Precision Swiss Products, Inc.	Document # **SOP-3.2-001** Revision **1** Effective Date **06/13/23**
Document Title **Standard Inspection Methods**	Document Type **Standard Operating Procedure**

1. **Purpose:**
   To provide a standard for inspection methods to be used during inspection, to ensure that all employees from the shop floor to quality, are inspecting each feature in the same method, using the same type of tooling, and in the same order of operations.

2. **Scope:**
   This is to be utilized at all stages of production depending on the inspection plan requirements including:
   a. Incoming inspection
   b. First article inspection
   c. In-process inspection (SPC)
   d. Pre and post outside process inspection
   e. Final inspection
   f. Nonconformance/RMA inspection

3. **Terms, Acronyms and Definitions:**
   a. Gage: A measurement or standard by which something is measured.
   b. Trig: An abbreviated word for trigonometry which is a method used to calculate angles and lengths of the hypotenuse, adjacent, and opposite surfaces of a triangle.
   c. GD&T: Form and location limit control dimensions (i.e. flatness, straightness, surface and line profiles, parallelism, perpendicularity, concentricity, position, etc.).
   d. SPC: Statistical process control (SPC) is a method of quality control which employs statistical methods to monitor and control a process. This helps to ensure that the process operates efficiently, producing more specification-conforming products with less waste (rework or scrap).
   e. AQL: Acceptance quality limit is defined as the “quality level that is the worst tolerable” in ISO 2859-1. The organization has an AQL process of C=0 which means that 0 parts defective is allowed. AQL levels chosen for the organization represent the number of pieces that will need to be inspected for that lot, and 0 of those can be defective. If a defect is found, then 100% inspection is required of the lot, or since the last passed inspected part.
   f. Critical Feature: A customer predetermined key characteristic (also known as deltas), or any tight tolerance dimension that needs to be closely monitored for conformance.
   g. Attribute data: A result from a characteristic or property that is appraised only as to whether it does or does not conform to a given requirement (go/no-go, accept/reject, pass/fail)
   h. Variable data: Quantitative measurements taken on a continuous scale. Example: diameter of a cylinder, the gap between mating parts

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i. Attribute gage: A type of instrument that gives a binary pass/fail measurement result. Examples of attribute gages include go/no go plug gages, slip gages, and many visual inspection processes.

4. References:

a. DOC-8.5-002 (C=0 Sampling Plan)
b. DOC-3.0-009 (Customer Drawing Basics)
c. WI-3.2-004 (Opening CMM programs)
d. DOC-3.2-002 (CMM Setup Sheet)

5. Responsibilities and Authority:

a. Machinists- All level of machinists are responsible for understanding the standard inspection methods for the organization and for abiding by these standards
b. Quality Inspectors- All levels of inspectors are responsible for understanding the standard inspection methods for The organization and for abiding by these standards

6. Inputs:

a. Manufactured parts
b. Inspection reports (FAI, SPC, etc.)
c. A properly programmed operation/machine specific CMM or Keyence program that has been test ran
d. Customer drawing and inspection requirements
e. Calibrated precision measuring equipment/gages

Note 1:

This process is meant to be a baseline for how to measure certain features and finishes. There will always be exceptions to these rules. For additional alternative methods of measurement, please refer to QC and/or your supervisor for the most accurate and acceptable way to measure any features and finishes on machined parts and assemblies.

7. Process for Inspections:

Follow the guide below for what to inspect first, when you are starting your inspection, no matter at what point in production:

a. Documentation:
    i. If your inspection step requires a documentation review and/or sign off, do this part first. If there are any issues with the documentation, alert the lead/process owner and continue to work in parallel until resolved. Also alert your supervisor of the issue.
b. Visual inspection for:
    i. Cosmetic issues (dings, dents, scratches).
    ii. Burrs. Use a microscope at max 5-10x magnification unless otherwise stated on your inspection plan. Run your finger along the parts to ensure the part has no major burrs .
    iii. Compare your part to the drawing's isometric view (if available) to ensure part orientation is correct per the drawing. If an isometric view is not available, compare your part to the current available CAD model. Refer to your supervisor for any special circumstances.

