Statistical Process Control
Data Analysis Part I

by Brynn Keenan, Grist Analytics

Every brewery has unused production data whether it's on paper, google sheets, or in a software platform. When analyzed, production data can become an integral part of a QC program through statistical process control (SPC). Larger breweries have been doing this for decades with significant financial and quality returns. As one of the cheapest forms of QC, there is no reason small breweries can't do it too. In part 1 we'll review a few basic principles of statistical process control (SPC) before giving you examples to work through in part 2.

Breweries Applying Process Control

Before getting into the nuts and bolts of process control, here are a few breweries using these tools successfully to make better beer with less money.

New Belgium Increased Tank Capacity

Ninkasi Cut Production Cost by $30/BBL

MillerCoors Lowered Trans-2-Nonenal

The Concept

Let's start with an example before getting into the complexity of making good beer.

These example bolts need to be manufactured at a certain width. Every manufacturing process has ***inherent variability***. The manufacturer needs to reduce the variability enough so that each bolt is an acceptable width.

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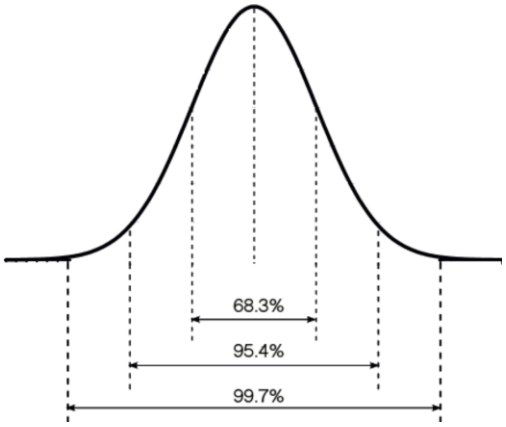
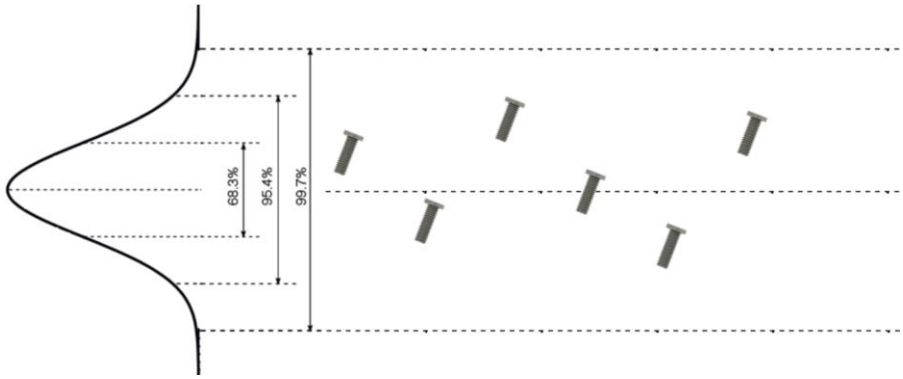
If the variation in bolt width is normal, it will look like the bell curve below. 99.7% of measurements will fall within 3 standard deviations of the average, which we'll call the ***control limits***. That range is what we are reliably capable of producing, so it's called the ***process capability***.



Let's flip this bell curve on its side and plot the points on a graph. Now we can see as we're plotting measurements if they fall within normal variation.



If a width falls outside of control limits, we'll know that it is abnormal variation. Once identified, we can identify the cause and get back on track.

