



# CMM Program and Documentation Specification

Global Common

SD-1019

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## 1. Scope

The following specification defines Nexteer Automotive's requirements for creating standardized **Zeiss CMM programs** for all production and non-production intent, internal and purchased parts to determine conformance to part print specifications **measured on Zeiss equipment\***. This standardization allows Nexteer to take advantage of a common Global CMM Program Library that will be contained within Teamcenter or other central storage system. All programs will be fully utilized by Nexteer, or authorized part supplier to Nexteer. Purchased programs will become property of Nexteer Automotive once all requirements and obligations have been met.

\* Equipment used at Nexteer Automotive ranges in accuracy from 1.0µm to 2.4µm. Assuming tolerances fall within the machine specification the following repeatability values can be expected:

- Characteristics with tolerances over 30µm are anticipated to repeat within 10% of the total tolerance
- Characteristics with tolerances between 15-30µm are anticipated to repeat within 20% of the total tolerance
- Characteristics with tolerances less than 15µm will be evaluated on a case-by-case basis

## 2. Acronyms and Definitions

- NEiC – Nexteer Engineer in Charge (Central Metrology Group)
- SWI – Standard Work Instruction
- PCM – Parameter Coded Measurement
- CMM programming source – Can be an internal or external programmer
- CMM Program – CMM Measurement Plan
- Probe Elements – Any element (styli, extensions, cubes..) used to create a Probe Configuration
- Probe Configuration – Assembly of probe elements used to physically contact with the part during inspection, commonly called a Stylus System
- PT - Performance to Tolerance
- Feasibility review – Review of measurement plan for inspection abilities and expectations
- MSA – Measurement System Analysis
- Production Program – Any program used to release production or validate incoming material on a periodic or frequent basis (qualification study required).
- Non-Production Program – Any program used for infrequent inspection also known as spot checks.
- Nexteer Central CMM group - [ZeissCMM@nexteerautomotive.onmicrosoft.com](mailto:ZeissCMM@nexteerautomotive.onmicrosoft.com)
- Road Map – Bubbled number next to the print feature for quick identification

## 3. CMM Program and Documentation Requirements

### 3.1 Programming Software and Hardware

3.1.1 CMM programs must be written utilizing a scanning probe.

3.1.2 Unless otherwise specified by the NEiC, CMM programs must be written utilizing versions of software components defined below (versions to be in place by the end of Q2 2025):

- Calypso Version with Windows 10/11: 7.8 (2024)
  - PCM and Curve add-ons shall be at the current Calypso version
- Gear Pro Version with Windows 10/11: 7.2 (2024)
- PiWeb Templates: Shall be at the current Calypso version

**NOTE:** The CMM programs shall be run in the versions they were written in.

**NOTE:** New versions of Calypso and supporting software will be updated to the newest released versions by February of the following year.

3.1.3 A rotary table should be utilized when a part has an axis of rotation.

**NOTE:** This will be determined during program development or a feasibility review.

## 3.2 Fixturing – Nexteer Supplied

3.2.1 The NEiC will supply the program developer with a fixture in order to properly complete program development and testing.

3.2.2 A 3D Fixture model will be provided when requested by the CMM programming source.

3.2.3 CMM programs for complex parts, where fixturing plays an integral part in the repeatability of the program, the NEiC will review the provided fixture design with the CMM programming source.

## 3.3 Fixturing – Program Developer Supplied

3.3.1 If fixturing is for production intent programs:

- Designs must be approved by the NEiC
- Reference fixture packages may be available, contact NEiC
- For custom-made fixtures, fixture design must be provided utilizing Nexteer Drawing Standard "SD-003: General Drawing and Manuals Specification"

**NOTE:** 3D models with corresponding drawings are preferred

- Catalog information for standard fixture components must be provided

3.3.2 If fixturing is temporary for performing spot checks or preliminary proof of concept, the submission package (Section 3.21) must include:

- Photos of fixture components
- Documentation describing proper setup and alignment of the fixture

## 3.4 General Program Requirements

3.4.1 Programs and all related documentation must be written in English.

3.4.2 Programs shall be identified by the Nexteer program naming convention as described in Section 3.5

3.4.3 Nexteer print road maps shall be used as the primary description to identify CMM program characteristics whenever specified on the part print. In cases where components are purchased, supplier roadmaps can be used as a secondary description. (ex.: 316 Profile Datum A to XYZ, where 316 is the Roadmap number on the Nexteer print)

3.4.4 Programs should use appropriate templates, tables, and variables for features and feature setups.

**NOTE:** Teamcenter documents describing templates, tables and variables may be available upon request from the NEiC.

3.4.5 Programs shall run "From Feature List" unless otherwise approved by the NEiC.

3.4.6 PCM shall be utilized for all programs that are being used to measure parts that are similar in many ways, such as from the same part family or same geometry spec, based on the recommendation of the NEiC or programming source.

