Corporation Quality Assurance and Master Brewers

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DTU: One university – many locations

Hirtshals
Østerild
Mors
Silkeborg
Høvsøre

Arctic Technology Centre (ARTEK)

DTU Lyngby Campus
DTU Ballerup Campus
DTU Risø Campus
Charlottenlund
Frederiksberg
Mørkhøj
Lindholm

COPENHAGEN

DTU Lyngby Campus
DTU Ballerup
DTU Risø Campus
Staff and students

**Human resources (FTEs)**

6,008

- 36% researchers and educators (VIP)
- 21% PhD fellows*
- 43% in support functions

**Full-time students**

11,221

- 37% BEng
- 28% BSc Eng
- 35% MSc Eng

* Employees only
Why this presentation?

In the spring 2017 Prof. Ludwig Narziss and Axel G. Kristiansen realized, that Laboratory staff ("QA") and Master Brewers / Process Managers / Packaging Line Managers ("Brewmasters") often live in different worlds even though both groups work for the same brewery / brewing group.

QA at work

Brewmasters at work
How and when our work was organized

• Narziss and Kristiansen decided to look for the historical reasons for this observation and also to look for ideas how to build an understanding between QA and Brewmasters and for the two professions to create less unnecessary paperwork and to profit more from one another.

• We embarked on our work in July 2017 and worked through till late October 2017 to collect history, examples and data. Late 2017 our work was submitted to Brauwelt Int.

• Our work is being published in the Brauwelt Int. between June and December 2018 and in Brauwelt since April 2018 (German language)
This Presentation falls into 3 parts:

1. A review of the classic Production – and QA professions, as they are often carried out in our breweries

2. A proposal for how the QA and the Brewmasters could corporate with less analysis and faster deviation management

3. A Q & A session where ideas from the BSG audiences are encouraged
Some examples of stereotype statements heard from QA and from Brewmasters:

Some Brewmaster thoughts of QA:
- “Laboratory people produce complicated reports, usually arriving late”
- “QA is a rather academic profession, often distant to the reality in the brewery”
- “We are busy creating the products, the brewery can sell, while QA create reports”

Some QA thoughts of Brewmasters:
- “Brewmasters don’t care about well documented product deviations from official brewery specifications”
- “Brewmasters are focused on getting products released for the market, even when the products are out of specification’and potentially harming our brands”
- “Our analysis reports are sometimes not even looked at by the Brewmasters”
Consequences when QA and Brewmasters do not cooperate well:

- Too many samples may be taken from the production and analysed
- A lot of analysis work engages the QA – but is the work used?
- QA produces their findings – some times a bit late for the Brewmasters
- Brewmasters sometimes develop their own rapid analysis assessments rather than waiting for late QA reports
- Quality deviations may not be managed => risk of quality decreasing
- Products may get to the market without the formal approvals

“QA produces results needed for the brewmaster, but do the two professions help each other sufficiently?”

QA metering Diacetyl by distillation
Sampling can also be undertaken by Production Operators

“One measurement is better than 1000 opinions”
Why is (costly) QA still needed in the brewery?

- *Because Quality is inexpensive, and missing quality is rather costly...*

- All Brewery Quality Assurance Systems require some documentation, and the documents become part of a formal QA system. The brewery will need so called controlled documents, and it may wish also to use so called uncontrolled documents.

- Controlled documents are characterised with being authorised by a person given the mandate for this responsibility, by a date it is issued, and by a registered number of copies of the document in circulation. This way obsolete documents will not be used in the brewery.

- Uncontrolled documents can be documents like guidelines, user guides, instructions not pertaining to quality etc., and no authority is obliged to keep a log of their existence or current relevance.
The brewing profession carries examples of negligence of QA:

• ‘‘The Schlitz mistake’’: A documented business case of disregarding consumers need for quality versus the brewery’s wish for more profit, which resulted in the collapse of Schlitz as one of the Anheuser – Busch rivals in Milwaukee by 1982.

• This case has now become an often used example of under-estimating the importance of product quality, because it resulted in the fall of a leading Milwaukee brewery which until 1957 competing directly with Anheuser Busch, also in Milwaukee.
The brewing profession carries also examples of overdoing QA:

- In the strive for a safe quality level and a minimum amount of customer complaints some breweries have developed comprehensive raw material - and intermediate product analysis: Brewery managers and customers sometimes ask “give me a full beer analysis”, all documented by QA and driven by a small army of lab. technicians taken samples, carrying out analysis day and night and QA managers producing reports for the Brewmasters.

