# Improving Metrology Calibration Frequency and Traceability

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***Abstract* — For this project, Paragon Medical, a medical component manufacturer in Bloomindale, Illinois, reached out to Northern Illinois for a team of students to assist in improving the Q/C and Metrology department gage calibration frequency and traceability. The team conducted reliability analysis to determine whether 250 tool uses before validation of gages is sustainable and can be revised to a data driven value to minimize calibrations conducted daily. Concurrently times studies and various 5S+1 audits were conducted in order to improve standardization of set ups for in process inspections of various parts made by Paragon Medical as well as reducing the set up time it takes to set up Coordinate Measuring Machines. Another area of focus is the editing and creation of work instructions to assist in training for current and future employees. With improvements in work instructions, employees will be able to confidently conduct calibrations of the various measuring machines available at Paragon Medical.**

***Keywords-5S, Reliability Anlaysis, Work Instructions, Process Improvement, Time Studies***

## I. INTRODUCTION

Paragon is split into several departments, grouped by smaller, more distinct "cells". The focus of this project was centered on the Quality Control Lab department. The cell primary affected will be the Coordinate Measuring Machine area (CMM). The Quality Control Lab has been operating without data to support many of the process flows.

Employees were uncertain of the calibration frequency for gauges, whether it is a batch size of 250 pcs or 1000 pcs (depending on gauge type). There also seemed to be difficulty amongst the operators to keep track of the number of times a pin was used during the manufacturing of a part. They had trouble identifying how often to calibrate the gauge.

The Keyence, OGP, Hawk, and Zeiss CMM calibration work instructions needed validation to ensure that they meet the standard practices provided by vendors. We also applied 5S to various parts of the department such as the CMM setup as well as fixture and probe storage. The contractor will be responsible for developing and documenting a labeling system to assist in effective traceability of pin/ plug/ thread gages and other areas of the Metrology department.

## II. OBJECTIVES

### A. *Validate gauge calibration frequency*

- Analyzed tool wear and calibration dimensions.
- Improved calibration tracking and counts.

### B. *Improve CMM set-up time*

- Created work instructions to improve calibration times and reliability.
- Developed standardized process for CMM inspections.

### C. *Improve metrology and Q/C lab*

- Maximized storage for less used fixtures and probes based on used frequency.
- Implemented identification system to fixtures and have a set-up guide to eliminate set-up guess work.

## III. CURRENT STATE

In order to improve the quality of the Metrology department's calibration frequency and traceability, the team conducted the following methods:

### A. *Data Analysis*

The team observed the current state of the system. A process flow chart was created by the team to completely explains the current state. This can be seen in *Figure 1* below.

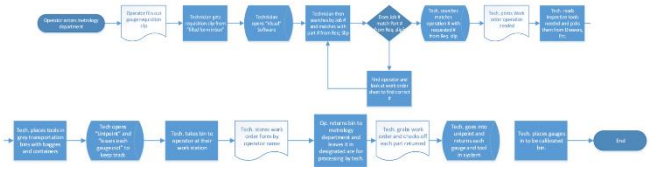

*Figure 1: Process Flow Chart*

### B. *Live Training*

The team shadowed the inspections department to analyze the true current practices for calibrating the CMM machines, and documented the process flow for a single artifact that was calibrated respectively with either the OGP, Keyence, Hawk, and Zeiss machines. Instructions on potential risks were also documented.

### C. *Data Collection*

To validate the 250-pc threshold for calibration, data was collected using Omega Cube and Unipoint. The Unipoint software provided annual, historical data for inspection records from 06/2014-06/2020. Unipoint contained calibration record. Past work orders were used to evaluate the number of uses. The team obtained the original work instructions for each CMM machine. The Zeiss machine did

not have any available work instructions and needed work instructions constructed.