3.4.7 Curve shall be used to create, measure, and evaluate open and closed part features that do not fit standard feature types.

**NOTE:** Freeform curves shall not be used in any program.

3.4.8 Program features must be arranged to minimize the number of probe changes.

3.4.9 Scanning and self-center probing should be used whenever possible unless otherwise approved by the NEiC.

3.4.10 Calypso standard filtering methods are to be used unless otherwise specified or approved by the NEiC.

3.4.11 Calypso standard outlier elimination (3X Std. Dev.) to be used unless otherwise specified or approved by the NEiC.

3.4.12 The evaluation method (i.e., Best Fit, Max Inscribed, Min Circumscribed, etc.) for circles, cylinders, cones and other features must be approved by the NEiC.

3.4.13 For positional measurements, the additional x, y, z printout information must be included.

**NOTE:** For Profile characteristics, the additional x, y, z printout information should not be used. Reference characteristics can be used to give component level data as needed.

3.4.14 For GD&T that calls out MMC on Datums in a Feature Control Frame, Datum feature size will not be added in Calypso (no bonus tolerance added to the Datums).

3.4.15 If a program utilizes a rotary table, a rotary table part alignment must be included within the program

3.4.16 PiWeb templates shall be used in all cases and can be found on the Nexteer Data Exchange web page (<https://nexteerdatabexchange.com/>).

- Nexteer Standard Report templates will be used for all general output.
- Nexteer Exception Report templates will be used to specifically identify "out of spec." or "out of warning limit" items.

- Graphical output must be placed on a Nexteer formatted PiWeb template
- Header information shall include as a minimum:
  - Measurement Plan name
  - Mini-plan name
  - Part number or drawing number of the part being inspected
  - Drawing rev number (part rev the program was written to)
  - Project Information
  - Incremental Part Number
  - Date of inspection
  - CMM Serial Number
  - Calypso Software version
  - Teamcenter measurement plan version information
  - Programmer Name
  - Barcode (as defined by the Nexteer product print) information if requested by the NEiC

3.4.17 Gear Pro program shall not be run without a Calypso measurement plan, which at a minimum, sets up the part alignment.

3.4.18 A probe qualification program must be provided if requested by the NEiC:

- Program shall somehow identify the orientation of the qualification sphere.

**NOTE:** A Qualification sphere orientation document (07-1-5-F50) is available upon request from the NEiC

- Qualification results must print out after completion of the probe qualification.
- Printouts must include the calibration sphere identification number.
- Printouts must include the probe diameter and form deviation for each probe configuration and stylus

### 3.5 Program Naming Convention

CMM programs will be named using one of the following naming conventions:

3.5.1 Production Program Name (Calypso)

(MPXXXXXXXX)\_ (Part #)

└──┬──┘ └──┬──┘

(1)      (2)

(R)      (R)

**Example:** MP34400123\_28180797

**NOTE:** Each part of the name must be separated by an underscore “\_”.

(1) - **MP34400123:** Teamcenter Auto-Generated Number (supplied by the NEiC) (R = Required)

(2) - **28180797:** The 8-digit Part Number or Charted Number (R = required)

### 3.5.2 Production Program Name (Calypso) – Special Cases

- Program with Multiple Part Numbers

**Example:** MP34400123 *or* MP34400123\_Multiple

**NOTE:** In cases where multiple part numbers are referenced in the CMM Program, the Part # section of the MP name can be left blank or optionally include “\_Multiple”

- Program with Multiple Part Numbers under a charted drawing number

**Example:** MP34400123\_34005544

**NOTE:** In cases where multiple part numbers are referenced under (1) charted drawing, the charted drawing number may be used

- Programs that are Probe Qualifications

**Example:** MP34400123\_PO

- Programs that are Fixture Alignments

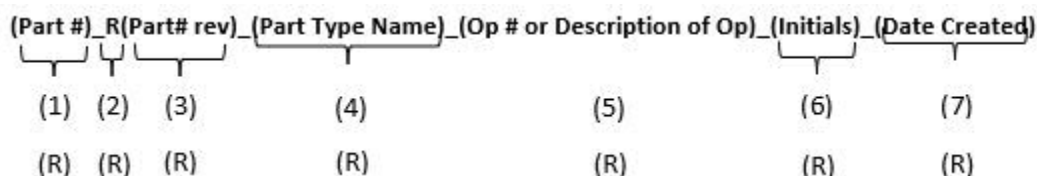
**Example:** MP34400123\_FA\_GA123456 *or* MP34400123\_FA\_TL123456

- Programs that are full REPS Assembly Gears

**Example:** MP34400123\_BT1XX

**NOTE:** In cases for full gear assemblies, the name should be MP344XXXXX\_Product Program Name (CPI Program Name). This naming convention is used because gears can have multiple part numbers, and part numbers can change often.

