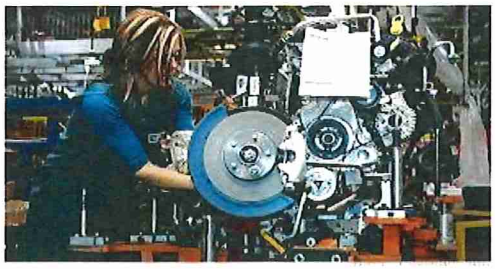
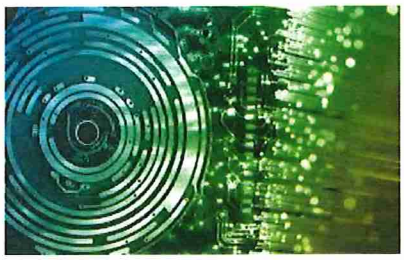
Amp It Up! Engineering/Technology and Industry Lesson Extension

Teacher Name(s):	**Marianne Springer**
School and District:	**Danvers High School, Danvers**
Course:	**AP Statistics**

Abstract: In 200 words or less, please provide a summary of the goal for the lesson extension and its relationship between industry and academic topic.

The goal for this lesson is to introduce AP Statistics students to the use of statistics within the Lean Six Sigma statistical process control methodology used at Microline Surgical while drawing connections to the concepts that they have studied during the year. As this lesson occurs after the AP Exam, students will analyze actual company data while applying concepts that go beyond the AP curriculum. Students will first analyze visual presentations and articles explaining complex Statistical Process Control concepts and then apply those concepts to the Jaw Break Test data. Discussions will center on quality management in a medical device company. Students will generalize from their introductory exposure to statistics within a specific application area: Lean Six Sigma. Hopefully some students will choose to conduct additional independent research into this application of statistics for their year-end project.

Engineering/Technology Link:

1. How did you *introduce* engineering/ technology concepts or the company/industry focus in your course? Check the appropriate box(es) or choose Other.

   ☐ Defined terms (science, engineering, technology)

   ☐ Described the engineering design process

   ☐ Engineering design challenge related to industry

   ✓ Overview of the company

   ✓ Challenge based on 'industry specific' area of focus (manufacturing process, quality control, measurement, development, teamwork etc.)

   Other: _____

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Level of Inquiry: Which of the following best describes the level of inquiry (adapted from Bell 2005) you used for this lesson/unit? Check the appropriate level.

☐ *Structured inquiry*: Instructor provides question and procedure. Students determine the results based on given procedures.

✓ *Guided inquiry*: Instructor provides question. Students design procedure and determine the results.

☐ *Open inquiry*: Students investigate their own research question. Students design procedures and implement the procedure on their own.

Lesson Extension Plan:

Title/Topic: Introduction to Statistical Process Control at Microline Surgical
Time (minutes): This will be a 90-minute lesson that will be completed in class following the AP Exam. Hopefully, some students will then decide to further pursue the Lean Six Sigma statistical process control concepts in their independent research project.
Company Name and brief Description: Microline Surgical: Microline Surgical develops and manufactures high precision open and laparoscopic reposable instruments. Microline's laparoscopic reposable instruments provide a cost effective, eco-friendly solution for today's OR.
Overview of the Lesson: AP Statistics students are familiar with sampling methods and basic inference techniques, however, they are unfamiliar with Statistical Process Control applications. This lesson will introduce them to a local company and one aspect of quality control using two sets of data and some standard statistical process control concepts.
Standard(s)/Unit Goal(s) to be addressed in this lesson: Students will describe and analyze quantitative data by calculating summary measures and creating appropriate graphs. They will also perform a one-sample hypothesis test for the mean of the maximum load data.
Essential Question(s) addressed in this lesson: How does Microline Surgical use testing and sample measurements to ensure that their product will meet customer specifications?
Objectives (academic and/or engineering/technology, career): Extend classroom statistics knowledge to quality and control of manufacturing processes in a medical device company.
Link to Industry (how the lesson connects to the industry visited: Microline provided company information, procedures for performing tests to gather sample data, the data itself, and visual overviews of Statistical Process Control concepts that illustrate these complex concepts as used at Microline Surgical.

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What students should know and be able to do before starting this lesson: Students should understand the importance of random sampling and the impact of sample size on analysis for overall conclusions. Students must be able to perform quantitative data analysis and perform inference procedures.