- This way of operation is no real news, and sometimes aggravated by additional need for QA documentation for ISO 9000 – and other QA – systems including HACCP requirements and other certificates more and more wished for among leading supermarket chains.

Quote from Dr. Deming.
Expect Two more quotes
In the end of the presentation
(Dr. W.E. Deming, 1900 - 1993)
Examples of QA - documents, the brewery in most cases needs to control

All breweries operating commercially and selling beers with a defined shelf life need a minimum of QA controlled documents, partly because of own need, and partly because of national or EU – legislation. Increasingly, some supermarket chains add to the list:

Examples of Controlled documents include:

• Quality Policy: Defines the brewery’s place in the market segment
• Sample Plans: Mandatory samples throughout the brewery
• Recipe: For each wort and each product
• Bill of Material (BoM): The recipe data ready for computer input
• Quality Manual: The “who does what” in the QA theater
• Process Description: I.e. mashing diagrams, fermentation diagrams
• Procedures: Descriptions for carrying out specific processes
• Specifications: Targets, under – and upper limits for various products
• Work Instructions: Detailed instructions intended for manual level
• Analytical Methods: The precise analysis method used for a given analysis
• HACCP systems: The system to ensure no hazards in the brewery
• Traceability: A system able to trace a product up – stream in the process
• Instrument calibration A system to monitor the function of analytical instruments
Amount of QA documents:

When a brewery has built a comprehensive QA – system over some years, seen a number of organizational changes, has gained new customers and perhaps lost others, the brewery QA – function and the production departments are well advised to go through all QA – documents and with critical eyes look for:

1) Obsolete document
2) Documents not any longer adding value
3) opportunities to merge several documents into one document and
4) opportunities for production staff to take over responsibility for some of the documents.

In some breweries, this task is not prioritized Causing the list of controlled documents to Grow without real reasons and benefits

“Review of needed QA documents”
The sample plan: Purpose, what should it consist of, analytical methods (EBC, IOB, MEBAK, ASBC)

Sampling and basic statistical tools

- Perhaps the one, fundamental QA document is the Sample Plan, and every brewery has got one.
- The purpose of sampling is to make some estimate as to the without examining the whole of it. The sample must be representative of the bulk as precise laboratory analysis of non-representative samples may give seriously misleading information.
- But is the sample plan design reviewed regularly, or does amounts of samples grow over time?

“Sampling has become a practical necessity”

It is not possible to sample each of 50.000 crates
Analysis and Process Controls day by day

- Large breweries tend to apply comprehensive analysis throughout the process from raw materials to final product, often dictated from an international Group Head Quarter and always with respect to the Sample Plan. All analysis are recorded and documented.

- It may happen, that samples and analysis are carried out, when not needed, because “the system demands it”.
### Basis Brewing analytical work

Wort, fermenting beer and final beer is – chemically - defined by relatively few characteristics:

<table>
<thead>
<tr>
<th><strong>Parameter</strong></th>
<th><strong>Unit</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Extract (OE)</td>
<td>% P</td>
</tr>
<tr>
<td>Real Extract (ER)</td>
<td>% P</td>
</tr>
<tr>
<td>Apparent Extract (EA)</td>
<td>% P</td>
</tr>
<tr>
<td>Real Degree of Fermentation (RDF)</td>
<td>%</td>
</tr>
<tr>
<td>pH</td>
<td>no.</td>
</tr>
<tr>
<td>Colour</td>
<td>EBC Scale</td>
</tr>
<tr>
<td>Bitterness</td>
<td>EBC Scale</td>
</tr>
<tr>
<td>Alcohol by Volume (ABV)</td>
<td>%</td>
</tr>
<tr>
<td>Alcohol by Weight (ABW)</td>
<td>%</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>%</td>
</tr>
</tbody>
</table>

Above chemical parameters can be sampled and analyzed with relatively basic instruments in most even small breweries.
Microbiology – the forgotten challenge

• Beer spoilage caused by bacteria or wild yeasts are still hurting breweries, some times, because microbiology is not taking into account. Work by Professor Werner Back (Döhler and Weihenstephan) using NBB agar has provided modern the NBB – tests for beer spoilage organisms.