### 3.5.3 Non-Production Program Name (Calypso)



**Example:** 28180797\_R005\_Rack\_Green Teeth\_NW\_24MR20

**NOTE:** Each part of the name (except following the “R” on part (2) of the name) must be separated by an underscore “\_”.

**NOTE:** No special characters can be used in the naming sequence (e.g. !, @, #, \$, /, \ ...).

(1) - **28180797:** The 8-digit Part Number (**R = required**)

**NOTE:** If the program is used for multiple part numbers, a “(project name) Para” will be substituted for the part number and will be provided by the NEiC.

(2) - **R:** R is required before the revision level of the drawing (**R = required**).

(3) - **005:** Part number revision from the drawing (**R = required**).

(4) - **Rack:** Part Type Name, use a shortened name for the part type, refer to list in Appendix A (**R = required**)

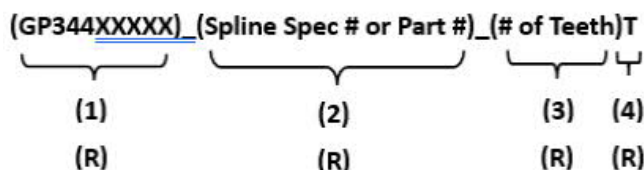
- (3) - **OP40 or Green Teeth:** Operation number consisting of 4 to 5 characters which must include "OP," or the descriptive identifier if OP number is unknown (**R = required**).

**NOTE:** OP999 shall be used for a Supplier (non-Nexteer) part.

- (6) - **NW:** Initials of the person who created or updated the program (**R = required**).
- (7) - **24MR20:** 6-character date (day, month, year; each being 2 digits in length) when the program was created or updated in the format: DDMMYY (**R = required**)

**NOTE:** If a number is less than 10, then the 2-digit identifier starts with a zero.

### 3.5.4 Gear Pro Production Program Name



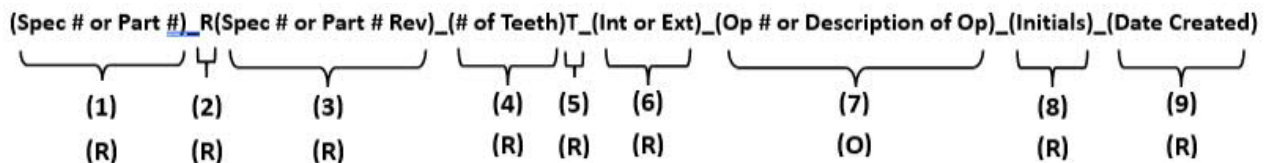
**Example:** GP34400123\_34200797\_24T

**NOTE:** Each part of the name must be separated by an underscore "\_".

- (1) - **GP34400123:** Teamcenter Auto-Generated Number (supplied by the NEIC) (**R = Required**)
- (2) - **34200797:** The 8-digit Spec, Part Number or Charted Number (**R = required**)
- (3) - **24:** The number of Teeth (**R = required**)
- (4) - **T:** T is required after the numeric value for number of Teeth (**R = required**).

**NOTE:** For additional information on required program fields to be entered in Teamcenter.

### 3.5.5 Gear Pro Non-Production Program Name



**Example:** 34200797\_R003\_24T\_Ext\_Hob\_NW\_07AU23

**NOTE:** Each part of the name must be separated by an underscore "\_".

- (1) - **34200797:** The 8-digit Spec, Part Number or Charted Number (**R = required**)
- (2) - **R:** R is required before the revision level of the spec or drawing (**R = required**).
- (3) - **003:** Spec or Part number revision from the drawing (**R = required**).
- (4) - **24:** The number of Teeth (**R = required**)
- (5) - **T:** T is required after the numeric value for number of Teeth (**R = required**).
- (6) - **Ext:** Ext for External Splines or Int For Internal Splines (**R = required**).



(7) - **Hob**: Operation number consisting of 4 to 5 characters which must include "OP," or the descriptive identifier if OP number is unknown (**O = optional**).

(8) - **NW**: Initials of the person who created or updated the program (**R = required**).

(9) - **07AU23**: 6-character date (day, month, year; each being 2 digits in length) when the program was created or updated in the format: DDMMYY (**R = required**)

**NOTE**: If a number is less than 10, then the 2-digit identifier starts with a zero.

### 3.6 Probe Element Selection and Configuration

3.6.1 When possible, select probe elements from the "Nexteer Standard Probe Element and Configuration" file (see Nexteer Data Exchange page <https://nexteerdatabase.com/>).

