# Process Engineering
*A Develop Understanding Task*

**Purpose:** The purpose of this task is to show students some basic statistics evaluation completed as part of the manufacturing process, as well as to provide a motivation for learning to leverage the power of technology to complete such tasks in a large data set. Spreadsheet skills will be applied.

**Career Field: Process Engineering**

**WTCC Associate Program of Study and Contact Person:**
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**NC Math 4 Standards:**
NC.M4.SP.1 Create statistical investigations to make sense of real world phenomena.
NC.M4.SP.1.3 Organize large datasets of real world contexts (ie., datasets that include 3 or more measures and have sample sizes >200) using technology (e.g., spreadsheets, dynamic data analysis tools) to determine types of variables in the data set, possible outcomes for each variable, statistical questions that could be asked of the data, and types of numerical and graphical summaries could be used to make sense of the data.

**Unit Alignment:**
NC Math 4 - Unit 5, Lesson 6
WTCC – MAT 152 - Statistics

**Common Core State Standards for Mathematical Practice**
   2. Reason abstractly and quantitatively.
   3. Construct viable arguments and critique the reasoning of others.
   4. Model with mathematics.
   5. Use appropriate tools strategically.
   6. Attend to precision.

**Prerequisite Skills**
*These skills could be reviewed in a warm-up and are addressed in the Desmos Activity*

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- Identify the limits of an interval described in words (e.g., "within 1.3*cm* of the specified 20.8*cm*" or "20.8*cm* $\pm$1.3*cm*") "within tolerances"
- Enter values/formulas into a spreadsheet tool

**Time Required**
The time required to complete this activity is approximately 80-90 minutes.

**Materials Needed**

- Student Activity Sheet: "Mind Your Tolerance"
- Spreadsheet "Canister Sample Data". This spreadsheet can be used in either Google Sheets or Excel.
  - NOTE: data in this spreadsheet was generated using spreadsheet functions. For example, the formula for each CrimpHeight value was "=6.96+randbetween(-825,825)/10000". Most values remain within tolerance and there is sufficient variation among the items, but the range of data values is realistic to industry standards. If you use this formula to generate values, it will create new values every time something is entered into the sheet and change the answer key.

**The Teaching Cycle:**
**Launch:** Students can work in pairs or individually. The class should have three groups of pairs. Distribute the student activity sheet and be sure that each pair is assigned to one of the 3 Samples. Have students complete the [Desmos Launch Activity (opens in a new window)](https://teacher.desmos.com/activitybuilder/custom/5ff4859fc52e860d05268c42?collections=5f6cae0049988f0bfcd6f9f8) [plain text link: https://teacher.desmos.com/ activitybuilder/custom/ 5ff4859fc52e860d05268c42?collections=5f6cae0049988f0bfcd6f9f8]. Students are taking on the role of Process Engineer for the day as described in the video.  The task is to examine the data set and make recommendations about the operation of the manufacturing equipment.

**Explore:** Students sort through one of the 3 Sample data sets and answer the questions on pages 1 & 2 of the handout. It is expected that students will "browse" the data set visually, looking for numbers that are outside the indicated range. It is likely at least one group will make a table of acceptable intervals for each parameter. share this strategy with the group. Some groups might suggest sorting the data. Remind them that the readings need to remain connected with the sample number.

**Discuss1:** Have one or two groups from each data set share out how many samples had at least one value outside the data range, and the methods they described to identify them. In both sample sets 1 & 2, fill levels are increasing with each of the last several samples. While levels are within spec, a trend in the data could indicate a need for adjustment or monitoring of the equipment.

**Explore2:** Remix Sample is a practice exercise measuring a different set of parameters. Each individual should evaluate this sample of the remix processes.
If no group had discussed using graphing to identify samples that are out of spec, this could be a suggestion incorporated into the introduction of the Remix Example. Students could graph the data in Desmos along with inequalities illustrating the desired intervals (e.g., 6.88<y<7.04) or in the spreadsheet to look for points outside the interval.

After completing RemixSample, students should take a look at the BatchSample sheet. The sample here is too large (300 samples with 3 measurements each) to be scanned visually, and a graphical representation in Desmos is not helpful.

Discussion should connect back to the language used to identify those measurements out of tolerance - if a CrimpHeight is less than 6.88mm, it is out of tolerance. There are six of these questions for each measurement - CrimpHeight < 6.88, CrimpHeight > 7.04, etc.
Leverage students' use of the word "IF". The "Out of Range Flag" column can be used to display the results of these comparisons. Each statement such as "E5<6.88" is assigned a value of 0 if FALSE and 1 if TRUE. Since we are only concerned with whether any of the tolerances are violated, we can see if the sum of the values of these comparison statements is 0 (all FALSE) or greater than 0 (at least one is TRUE).
The statement =IF((E5<6.880+(E5>7.04)+(F5<17.70)+(F5>17.90)+(G5<6.20)+(G5>6.80)) yields a value of 0 if all the statements are FALSE, and a value greater than 0 if all the values are true. The formula =IF((E5<6.880+(E5>7.04)+(F5<17.70)+(F5>17.90)+(G5<6.20)+(G5>6.80), "Out of Range", "") will display the words "Out of Range" in that cell if any measurement is out of tolerance, and nothing if all measures are within tolerance. This formula can be filled down in that column, making a visual scan of the data helpful.

**Discuss2:** Students are likely to suggest similar methods to their previous work, scanning the data columns for numbers that are out of tolerance, but will likely acknowledge that this is inefficient. If students' spreadsheet skills do not include this type of formula use, the group may need a good deal of guidance building the formula and filling the cells.

**Exit Ticket:** *Evaluate each of the following statements:*
*Given*: X=4.5, Y=7.6, Z=11.8          *Evaluate:*((X<5)+(X>7)+(Y<7.0)+(Y>9.0)+(Z<10.8)+(Z>11.6))  2
*Given*: A=11.8, B=9.72, C=0.65          *Evaluate:* ((A<10.5)+(A>11.5)+(B<9.8)+(B>10.2)+(C<0.5)+(C>6.5)  1

Write a statement in D2 for a spreadsheet that will display a flag for any reading in the row that is out of tolerance, and indicate which row(s) would return an "Out of Range" flag.
Row 1 gives the standard values and tolerances.

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **20±3.5** | **7.25±0.65** | **10.0±4.8** | |
| 2 | 22.8 | 9.05 | 5.6 | =IF((A2<16.5)+(A2>23.5)+(B2<6.6)+(B2>7.9)+(C2<5.2)+C2>14.8)." Out of Range", "")  **Out of Range** |
| 3 | 20.5 | 7.40 | 12.3 | leave blank, all within tolerance |
| 4 | 15.8 | 8.10 | 14.9 | **Out of Range** |

Speculation on statistical anomaly questions could be used for an extension if time.