is bad.
- Proper calibration is more important than the actual measurement!
- Phase detection and fewer phases.

Thank You!

“measure what is measurable and make measurable what is not”
- Galileo Galilei