**NOTE**: If a probe element is not in the Nexteer Standard Probe Elements List, probe elements must be approved by the NEiC.

3.6.2 When possible, minimize the number of probes and probe configurations required for the part program.

3.6.3 When possible, utilize existing probe configurations already designed and built within Nexteer, especially within same part families (i.e., R&P housings, pinions, input shafts, etc.).

3.6.4 Zeiss adapter plates with ID chips must be used for all probe configurations.

3.6.5 Stylus that are at an angle should have the angle permanently set by one of the following:

- Machining the angle into adapter plate
- Creating a custom connection bar
- Using the appropriate probe element (e.g., knuckle joint) (*least preferred method*)

3.6.6 Custom connection bars shall be made of Titanium.

3.6.7 Standard extensions used in probe configurations should be as follows:

- Titanium

**NOTE**: A Zeiss CFX-1 carbon fiber extension may be substituted

- Where higher precision is required, a Therm-X carbon fiber shall be used

**NOTE**: A Zeiss CFX-3 or CFX-5 carbon fiber extension may be substituted

3.6.8 Styli with ruby balls shall be used for all probe configurations.

**NOTE**: Exceptions to the standard ruby ball styli are defined as follows:

- Silicon Nitride (SiNi) ball styli shall be used when a vibration is caused with the use of ruby ball styli (i.e., a high-pitched noise), or if buildup of material is a concern on Aluminum components.
- Diamond ball styli should be used when probe wear is an issue (i.e., flat spots are made by excessively running the styli over long distances or multiple short sharp surfaces) and high precision is required (e.g., rack tooth scan, ballnut balltracks, etc.).

**NOTE**: When a diamond ball stylus is considered, it must be discussed with the NEiC.

- Carbide ball styli shall be used if the ball size is the limiting factor (i.e., small or large specialized ball sizes).

**3.6.9** In a probe configuration where multiple styli are used to measure a single feature, the styli shall be paired for size as stated in 3.16

### 3.7 Custom Probe Elements

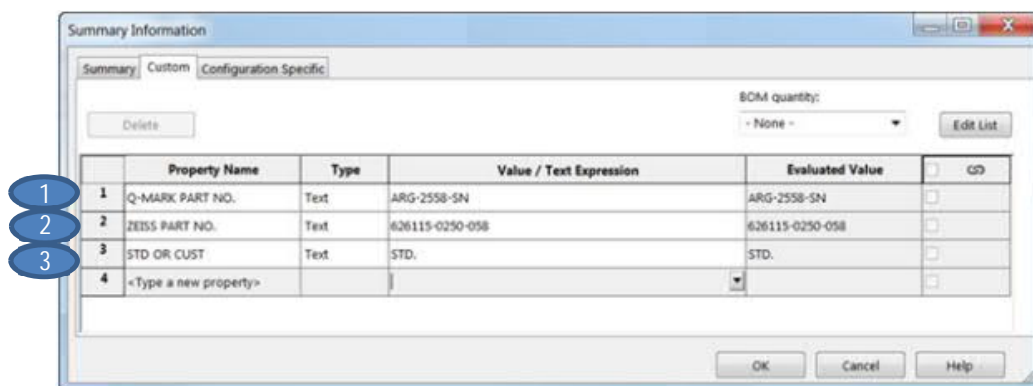
- 3.7.1** If a standard probe element must be altered, or a new connection bar must be made, a probe element model and drawing must be created or modified.
- 3.7.2** Custom probe element models must be created in SolidWorks (reference SD-003 for latest software revision) and conform to Nexteer probe element model standards stated in Section 3.8.

**NOTE:** A standard probe element model template should be used as a starting point for custom probe elements. These standard probe elements can be found on Nexteer Data Exchange web page (<https://nexteerdatabexchange.com/>)

- 3.7.3** Custom probe element drawings must follow the standard Nexteer drawing template and conform to Nexteer Probe Drawing specs stated in Section 3.9 & Section 3.10.

### 3.8 Probe Element Model Standards

- 3.8.1** A standard list of probe element models can be found on the Nexteer Data Exchange web page (<https://nexteerdatabexchange.com/>).
- 3.8.2** The file name of the probe element model shall follow the standard probe element naming convention found in Section 3.11.
- 3.8.3** New probe elements must have a probe element number (e.g., PE34400123) assigned by the NEiC.
- 3.8.4** The SolidWorks probe element model must have the following three fields populated in the Custom tab of the File Properties (refer to the example below):
1. The Q-Mark Part Number as listed on their web page (<https://qmarkdirect.com/>)
  2. The Zeiss Part Number as listed on their web page (<https://shop.metrology.zeiss.com/>)
  3. STD or CUST (Standard or Custom)



### 3.9 General Drawing Standards

Probe element and probe configuration drawings shall use a standard Nexteer drawing template and conform to Nexteer Probe Drawing specs stated in this section and Section 3.10 for Probe Element Drawing Standards, or Section 3.13 for Probe Configuration Drawing Standards.