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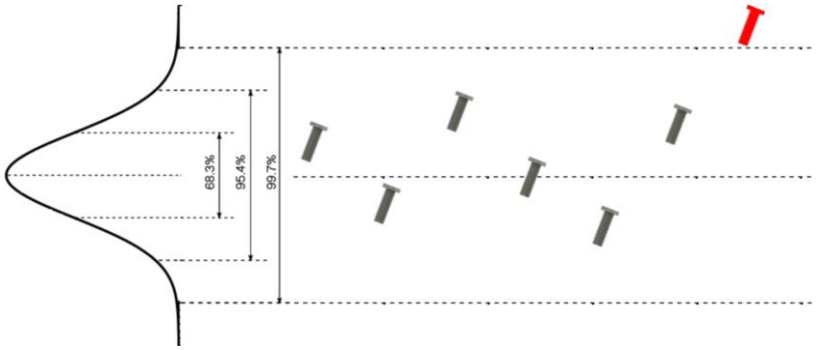
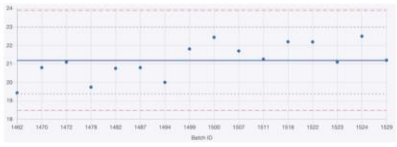
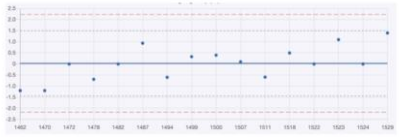


If we apply this same concept to control points along the way, we can identify out of control parameters *before* they become an issue in the final product. View the charts below. If Machine Feedback 3 were in control, our final product may not have been out of width specification.



Machine Feedback 1



Machine Feedback 2

Machine Feedback 3

View fullsize
Machine Feedback 1
View fullsize
Machine Feedback 2
View fullsize
Machine Feedback 3

The upper and lower control limits are calculated values based on what the manufacturer is producing. Sometimes these limits do not match up with the actual goal. In that case we would label the process ***incapable*** of meeting demand.

In this example, only a portion of the bolts that we are producing work. We'll have to throw away all of the products on the right side of the red line.

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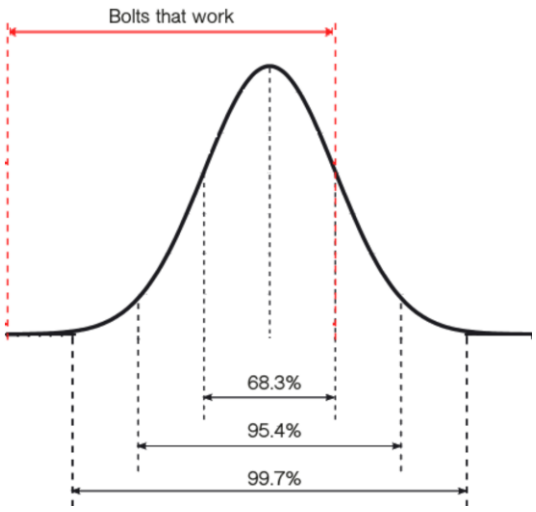

To address this, we have to reduce the variability in our intermediate products until the final product is less variable. Then we can adjust one element of the process at a time, to shift the mean.

Applying SPC in Brewing

The ultimate goal is to make good beer consistently every time. To do that we need to control the intermediate products. We'll walk through how to define what those are, and monitor them.

1. Defining Intermediate Products

Beer is complicated, with hundreds of variables effecting the final product. If we view it in pieces, the task becomes less daunting.

The ASBC has defined the intermediate products for us. Under the sampling plan you'll see the brewing process split into stages. If we control what comes out of each of these stages, we control the final beer.

2. Deciding what data to collect

Every piece of data collected in the brewery should be for the purpose of controlling intermediate products. If we are collecting and analyzing the correct data, we should be able to trouble shoot unanticipated results with little downtime.