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c. Thread inspection:
    i. Always inspect threads prior to any other dimensional inspection. If the thread of a part is nonconforming, then we can provide immediate feedback to the team.
d. Dimensional inspection:
    i. After the above has been confirmed and inspected, you can move on to the other dimensional inspections required. See section below for methods and inspection equipment for specific types of features.

8. Inspection Methods for Specific Features:

a. The CMM is the most accurate method to measure a part, as there are limited operator errors and no bias.
    i. Ensure your part set up is stable. Use custom fixtures whenever possible and ensure set up instructions are available/being used.
    ii. Ensure that DOC-3.2-002 (CMM Setup Sheet) is complete and attached to the "User Information" tab in the CMM program.
b. The Keyence Measuring System is another alternate precision measuring device that can be used when a hard check is not possible, or when something with a higher resolution than an Optical Comparator is needed.
    i. Ensure your part set up is stable. Use custom fixtures whenever possible and ensure set up instructions are available/being used.
c. The following methods are a baseline for hard check inspections when the CMM/CMM Program or Keyence/Keyence Program is either not available or has produced a failed result.
    i. **Surface Finishes**:
        1. Surface finishes should always be checked with a Profilometer. Check as much of the surface as the part's length allows for, within the travel limitations of the measuring machine.
        2. Secondary method: there is no other method for inspecting the surface finish with resulting variable data.
    ii. **Feature Depths**:
        1. <u>Counterbores</u>: whenever possible, use a Drop Indicator Gage.
            a. Secondary Method: If a drop indicator does not have enough reach, the Hi_Cal height gage can be used to accurately check depths.
            b. Tertiary Method: If a drop indicator or Hi_Cal does not have enough reach/ is not available, a Gage Pin and a Caliper can be used for depths with a tolerance of > ± .005", as well as a Gage Pin and an Optical Comparator for depths with a tolerance of > ± .005".
        2. <u>Threads</u>: the best way to measure a thread depth is with a Thread Gage and an Optical Comparator. Screw your part onto a thread gage, zero the optical comparator's crosshairs on the surface the depth is called out from, then unscrew your part from the thread gage being careful not to move it, then travel the crosshairs to the center of the furthest (last) Full Thread.
            a. Secondary method: If this method is not possible, a Thread Gage and a Caliper can be used for depths with a tolerance of > ± .005".

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3. Countersink: there are three acceptable ways to measure a countersink depth, in the order listed below:
    a. Make a mold of the countersink using a thin pour rubber casting compound (repro-rubber®). When the mold hardens, carefully remove it from your part and check the countersink depth and angle on the Optical Comparator.
    b. You can also measure the width of one side of the countersink using an Optical Comparator, then you can use that number, combined with the countersink angle to trig out the depth using a trig calculator or trigonometric formulas.
    c. If the first two options are not possible, you can section the part (cut in half) to expose the countersink profile, then measure the angles, surface lengths, and depths required on an Optical Comparator. A minimum of two (2) points should be used to measure a line and a minimum of two (2) lines should be used to measure an angle.

iii. **Outside Diameters (O.D.)**:
1. ALWAYS measure an Outside Diameter with an Outside Micrometer. How many sections of the O.D. you measure will always be length specific. Regardless of the number of sections measured, each section should be measured at two (2) places, 90° apart within that section. The longer your part, the more sections you will need to check.
2. Note: the only acceptable time it's okay to measure an O.D. with anything other than a micrometer (i.e. a Caliper) is when your tolerance for the O.D. is > ±.010".

iv. **Inside Diameter (I.D.)**:
1. ALWAYS measure an Inside Diameter with a Gage Pin and always verify the pin diameter with a calibrated Outside Micrometer.
2. Note: in special circumstances where using a gage pin is not possible, refer to your supervisor for alternate methods of measurements (i.e., bore gages, etc.).