3.9.1 Nexteer drawing templates can be found on the Nexteer Data Exchange web page (<https://nexteerdatabase.com/>).

3.9.2 "Det Info" and "Det Balloon" layers of the template must be set to invisible.

**NOTE:** These layers are not used, but are part of the standard Nexteer drawing template

3.9.3 Title block fields in probe drawings must be completed as shown in Appendix B.

3.9.4 Unless otherwise specified, all dimensions shall be in millimeters (mm).

3.9.5 Each print change shall drive a revision number.

- Revision numbers shall be three digits (ex. 002, 003, etc.)
- A triangle representing each revision in the revision table must be present on the drawing next to the feature changing as shown in the following example:

REVISIONS						
REV	DET	DESCRIPTION	BY	CK	DATE	
001	--	ORIGINAL	BTM	NW	06MY20	
002	--	DIMS REVISED	BTM	NW	07MY20	

**NOTE:** The exception to the revision triangle is revision 001.

3.9.6 The drawing revision shall match the revision in Teamcenter (Responsibility of the NEIC).

### 3.10 Probe Element Drawing Standards

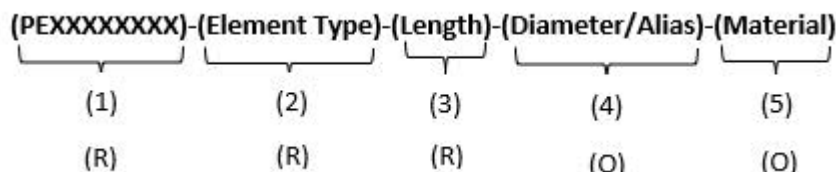
Probe element drawings must follow General Drawing Standards identified in Section 3.9 and conform to Nexteer probe element drawing specs stated in this section.

3.10.1 Drawings shall be created by the CMM programming source for all custom or altered probe elements.

3.10.2 Probe element drawings must be created in SolidWorks utilizing the probe element model as described in Section 3.8 of this document.

### 3.11 Probe Element Naming Convention

Probe documentation and probe elements shall be identified with a name structured in the following format:



**Example:** PE34400123-PROBE EXTENSION-100-11-TITANIUM

**NOTE:** Each part of the name must be separated by a dash "-".

**NOTE:** No special characters can be used in the naming sequence (e.g.: !, @, #, \$, /, \ ...).

(1) - **PE34400123:** Teamcenter auto generated number (provided by the NEiC)(**R = required**)

(2) - **PROBE EXTENSION:** The probe element type (**R = required**)

(3) - **100:** Length of the probe element in millimeters (mm) (**R = required**)

(4) - **11:** Diameter of the probe element millimeters (mm) or Alias Info (**O = as needed**)

(5) - **TITANIUM:** Material the element is made of (**O = as needed**)

**NOTE:** The probe element name structure will vary depending on the type of probe element as shown in the following chart:

Probe Element Type	Probe Element Name Structure
Base (Adapter) Plate	PEXXXXXXXX-ELEMENT TYPE-LENGTH-ALIAS(Machined angle)
Connection Bar	PEXXXXXXXX-ELEMENT TYPE-LENGTH-ALIAS(Shape – "C(Center angle) XX Deg" or "E(End angle) XX Deg") ALIAS Example: Straight E 55 Deg
Cube	PEXXXXXXXX-ELEMENT TYPE-LENGTH
Probe Adapter	PEXXXXXXXX-ELEMENT TYPE-LENGTH-ALIAS(*Type of Adapter)
Probe Extension	PEXXXXXXXX-ELEMENT TYPE-LENGTH-DIAMETER -MATERIAL
Stylus	PEXXXXXXXX-ELEMENT TYPE-LENGTH-DIAMETER

\* Type of Adapter - (Stylus Holder, Rotary Adapter, Knuckle, or XX Angle).

### 3.12 Probe Configurations Model Standards

3.12.1 Probe configurations shall be modeled using SolidWorks and will be provided to the NEiC.

3.12.2 The file name for the probe configuration model shall follow probe configuration naming conventions found in Section 3.14.

3.12.3 Nexteer standard probe element models shall be used to build probe configuration models.

**NOTE:** Nexteer standard probe element models can be found on the Nexteer Data Exchange web page (<https://nexteerdatabexchange.com/>).