• Tunnel pasteurizers are working with temperatures which are relatively low to avoid any flavor defects. Bottles with inbuilt thermometers or PU – meters are run every two hours to manage the PU – control.

“Do not underestimate microbiological challenges”

NBB detection kit for Beer Spoilage organisms
**Specification ranges (tolerances) and Control Charts**

- When specification ranges are set, allowance must be made not only for analytical errors but also for process capability and errors derived from sampling.
- To estimate the total errors involved, one approach is described in the Statistical Section methods based upon Statistical Process Control Theory.

**“Control Charts are a powerful quality tool”**
Relation Specifications and our Cp

The specification range, the interval between Upper Limit (UL) and the Lower Limit (LL) must therefore equal or exceed 6 x sigma. The ratio of the specification band width to 6 x sigma is termed the process capability (Cp):

\[ Cp = \frac{UL - LL}{6 \times \text{Sigma}} = \frac{UL - LL}{UCL - LCL} \]
Taste tests – further applications

Applying taste tests in the different process stages
Taste tests are needed, from the green beer, the matured beer, or in conventional storage, mostly from one and the same tank of a batch periodically, preferably every 2 weeks throughout the whole storage time of 4-8 weeks, later on prior to filtration

“Taste testing is a global brewery discipline”

Taste testing conducted in a brewery in Africa
## Use of taste testing for process corrections

### Figure 3: Flavours, their causes and remedies

Exhibit from Brauwelt Int. V/2014 p. 304

<table>
<thead>
<tr>
<th>Flavour no.</th>
<th>Flavour term</th>
<th>Associated fault</th>
<th>Suggested remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0111</td>
<td>Spicy</td>
<td>Formed during beer maturation</td>
<td>Hygiene</td>
</tr>
<tr>
<td>0121</td>
<td>Plastic</td>
<td>Wild yeast during fermentation or infected CO₂ supply</td>
<td>Hygiene, clean CO₂ supply</td>
</tr>
<tr>
<td>0130 group</td>
<td>2-phenylethyl acetate (roses, honey)</td>
<td>Produced by yeast during fermentation</td>
<td>To decrease: decrease wort gravity, increase aeration, decrease the fermentation temperature</td>
</tr>
<tr>
<td>0130 group</td>
<td>Ethyl butyrate (tropical fruits)</td>
<td>Produced by yeast during fermentation, yeast strain-dependent. Can also originate from poor brewhouse hygiene</td>
<td>To decrease: Select other yeast strain, lower the fermentation temperature, To increase: Select other yeast strain, lower the level of saturated fatty acids, increase the fermentation temperature</td>
</tr>
<tr>
<td>0130 group</td>
<td>Ethyl octanoate (fruity, sweet, waxy)</td>
<td>Produced by yeast during fermentation</td>
<td>To decrease: decrease wort gravity, increase aeration, decrease temperature</td>
</tr>
<tr>
<td>0131</td>
<td>Isoamyl acetate</td>
<td>High primary fermentation temperature</td>
<td>To decrease: Select other yeast strain, decrease the fermentation temperature</td>
</tr>
<tr>
<td>0132</td>
<td>Ethyl hexanoate (rod apples, anise seed)</td>
<td>Produced by yeast during primary and secondary fermentation, high content of fatty acids, strain-dependent</td>
<td>To decrease: Select other yeast strain, decrease the wort gravity, increase aeration, increase the fermentation temperature</td>
</tr>
<tr>
<td>0133</td>
<td>Ethyl acetate (nail polish remover)</td>
<td>Yeast stress during high gravity fermentation, contamination of wild yeast</td>
<td>Select other yeast strain, decrease wort gravity, increase wort aeration, lower the fermentation temperature, agitation/mixing during fermentation, increase pressure during fermentation</td>
</tr>
<tr>
<td>0150</td>
<td>Acetaldehyde (green bruised apples)</td>
<td>Precursor from malt, precursor to alcohol, oxidation of alcohol during fermentation, stuck fermentation</td>
<td>Long maturation, re-pitching of fresh yeast for stuck fermentation to increase attenuation</td>
</tr>
<tr>
<td>160</td>
<td>Flowery rose</td>
<td>Strecker degradation by thermal stress</td>
<td>Lower thermal stress from: wort boiling (more efficient cooling in the whirlpool and shorter boiling times), pasteurisation and storage conditions</td>
</tr>
</tbody>
</table>

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Use of AQL in sampling and QA

- The AQL is the maximal percent of nonconforming items (or the maximal number of nonconformities per 100 items), which is considered, for inspection purposes, as a satisfying process mean.