### D. 5S+1: Probes and Fixtures

Currently, the fixture and probe storage were not fully utilized. We can establish an organizational system based on the frequency of use and ease of access. The cabinets were used for probes and fixtures that are less commonly used or required a more unique set up requirement. Each CMM station had its own set of probes and had a storage carousel to store their respective probes. However, the stations lacked labeling and organization for all the equipment at the station. The current time it takes for a metrology technician to set up a CMM and run their "in process" set-up is 20 minutes. Using 5S+1 Methodology, the team can reduce the time it takes for them to perform the task and save Paragon Medical money.

## IV. Deliverables and Conclusion

### A. Validation of Calibration frequency

Data about tool wear and number of uses from Unipoint and Omega Cube was needed to use Minitab to conduct a reliability analysis. Every calibration conducted is recorded. The relevant information were the nominal dimensions, actual dimensions, tolerances for each specific tool being inspected and finally a pass or fail based on tolerance specifications of each part. We focused on the "0-80" thread gage, which had the most historical data points in both systems. We collected previous work orders that used the "0-80" Gage. There were ~16,000 uses for the tool with about 5 points of failure due to wear or damaged and chipped threads.

This thread gage required 100% inspection which meant every unit made with this thread gage for inspection was checked. The only thing that the tool use count didn't contain was the amount of uses for final inspection. Only in process parts were inspected and recorded. But for final inspection they were inspected but the tool use is not recorded. To account for this there are two approaches: (1) remove missing data points and conduct the reliability analysis, (2) fill in missing data with an average of production rate and actual number of days between each missing point. In Minitab, we performed both approaches.

Both approaches show that increasing the tool use count from 250 uses between validations to 500 has about 83% chance of survival for approach 1 and 92% of survival for approach 2. We can reduce the number of calibrations needed between parts and reduce the time spent calibrating each day.

Table 1: Survival probabilities for approach 1

| | | 95.0% Normal CI | |
|---|---|---|---|
| Time | Probability | Lower | Upper |
| 250 | 0.934950 | 0.825149 | 0.981792 |
| 500 | 0.836660 | 0.666836 | 0.937048 |
| 750 | 0.748285 | 0.522537 | 0.900023 |
| 1000 | 0.672900 | 0.406521 | 0.871261 |

Table 2: Survival probabilities for approach 2

| | | 95.0% Normal CI | |
|---|---|---|---|
| Time | Probability | Lower | Upper |
| 250 | 0.946223 | 0.877569 | 0.976875 |
| 500 | 0.922839 | 0.841753 | 0.963261 |
| 750 | 0.904925 | 0.813790 | 0.952717 |
| 1000 | 0.889896 | 0.789670 | 0.944005 |

It is strongly recommended to continue to perform reliability analysis with the collection of more data points.

### B. Work Instructions

The updated work instructions for Keyence, OGP, and Hawk machines could improve calibration times and reliability. Lower-level calibration instructions, mitigation measures, images, and set up instructions that reflect Paragon's current practices were added. The Zeiss work instructions' first revision was verified. We recommended that the company transition from hard copy work instructions to an electronic database that is easily accessible to operators. The continuous application of 5S should also apply to work instructions. These efforts will guarantee continuous improvement in calibration flow and reliability.

### C. 5S+1: Probes and Fixtures

While implementing 5S+1, the team standardized the process by minimizing time searching for equipment and decluttered the CMM station. A picture displaying all the contents inside of the storage cabinets was attached on the outside of door. This will help the technician find what they need before opening the door. Additionally, the team added labels to the carousel storages and gave each probe a designated home. This reduces the time it takes for each technician to locate the probes that they need. It also declutters the workstation so that efficient work can be performed. The racks under the CMM station tables stored less frequently used fixtures. A 5S+1 audit sheet was created that allows the metrology team to track their progress, while making abnormalities easily recognizable. The team conducted a 5S+1 Workshop to introduce the concepts of 5S+1 and how to implement in the future.

Finally, a time study was conducted a final time to determine the updated time it takes a technician to execute an "in process" set-up. The updated time it took the technician was 7 minutes, which reduced the original time by 13 minutes. A cost analysis was performed, and it saved the company $21 per each "in process" set-up.

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