Instructional Materials/Resources/Tools

Microline product usage video, simplified overview presentation of the relationship of PP, PPK, CP, and CPK concepts in Lean Six Sigma Statistical Process Control, visual of PpK and CpK concepts within a manufacturing extrusion flow process, product images of the jaw break testing (before and after), a few components of a product, a Single Jaw Bending Test Procedure document (for classroom use only) and two sets of sample data from a break test.

Lesson Delivery

Lesson Opening

Engage students with an exploration of the Microline Surgical website. Pass around brochures and sample product. Encourage students to view the Tonsillectomy Video using Microline Product with a cautionary note that it shows an actual surgery.

On the Microline Surgical website, students will be instructed to read:
Spotlight

APR 22, 2015 BY SURGICALPRODUCTSMAG.COM Achieving Healthcare Reform's Goals of Higher Quality, Cost Effective Care through Reposable Laparoscopic Instrumentation

Questions for Class Discussion:

What is laparoscopic surgery?

Why does the term "reposable" describe the Microline Surgical product line?

How do you think Microline Surgical ensures the quality of their products?

Teacher will provide highlights of the company visit to students during the discussion session.

During the Lesson (activities/labs/challenges)

Part 1: What is Statistical Process Control?

Present Microline's: Introduction to Statistical Process Control (attachment 1)
Present Extrusion Flow Overview with CpK and PpK (attachment 2)
Assign reading CpK and PpK in Statistical Process Control.
Students will individually answer these comprehension checkpoint questions:

1. In your own words, explain the difference between PP and PPK.
2. In your own words, explain how the PPK and CPK relate to our study of Statistics and Parameters.
3. Assume that you are making plastic cups for iced-coffee drinks. The diameter must be 7 cm with a tolerance of .02 cm, and the hole for the straw must be located at the center of the cup. If these specifications can be given the number "1", how could you describe a situation where you obtain a sample with a PP value of 1.5 but the PPK value is 0.5?

4. Using the Extrusion Control diagram, explain how the challenges presented relate to what we've learned about the "random sample" condition for inference.

Part 2: Data Collection and Analysis:

Data Collection --
Provide students with Microline Single Jaw Bending Test Procedure and images of the product that is being tested. Review the aspects of this test (destructive) so students can appreciate the reasons that small samples might be preferred. Show the separate procedure that was done in R&D to obtain an average torque measurement. *(Note: these documents are not available for publishing online but will be used in this classroom)*

Questions for Class Discussion --

How and why would procedure documents like these might important for statistical analysis in a company?

How much time do you think an engineer might spend writing, peer-editing, following procedures?

How does this connect to your academic work in school?

Data Analysis --
Jaw Break Test Data (attachment 3)
Give small groups of students the two sample data sets to analyze. They will create a histogram, a normal probability plot of the data, and then calculate the mean and standard deviation using technology.
Teacher will check this work, and then students will be tasked with calculating the CpK value (referring back to the linked articles as necessary).
Validate student work.

Questions for Class Discussion

What is an LSL?

Why are all the data values so much larger than the LSL?

What similarities and differences do you see in the two sample data distributions?

Lesson Closing

Students will reflect on and discuss similarities and differences between the classroom instruction through the year and this specific application of statistical process control (particularly Lean Six Sigma) at Microline Surgical. This will generate a summary of lessons learned and a list of questions for further investigation/research.

Assessment
Student Assessment: Students will create a report of their data analysis and a list of follow-up questions that are of most interest to them. Students will also create a brief presentation (suggestions: video, powerpoint, proposal for their independent research project, or AP Statistics recruiting poster or letter to future student)
Delivery Assessment: One measure of lesson success will be the quality of the lists of follow-up questions generated by the students and any expressed interest in conducting independent research as a follow-on project. Another measure of success of the lesson will be the amount of student difficulty in processing the new concepts and connecting them to previous knowledge.

Additional resources and assessments: Attachments should include handouts, readings (with references), lab write-ups, rubrics, exams/quizzes, and/or other similar materials.