v. **Thread Features (Inside and Outside Threads)**:
1. ALWAYS check threads using a thread gage.
    a. For internal threads, use a threaded go/no-go Plug gage to verify thread size.
    b. For external threads, use threaded go/no-go Ring gages to verify thread size.
2. Secondary method:
    a. There is no secondary method of inspection for verifying internal threads.
    b. External threaded features can be verified by measuring the Major, Minor, and Pitch diameters of the thread either on the Keyence or manually using various methods. For manual external thread verification inspection methods, speak with a Senior Quality Inspector for training.

vi. **Thicknesses**:
1. Thicknesses of parts are best measured using an Outside Micrometer. To accurately determine the thickness of the entire part/section of the part, inspect in multiple places, including the middle of the part/section that is reachable.
2. Secondary Method: using a drop indicator or height gage and surface plate, inspect in multiple places as stated above.

vii. **GD&T**:
1. GD&T dimensions should always be checked on a CMM using a verified CMM Program.

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2. Secondary method: multiple methods are available for secondary inspection verification. If you are unsure, speak with a Senior Quality Inspector for training.

viii. **Edge Breaks**:

1. All edge breaks (i.e., chamfers and radii) are to be measured on an Optical Comparator. Check radii using at least three (3) points evenly spaced throughout the radius and the width, height, and angle of a chamfer.
2. Secondary method: there is no secondary method of inspection.

9. **Outputs:**

All machinists and inspectors should be able to inspect every part using the same methodology and equipment, outside of that defined on any inspection plan.

10. Flow Chart:

N/A

11. Quality Records:

There are no records that come directly from this SOP.

Record Name	Owner	Location	Record Media
N/A	N/A	N/A	N/A

Revision History			
Revision	**Description of Change**	**Approver**	**Effective Date**
1	Initial release	Daniela Kozar	06/13/23

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COMPREHENSION TEST/TRAINING RECORD

Submit to Supervisor/Trainer once complete

Employee Name: _____ Date: _____

Comprehension tests are only required for new employees, initial release training and major revision updates. If a comprehension test is not required for an up rev for current employees, it will state as such in the "description of change" section on the revision history above.

Each answer is worth 1 point. If a question has multiple answers, and the employee gets part of the question correct, they will receive a point for each correct answer in that question.

100% is considered a passing grade. If 100% is not achieved, the employee must retake the training and test.

1. What is a critical feature?

   A _____ predetermined key characteristic or any tight tolerance dimension that needs to be monitored for _____.

2. Which is one method you would use to visually inspect for burrs?
   a. Run your finger along the part to ensure there are no major burrs.
   b. Hold the part up to your eye as close as possible to see if you can find any burrs.
   c. You don't need to because the machine will never leave burrs on a part.
3. Always inspect threads prior to any other dimensional inspection
   a. True
   b. False
4. The _____is the most accurate method to measure a part as there are limited operator errors and no bias.
5. The _____ is an acceptable secondary method for inspection when a hard check is not possible.
6. Surface finishes should always be checked with a _____
   a. Caliper
   b. Profilometer
   c. 5-10x magnification microscope

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7. A counterbore depth should be checked with a _____
8. The best way to measure a thread depth is with a_____ and _____
    a. Drop Indicator Gage and Thread Gage
    b. Caliper and Go-gage
    c. Thread gage and Optical Comparator
9. What are the two best ways to measure countersink depth?
    a. _____
    b. _____
10. You should always measure an Outside Diameter with a Profilometer
    a. True
    b. False
11. You should always measure an Inside Diameter with a _____ and then verify that with a _____
12. Thickness of parts are best measured using an Outside Micrometer
    a. True
    b. False
13. GD&T dimensions should always be checked on a CMM using a verified CMM _____
14. Edge breaks are to be measured on a _____
    a. Drop Indicator Gage
    b. Microscope
    c. Optical Comparator
15. Show your instructor that you know how to properly handle/use the following tools to make the following inspection measurements.
    a. Using a Drop Indicator (ask instructor for sample part)
    b. Using a Thread Gage (ask instructor for sample part)
    c. Using a Dial Indicator (ask instructor for sample part)