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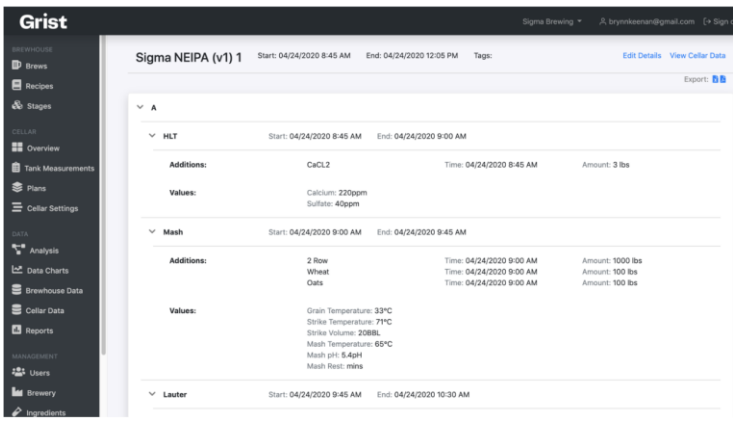
At Grist we recommend that breweries with limited resources start with values that give the most powerful information for the least time and money. We have helped define what those variables are - feel free to reach out for a prioritized brew log.

Lautering		
Vorlauf Duration		For trouble shooting effeciency and grain bed permeability
Clarity	<5EBC/20NTU	For trouble shooting grain bed permeability and effectiveness
Runoff Duration		Brewhouse effeciency
First Runnings DP		Establishing the grain bed at low DP to avoid early compreesion and later crashing
First Runnings Gravity	Brewery Target	Trouble Shooting
First Runnings pH	Brewery Target	Trouble Shooting
Sparge Duration		Brewhouse effeciency
Sparge Temp	168C	160-172 to reduce viscosity as much as possible w/o extracting tannins
Sparge pH	<7.0	Reduce tannin extraction
Sparge volume	Brewery Target	To hit kettle volume, or preboil gravity
Bed reset req/d?	No	Mash shearing releases Beta Glucan, and husk material
Final Runnings DP		Effeciency/Trouble Shooting/Quality Extract
Final Runnings Gravity	>2.5 P	Avoid tannin extraction
Final Runnings pH	>5.8	Avoid tannin extraction

3. Organizing the data

Unless data can be easily manipulated and compiled, it's next to useless (read; paper logs or brews on separate spreadsheet tabs). In Grist, you can store information however you'd like and it will be organized and analyzed for you. If spreadsheets are being used, batch information should be stored in one row. This allows us to see all values for the same variable in one column, and easily analyze that data.



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In Grist brew information can be stored in brew logs, and the software will organize it into table format.

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Ferm Sta	Style	Batch Numbe	Mash	Lauter	Boil	Whirlpoo	Total	OG	OpH	24hr	48h
1/5/21	Kolsch	1	77.5	87.5	97.5	30	292.5	10.44	5.31	7.54	4.2
1/7/21	Pale Ale	3	96	75	152.5	35	358.5	11.86	5.09	8.76	3.5
1/19/21	Kolsch	6	82.5	87.5	215	37.5	422.5	10.44	5.07	7.54	5.0
1/27/21	Pale Ale	9	97.5	87.5	110	35	330	12.10	5.12	9.96	6.5
2/2/21	Pale Ale	13	87.5	95	110	27.5	320	12.10	5.10	7.05	2.5
2/15/21	Kolsch	18	77.5	82.5	112.5	31.5	304	10.44	5.19		
2/23/21	Pale Ale	22	82.5	90	100	32.5	305	11.63	5.13	6.56	2.5
2/25/21	Kolsch	24	77.5	82.5	107.5	30	297.5	10.65	5.09		
8/18/20	IPA	325	85	126	71	78	360	16.4	5.15	14	11.5
8/25/20	Porter	332	87.5	121	70	76.75	355.25	15.2	4.95	9.8	6.8
9/9/20	IPA	341	101.5	128.5	82.5	74.5	387	16.3	5.09	14.8	11.5
9/15/20	Porter	345	96.5	126.5	75	48.5	346.5	15.2	5.02	13.3	9.5
9/16/20	IPA	347	88	120	75	70	353	16.5	5.18	14.5	11.5
9/29/20	IPA	353	91	118	70	72	351	16.6	5.26	15.1	13.6
10/14/20	Porter	363	86	127	70	76	359	15.3	5.01	12.8	9.3
10/20/20	IPA	367	90.5	121.5	75	73.5	360.5	16.5	5.24	13.5	10.4
10/28/20	IPA	373	84.5	119	75	47	325.5	16.7	5.22	15.8	14.5
11/6/20	Porter	378	88.5	120.5	80	47	336	15.1	5.01	11.3	8
11/18/20	IPA	384	87	119	90	75	371	16.1	5.18	14.2	9.2
11/23/20	Porter	389	92.5	114.5	85	76	368	15.3	4.97	12.85	10.9
12/10/20	Porter	398	99	123	85	73.5	380.5	15.25	5	11.36	9.7
12/29/20	Porter	407	90	119.5	115	72.5	397	15	5.13	8.48	6.8
12/31/20	IPA	408	85	118	130	72	405	15.6	5.34	14.2	12.8
1/20/21	Porter	420	94	123	90	72	379	15.14	5.07	11.27	6.7
2/3/21	IPA	428	85	123.5	70	77.5	356	15.7	4.93	9.2	7.0
2/11/21	Porter	435	92	126.5	80	47.5	346	14.55	4.74	11.43	8.9
9/14/20	Kolsch	938 + 939	87.5	83.5	116.5	30	317.5	10.56	5.06	8.27	4.3