Attachments:

1) Microline Introduction to Statistical Process Control
2) Extrusion Flow Overview with CpK and PpK
3) Sample Jaw Break Test Data (2 samples)

Statistics

Intro to Process Control

Statistical Process Control

S = WITH THE USE OF NUMBERS OR DATA

P = WE MONITOR THE PROCESS

C = TO MAKE IT BEHAVE THE WAY WE WANT

Understanding PP, PPK Values

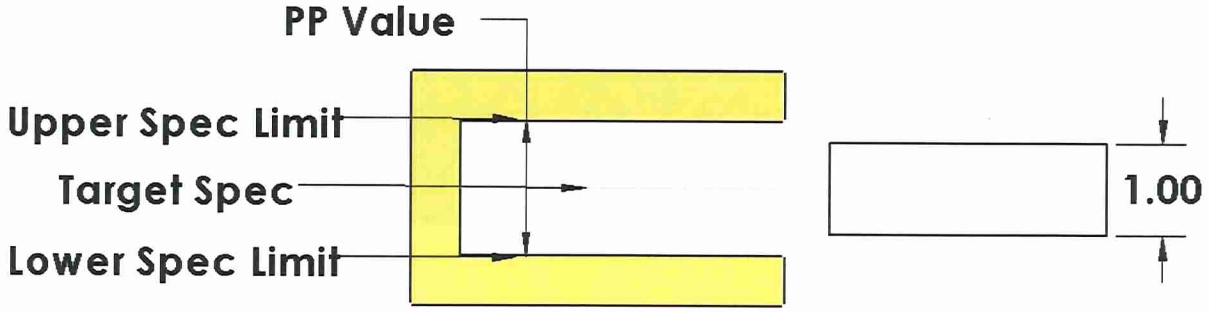
- Standard Deviation
- Pp Value (Process Performance)
- Ppk Value (Process Performance Index)
- Cpk, Cp vs Ppk, Pp (Difference is Cp, Cpk are process controls for multiple runs, Pp,Ppk and process control for a specific run)

Standard Deviation

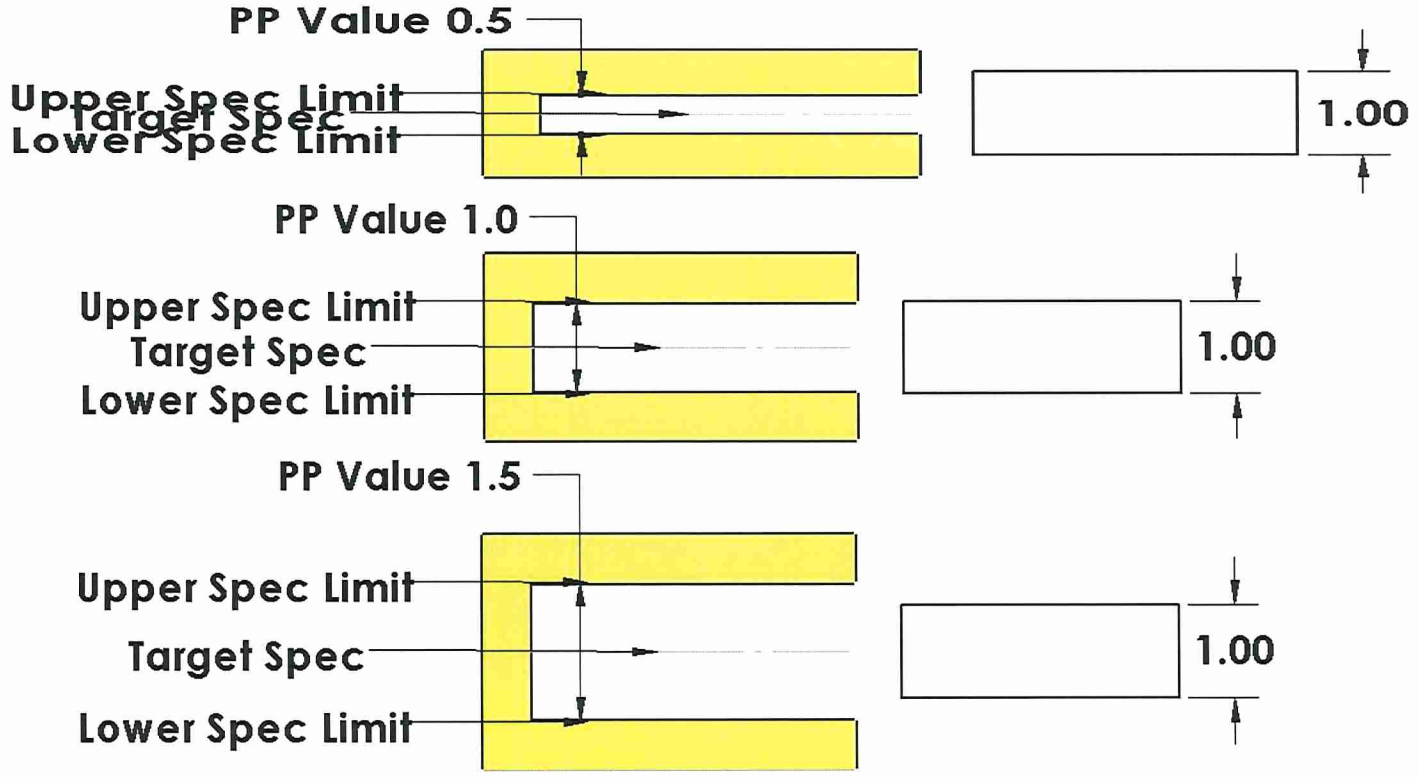
- Standard Deviation is a process controlled variable.
- Operators cannot control Standard Deviation without a change to the process.
- Standard Deviations are used to account for all your uncontrollable variables.
- Example, Water Temp, Dryness, Humidity, Vibrations, Melt Flow ETC.