3.12.4 New probe configurations shall have a probe configuration number (e.g., PC34400123) assigned by the NEiC.

3.12.5 Adapter plates must be positioned so the locating notch is oriented in the -X position.

3.12.6 Styli stick-out lengths and angles shall be set in the SolidWorks configuration model.

### 3.13 Probe Configuration Drawing Standards

Probe configuration drawings must follow General Drawing Standards identified in Section 3.9 and conform to Nexteer probe configuration drawing specs stated in this section.

- 3.13.1 Drawings shall be created by the CMM programming source for all probe configuration assembly models.
- 3.13.2 Probe configuration drawings shall be created in SolidWorks utilizing the probe configuration Model as described in Section 3.12 of this document.
- 3.13.3 Bill of materials (BOM) table shall be in the upper left corner of every probe configuration drawing, and must include the following:
  - Nexteer part number
  - Q-mark
  - Zeiss
  - Std or Cust
  - Qty
- 3.13.4 The length and width of each row and column of the BOM table can be adjusted as needed to fit the drawing.
- 3.13.5 An isometric view of the configuration model shall be located next to the revision table found in the upper right corner of each probe configuration drawing.
- 3.13.6 The location notch on the adapter plate shall be noted on the probe configuration drawing and must be positioned in the -X position.
- 3.13.7 Unthread styli shall have the stick-out length dimensioned.
  - Dimensions shall be oriented on the outer edge of the probe holding element to the outer tangent of the stylus sphere
  - Dimensions shall be shown with one (1) decimal place tolerance
- 3.13.8 Angles that are not multiples of 90 degrees shall be stated on the drawing.
- 3.13.9 Angles must be made reference if the angle is derived from a custom adapter or connection bar.

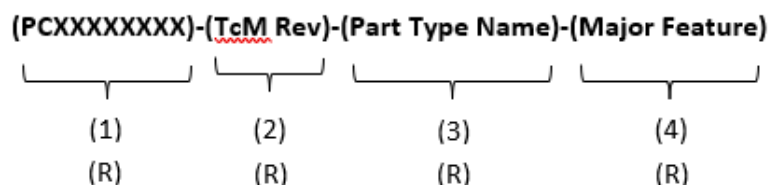
3.13.10 Probe tip numbers and names must be identified on the isometric view of the Probe Configuration drawing.

3.13.11 Reference (Qualification) sphere numbering (SP#) must be identified on the drawing.

3.13.12 For full probe configuration drawing examples, refer to Appendix C

### 3.14 Probe Configuration Naming Convention

For all probe documentation, probe configurations will be identified with a four-part name, the format is as follows:



**Example:** PC34400123-001-RP Hsg-Pinion Tower

**NOTE:** Each part of the name must be separated by a dash "-".

**NOTE:** No special characters can be used in the naming sequence (e.g. !, @, #, \$, /, \ ...).

(1) - **PC000000123:** Teamcenter auto generated number (provided by the NEiC) (**R = required**)

**NOTE:** Teamcenter auto generated number "PCXXXXXXXX" will be the only portion of the name used to identify the probe configuration in the Calypso program.

(2) - **001:** Teamcenter revision level (provided by the NEiC) (**R = required**).

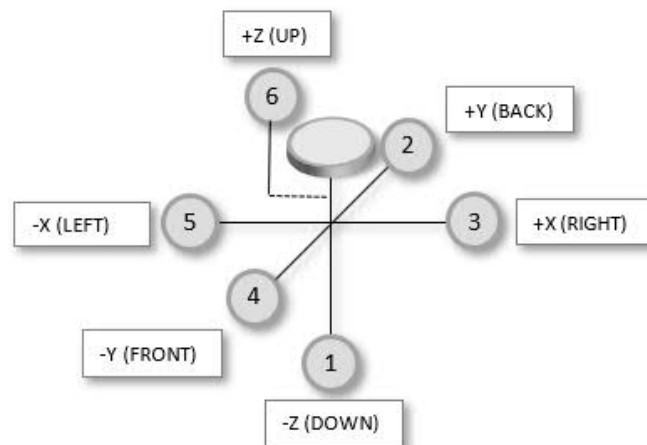
(3) - **RP Hsg:** Part Type Name, use a shortened name for the part type (use list in Appendix A) (**R = required**).

(4) - **Pinion Tower:** Major feature being checked with probe configuration (**R = required**).

### 3.15 Probe Tip Naming Convention

**3.15.1** When setting up new probe configurations, the numbering of probe tips in Calypso will start at the default number (Stylus no. 1), and each additional tip will take the next number, in ascending order, regardless of direction or orientation.