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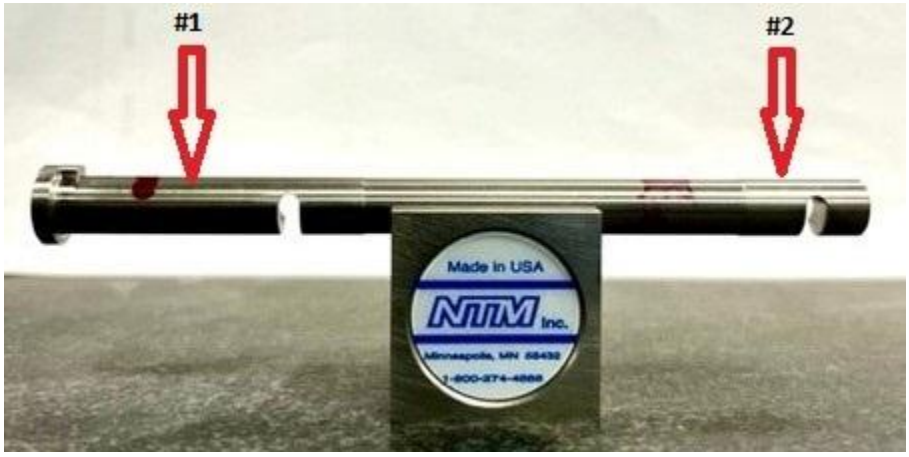
16. Using the Sample Part provided and an OD Micrometer, measure the OD in the places indicated based on the OD measuring instructions in this SOP above.

    What is the OD in both locations: Location #1_____ and Location #2 _____



17. Using a Caliper, Measure the overall length of the Sample Part.

    What is the overall length:_____

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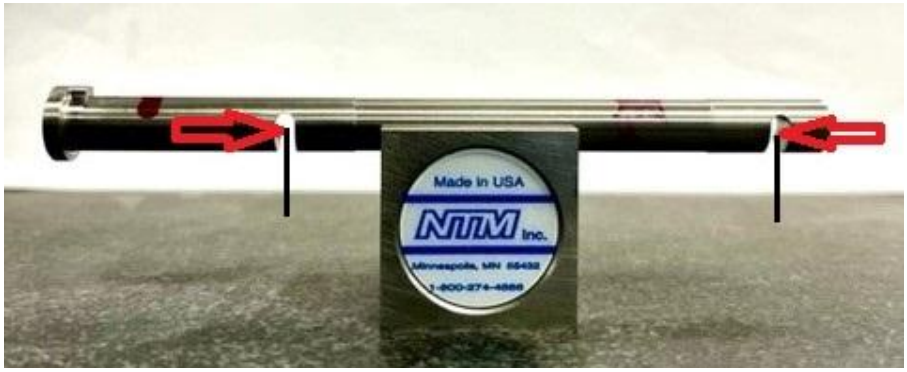
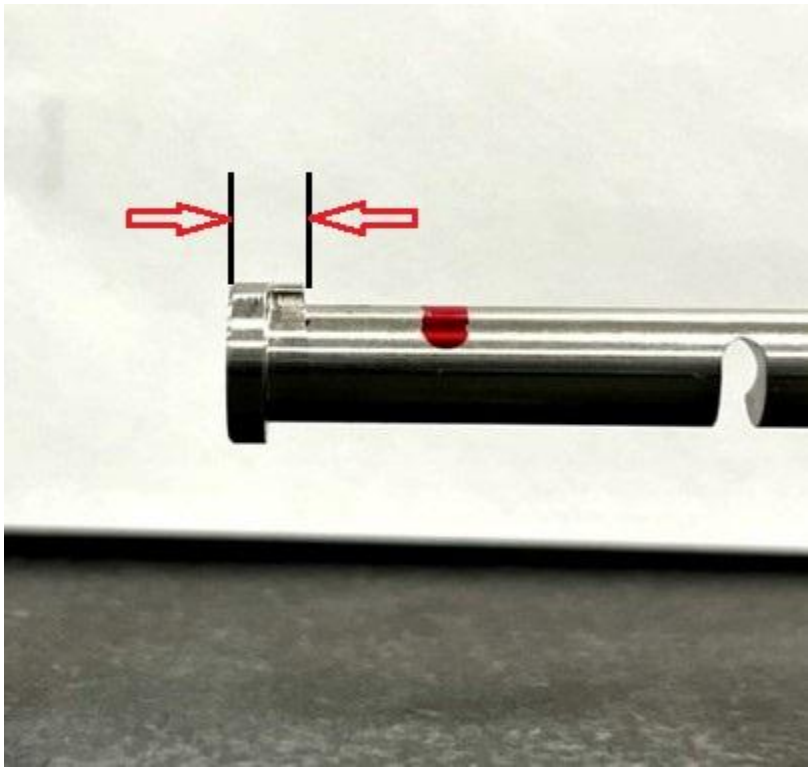
18. Using the Optical Comparator, measure the distance between the two slots, center to center on the sample part.