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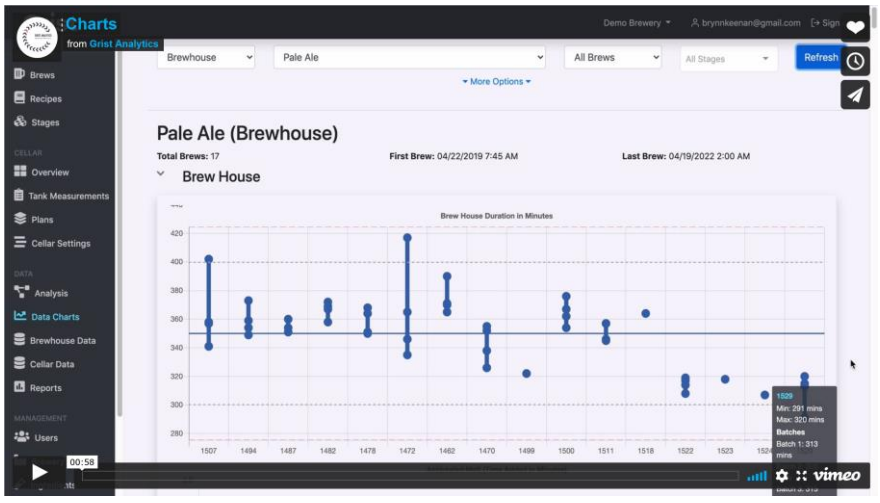
Brew information should be stored in rows, so variables can be easily compared in columns.

4. Analyzing Data

Now that we are collecting and recording data, it is easy to format each value into a control chart. This will allow you to trouble shoot process issues by identifying parameters with excessive variation. This is visualized below in Grist, but can be done in Excel to a certain extent if data is stored properly. (Link to Grist Analytics article and use the form below to receive an Excel control chart template.)



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5. Making Data Driven Decisions

The benefit of having data organized, analyzed, and visualized is that everyone in the brewery can be involved in making data driven decisions. Experience and intuition can help fill in the gaps, but data should not be ignored. Creating a culture where data is approached without expectation or ego will be important. We will touch on this more in Part 2 of Data Analysis for Craft Breweries.

Start A Brewery Note: This article is also available here in the Grist Analytics blog, and additional blog posts will be shared in the Start A Brewery Library on an ongoing basis courtesy of the author.

Contributing Author

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Brynn is a biochemist by training and fermentation scientist by trade. Her experience in brewing QC includes building micro, sensory, and analytical programs for Left Hand Brewing and Inland Island Yeast Laboratories. Brynn started Grist Analytics to bring big brewery QC tools to craft by making data entry, visualization, and analysis easy. She now helps breweries across the world turn production data into actionable information. Brynn is passionate about good beer, rock climbing, and building community.