PP Value

- Pp Value is a value that show how well the standard deviation falls within you specification limits.
- The PP Value is the size of your garage. The larger the PP Value the easier it is to park the car.
- The Car in this example is always 1. The 1 counts for the entire specification supplied by the customer.
- Operator cannot effect Pp Value

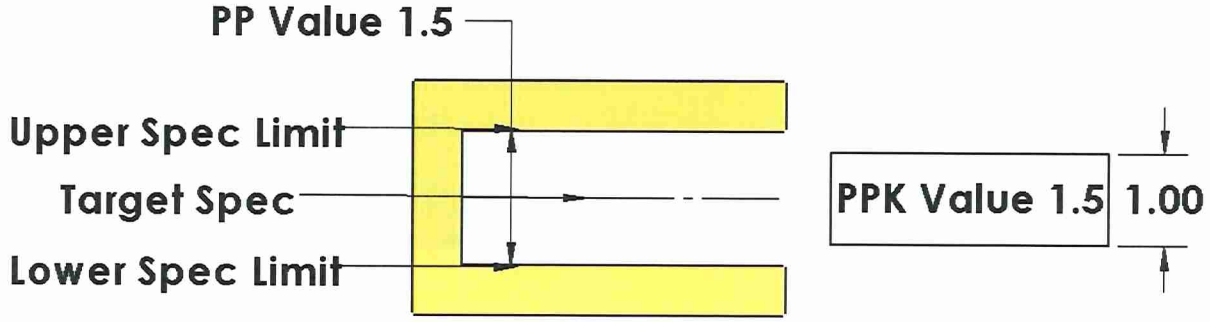


PP Value Continue

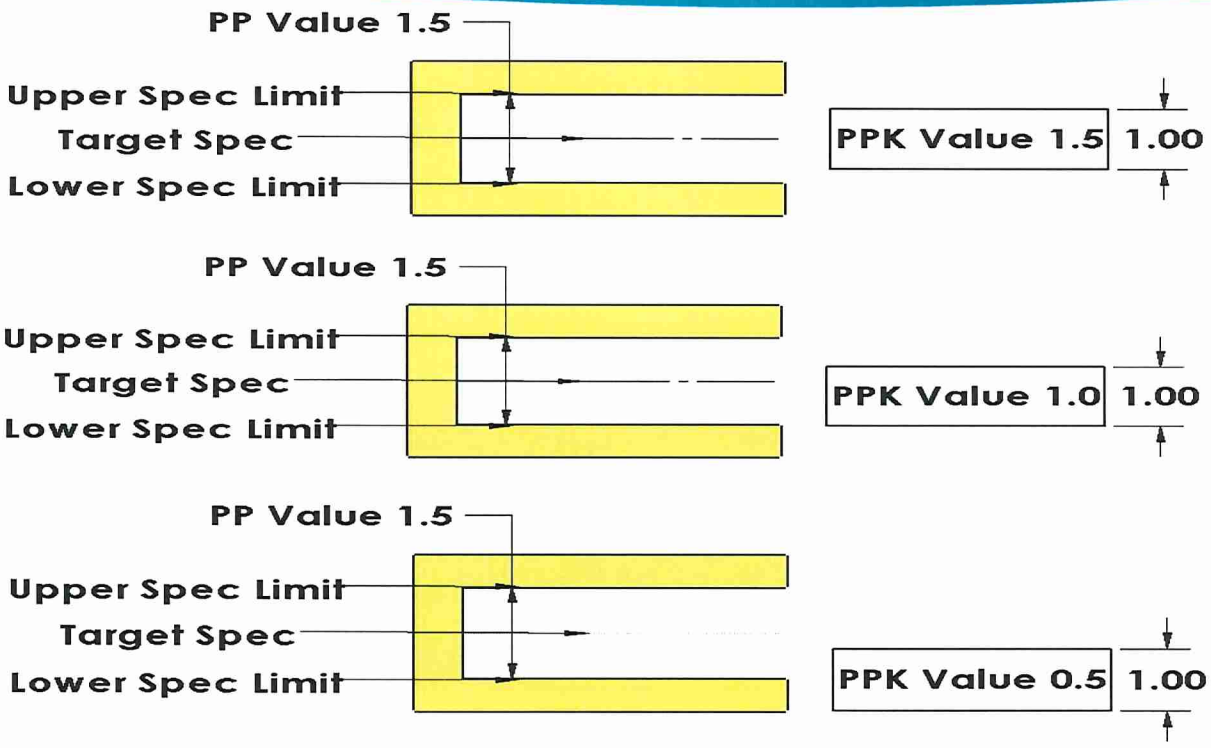


PPK

- PPK Value is how centered you are on your tolerance.
- PPK Value can never be larger than PP Value only equal at best.
- The Higher the PPK Value the further you can be off your Target
- The Example Below shows a PP value equal to a PPK Value.
- Operators can effect this value.



PPK Value


PP Value 1.5
Upper Spec Limit
Target Spec
Lower Spec Limit
PPK Value 1.5
1.00
PP Value 1.5
Upper Spec Limit
Target Spec
Lower Spec Limit
PPK Value 1.0
1.00
PP Value 1.5
Upper Spec Limit
Target Spec
Lower Spec Limit
PPK Value 0.5
1.00

Difference of Cp and Cpk and Pp and Ppk

Cp and Cpk
Process Capability Metrics

Cp is the capability index.
It measures how well the data **might fit between** the spec limits (USL, LSL). It doesn't care if the process is centered within the limits only if it would fit if it was centered.

Cpk is the centering capability index.
It measures how well the data is centered between the spec limits.

Use **Cp Cpk** when you have a **sample**, not the population, and are testing the potential capability of a process to meet customer needs.

Cp and Cpk use *Sigma estimator*.