**3.15.2** The standard Zeiss stylus directions will be used to identify a probe tip in space, designation as follows:



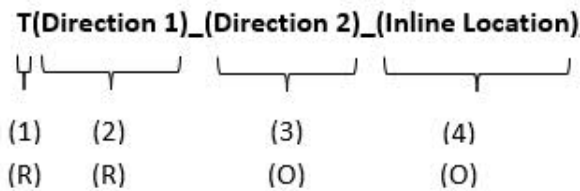
**3.15.3** Probe tips shall be named in a series of numbered directions (corresponding to standard Zeiss stylus directions noted in step 2), which best describes the path to get to the tip from the center of the base plate.

**3.15.4** Letter designations shall be used to represent multiple probes in the same orientation along the same axis of an extension, with probe tips closest to the center identified by the letter "A", and each additional probe moving away from the center, identified with the next ascending letter of the alphabet.

**3.15.5** For probe tips that are on an angle, the assigned direction number shall be the primary direction the probe is pointing.

**NOTE:** Primary direction is considered  $\leq 45^\circ$  in that direction.

3.15.6 Format for probe tip name is as follows:



**Example:** T5\_6\_B

**NOTE:** Each part of the name must be separated by an underscore “\_”.

**NOTE:** No special characters can be used in the naming sequence (e.g.: !, @, #, \$, /, \ ...).

- (1) - **T:** T is required to be the first character of probe tip names (**R = required**).
- (2) - **5:** 1st direction on getting out to the probe tip (**R = required**).
- (3) - **6:** 2nd direction on getting out to the probe tip (**O = as needed**).
- (4) - **B:** Inline locations of multiple probes in the same direction (**O = as needed**).

3.15.7 See more examples in Appendix D.

### 3.16 Probe Configuration Qualification Requirements

3.16.1 All probe configurations must be qualified before being used in a Measurement Plan

3.16.2 The sigma (**S**) value of all probe tips must be at or below a value of .0015mm

**NOTE:** A (**S**) value of up to .002mm may be allowed depending on Probe Configuration setup and usage within the Measurement Plan. Contact the NEiC for approval.

3.16.3 The radius (**R**) value of the probe tip must be within:

- +/- .003 of the nominal ball size, if size is used to achieve an overball or specific ball size called out on a part print.
- .0005mm of each other, if need for pairing of ball size on a probe config.

3.16.4 All probe configurations must have the (Form 07-1-5-F50) filled out for the remaining configuration qualification setup detail.

3.16.5 Reference (Qualification) sphere numbering (**SP#**) to describe the sphere size, tilt and rotation angle.

- Nexteer's Reference sphere numbering shall be as follows:
  - Shall be a 4-digit number
  - The 1<sup>st</sup> digit shall be 1-6 which indicated reference sphere size and tilt angle combination
  - Digits 2-4 shall indicate the Rotational angle from 0 to 359 degrees



1st digit	2nd - 4th digit	1st digit reference info	
		Inclination Angle (90,135,180)	Sphere Size (15,30,25)
1	(000-359)	135	30
2	(000-359)	90	30
3	(000-359)	180	30
4	(000-359)	135	15
5	(000-359)	90	15
6	(000-359)	180	15
7	(000-359)	135	25
8	(000-359)	90	25
9	(000-359)	180	25

### 3.17 Qualification Studies

A gage study consists of one or more of the following methods per NEiC.

**NOTE:** To properly document and justify exceptions to a qualification study, please reference form 07-1-5-F44 (Exceptions to Measurement Plan Gage Studies) and include it in the “RnR Results and Gage Studies” section of your measurement plan workflow in TcM.

3.17.1 PT studies shall be run in accordance with the MSA manual for “Gage R Study” as a percent to tolerance study.

- 1 part, 1 operator, 10 trials

3.17.2 Gage R&R Studies shall be run in accordance with the MSA manual.

- 5 parts, 3 trials, 2 operators shall be used as the Nexteer standard for CMMs
- Familied part gage studies **with a supplemental PT**. Part gage studies can be familied if they fall under the criteria below:
  - Same part type
  - Fixture design is similar
  - Programming methodologies are similar
  - Fixture design and programming have previously passed a Gage R&R
  - **Examples of** Part Families are listed below
    - Pinions
    - Input Shafts
    - Drive Pulley
    - Driven Pulley
    - Other – As determined by the NEiC
- Familied part gage studies without a supplemental PT. Part gage studies can be familied if they fall under the criteria below:
  - Same part type
  - Fixture design is the same
  - Programming is the same (*Template Programs*)
  - Fixture design and programming have previously passed a Gage R&R
  - Examples of Part Families are listed below



- Ball nuts
- Ball Screws
- Racks
- Splines
- Other – As determined by the NEiC

### 3.17.3 Gage Correlation Studies shall be run as defined below.

- 1 part, 1 trial, 1 operator shall be used as the Nexteer standard for Zeiss CMM to Zeiss CMM correlation. Reference Table 1 under Section 3.20 for additional correlation standards.\*
- Correlation calculation shall be calculated as follows:
  - $(\text{Delta in measurement} / \text{Total tolerance of feature}) \times 100 = \text{Correlation \%}$ .
- Correlation acceptance shall follow criteria as defined in Table 2 under Section 3.20.