What is the distance: _____

19. Using an Optical Comparator, measure the feature depicted below.



What is the distance: _____

20. Now, using the Hi_Cal Height Gage, measure the same feature depicted above.

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What is the distance: _____

21. Describe what the surface finish of a part is:_____

_____

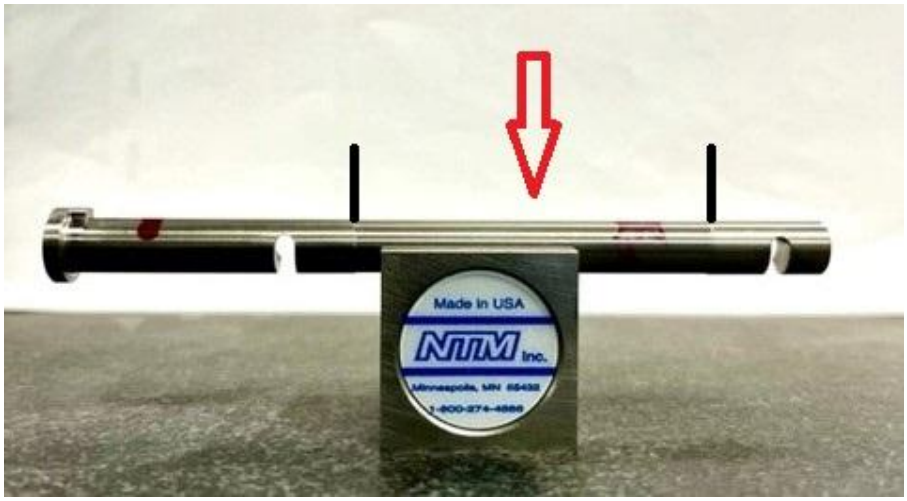
22. What is the most accurate method to measure a surface finish?

    a. Micrometer d. Microscope

    b. Profilometer e. Optical Comparator

    c. Caliper

23. Using this method, measure the surface finish anywhere between the two lines on the sample part provided.



What is your result: _____

Next, let's test your GD&T knowledge by answering the following questions.

24. Please Identify the following GD&T Symbols:

_____

_____

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 _____

 _____

 _____

 _____

25. Give a brief description of Concentricity:_____

26. Give a brief description of Perpendicularity:_____

27. Describe in your own words what GD&T callouts (like the symbols shown in question 21) on a drawing are used for:_____

_____

_____

Please give the completed test to Training Coordinator/Doc Control for saving

Supervisor/Trainer Print Name:	**Supervisor/Trainer Signature:**
Training Date:	**SCORE: _____ / _____ _____%**

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