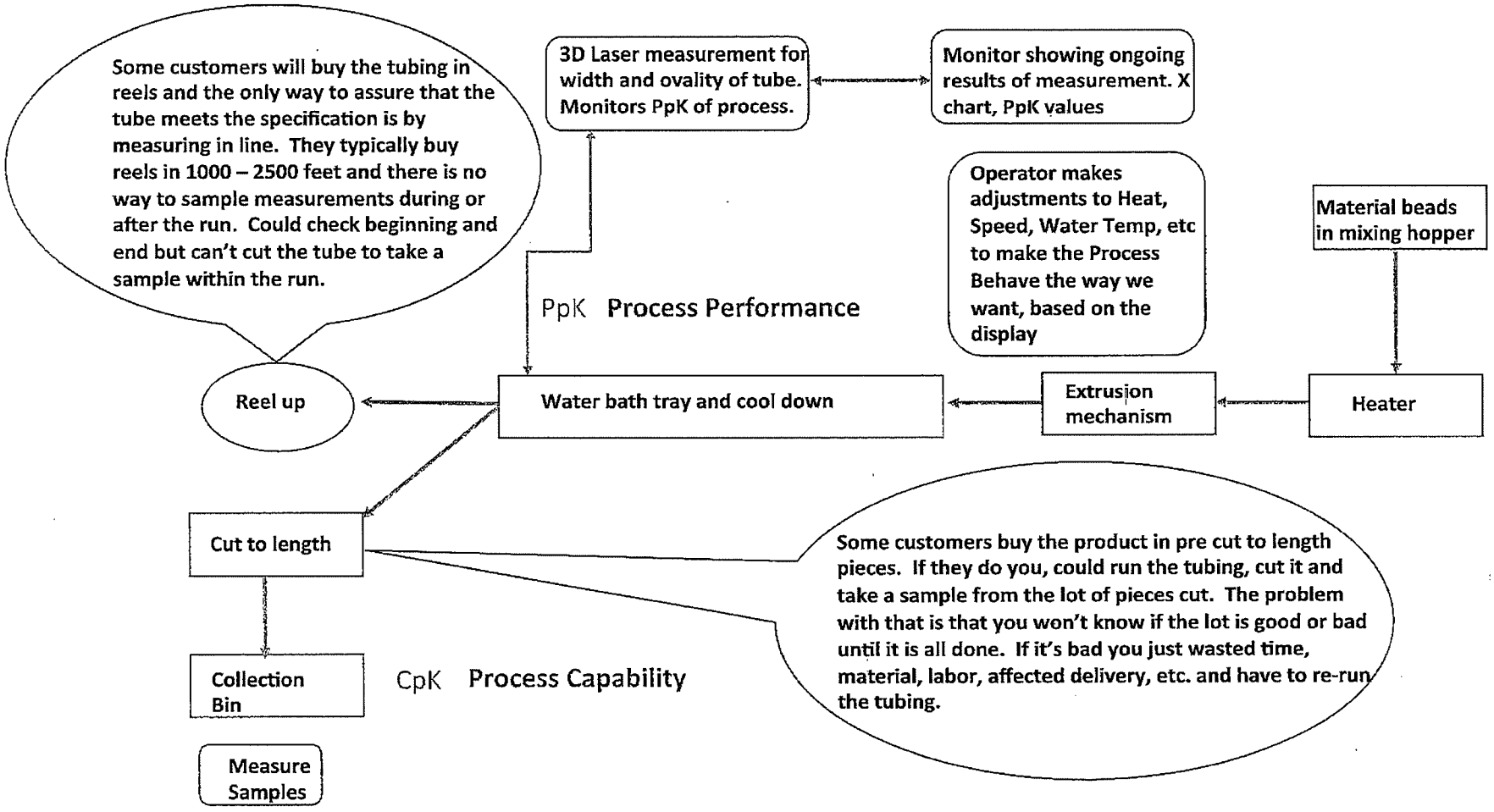
Pp and Ppk
Process Performance Metrics

Pp is the performance index.
It measures how well the data **might fit between** the spec limits (USL, LSL). It doesn't care if the process is centered within the limits only if it would fit if it was centered.

Ppk is the performance centering index.
It measures how well the data is centered between the spec limits.

Use **Pp Ppk** when you have the **total population** and are testing the performance of a system to meet customer needs.

Pp, Ppk use *standard deviation*.


Some customers will buy the tubing in reels and the only way to assure that the tube meets the specification is by measuring in line. They typically buy reels in 1000 – 2500 feet and there is no way to sample measurements during or after the run. Could check beginning and end but can't cut the tube to take a sample within the run.
3D Laser measurement for width and ovality of tube. Monitors PpK of process.
Monitor showing ongoing results of measurement. X chart, PpK values
Operator makes adjustments to Heat, Speed, Water Temp, etc to make the Process Behave the way we want, based on the display
Material beads in mixing hopper
PpK Process Performance
Reel up
Water bath tray and cool down
Extrusion mechanism
Heater
Cut to length
Some customers buy the product in pre cut to length pieces. If they do you, could run the tubing, cut it and take a sample from the lot of pieces cut. The problem with that is that you won't know if the lot is good or bad until it is all done. If it's bad you just wasted time, material, labor, affected delivery, etc. and have to re-run the tubing.
Collection Bin
CpK Process Capability
Measure Samples

2 Samples of Max Load Data for Jaw Break Test

Sample 1

Max Load (lbf)
19.34136503
18.54394209
18.86130502
19.51481554
18.74984117
20.2257069
19.33196395
19.6044891
19.48051942
18.81577343
19.09466044
19.21494349
19.54
19.2368383
14.87
19.07524302
19.78596979
19.83757593

Sample 2

Max Load (lbf)
18.06121574
17.56464735
17.91223196
18.00044956
17.77813068
17.34247262
17.80609321
18.02427318
17.84156848
17.57970084
17.67508968
18.03312289
17.69534665
17.13618456
17.66959687
17.63932943
18.41944208
17.79271522

LSL = 9.9