- The AQL is generally specified by the authority responsible of sampling. Different AQLs may be designated for different types of defects. It is common to use an AQL of 1% for major defects, and 2.5% for minor defects.

“What we cannot measure, we cannot manage, and what we cannot manage, we cannot improve”

Production Manager reviews AQL - values
AQL and Military standard 105 E as a QC tool for the brewery sample planning

Acceptable Quality Level (AQL), Military Standard 105 E.
MIL-STD-105 was a USA Defence standard issued by 1963, that provided procedures and tables for sampling based on Shewhart’s, Romig’s and Dodge’s sampling inspection theories and mathematical formulas.

MIL–STD 105 was developed gradually refined until version MIL – STD 105 E, and it was widely adopted also outside of military procurement.

“One measurement is better than 1000 opinions”

Brewing chemists at work
Operators may take on yet more QA work

- Sampling
- Analysis
- Reporting
- Deviation management

“Operators take care of more analysis”
Room for a review

A way forward is suggested, where QA and Brewmasters work closer together, and where their respective responsibilities become clearer. Opportunities exist for Production staff, i.e. the operators, to take on some more QA tasks like sampling, running basic analysis in production and using control charts contributing both less QA – documents, faster corrective actions and a reduced Brewery QA – costs by eliminating double work.

“Our task is not to describe the problems – but to deliver the solution”.

Production – and QA working together
Now You – dear BSG members – which are your views?

1) How is your experience working with QA and Brewmasters?

2) Which tasks (QA or Brewmaster) can be better managed?

3) Are we prepared for future demands from operations?

"In God we trust; all others must bring data"

"It is not necessary to change. Survival is not mandatory"

(Dr. W.E. Deming, 1900 - 1993)
Corporation between QA and Brewmasters, our recommendations

The brewery QA – function and the production departments may find, that the brewery operates with more QA and more QA – documents than necessary and used to achieve the necessary Quality. We may discover:

1) Obsolete documents
2) Documents not adding value any longer
3) Control Charts not used in Production
4) Opportunities for production staff to take over the responsibility for some of the sampling, analysis and documents
6) Implementation of basic, daily quality reviews based on simple chemical, microbiological and taste test results
7) A sample plan critically reviewed / simplified
8) AQL – values not yet defined.
9) Analytical results sometimes arriving later than wished for Production staff to take timely corrective QC – actions.
10) A need for training the QA – and Brewmasters for their new, common goals
How will our vision for the brewery look, where QA and Brewmasters work together?

- The Chief Brewmaster and the QA manager share offices
- QA takes care of documents and – rationalisations
- QA takes care of instrument calibrations, raw materials analysis and (very) special analysis
- Production takes care of all sampling, measurements and standard analytical reports
- QA and Brewmaster look through control charts from production to discover early drifting processes and plan any trouble shootings
- QA and brewmaster discuss needs for any training of QA – as well as production staff

“Head Brewer and QA – manager plan for tomorrow”
Work on the Brauwelt Int. paper covering this presentation was prepared by:

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References:

1) USA Department of Defence, 10 MAY 1989, Washington: “SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES” Military Standard 105 E.
2) Martyn Cornell: “The Fall of Schlitz”, The Beer Connoisseur, 1 OCT 2010
4) Helena Sørensen & Axel Kristiansen: “Flavours and off – flavours in beer” – Part 1 and 2, Brauwelt Int. 2014 – IV and V,
9) EBC: https://europeanbreweryconvention.eu/
ASBC: http://www.asbcnet.org
IOB: https://www.ibd.org.uk/home/
MEBAK: http://www.mebak.org/de/home.html
“QA and Brewmasters have a common task”

Prof. L. Narziss and A. Kristiansen preparing our work in Munich