\* For correlation studies with external suppliers. Please reference GSM's product gage correlation document (F1041)

### 3.17.4 Parts for CMM gage study must meet the criteria listed below.

**NOTE:** If parts do not meet all the criteria listed below, high Gage Study results may be caused by the parts and not the Measurement Plan or the part set up. The NEiC can accept the study results if this situation occurs.

- Parts must be at the same rev level that the CMM Program was made to.

**NOTE:** Exceptions to the part rev level may apply if the part rev change does not affect any features or tolerances.

- Parts must be made to print.
- Part features must represent surface finishes allowed for production.
- Sources for parts can include but not limited to:
  - Production parts
  - First off samples
  - Prototype parts
  - Machined from solid (assuming the above items are met on the parts)
- Parts must be allowed 24 hours to acclimate to CMM environment before completing any studies.

## 3.18 Installation and Debug

- 3.18.1 An external CMM programming source may be required to install the CMM program on a Nexteer CMM and repeat the Gage study using the same parts used during the original Gage study.
- 3.18.2 Fixturing and Probes may be from the original Gage study, or may be a duplicate set if it is determined that they do not affect the outcome of the study
- 3.18.3 Installation may be at any one of Nexteer's Global sites, or a designated facility processing parts for Nexteer, as indicated by the NEiC.

### 3.19 Locked Programs

- 3.19.1 In order to preserve proprietary information, the CMM programming source may be required to lock out a program going to an external Nexteer supplier. **Decision to lock a program is based on the discretion of the NEiC.**
- 3.19.2 The locked program may contain macros or other methods of encryption developed in order to meet Nexteer's requirements.
- 3.19.3 If a locked program is required, Nexteer will require an unlocked version for future changes or updates.

### 3.20 Revision Controls and Versioning of Programs and Probe Configurations

- 3.20.1 Production programs will be loaded into Teamcenter by Nexteer personnel and will be under version control thereafter.
- 3.20.2 If the CMM programming source or Nexteer personnel are required to make updates to a CMM program after it has been loaded into Teamcenter, the current version from Teamcenter shall be downloaded, updated, versioned and loaded back into Teamcenter.  
**NOTE:** The CMM programming source or Nexteer personnel shall not use a locally saved version of the CMM program to perform updates. The CMM program must come from the latest released version in Teamcenter.
- 3.20.3 Non-Production programs will be loaded into the program database developed for the CMM Program Tracker or other storage location determined by the Central CMM Group.
- 3.20.4 **Production probe configurations will be loaded into Teamcenter by Nexteer personnel and will be under version control thereafter.**

### 3.21 Program Acceptance

- 3.21.1 CMM programming source must perform a gage study, at their facility or location, on parts provided by the NEiC.
- 3.21.2 A gage study must be performed in accordance with the appropriate type, shown below in Figure 1 decision tree and detailed in Table 1, on all features, unless otherwise specified by the NEiC.
- 3.21.3 Gage study data shall be evaluated using a SPC statistical program such as QC Calc or Minitab.  
**NOTE:** Other statistical software can be used if approved by the NEiC.
- 3.21.4 Gage studies shall be done to percent of tolerance, unless otherwise specified by the NEiC.
- 3.21.5 The overall gage study result for each characteristic shall be accepted by Nexteer Automotive based on acceptance criteria shown below in Table 2.  
**NOTE:** If the gage study is greater than the allowed percent per each feature, the NEiC must approve. (less than 10% on CL's and less than 30% on standard dimensions)
- 3.21.6 CMM programming source must recheck key features by a different inspection method and provide documentation of this comparison.

**NOTE:** Key features will be identified during program development or a feasibility review.

- 3.21.7 One part from the CMM programming source's gage study will be used for a correlation study between the programming source's CMM and a CMM at the final Nexteer location. Results will be reviewed by the NEiC. Refer to section 3.16.3 for details on correlation studies.
- 3.21.8 For features such as best fit profiles, evaluation with a gage study may not be required. For true positions features, a gage study may only be done on the x, y, z components of the feature, not the calculated true position value

**NOTE:** NEiC will determine which feature may be excluded from the repeatability requirement.

Figure 1

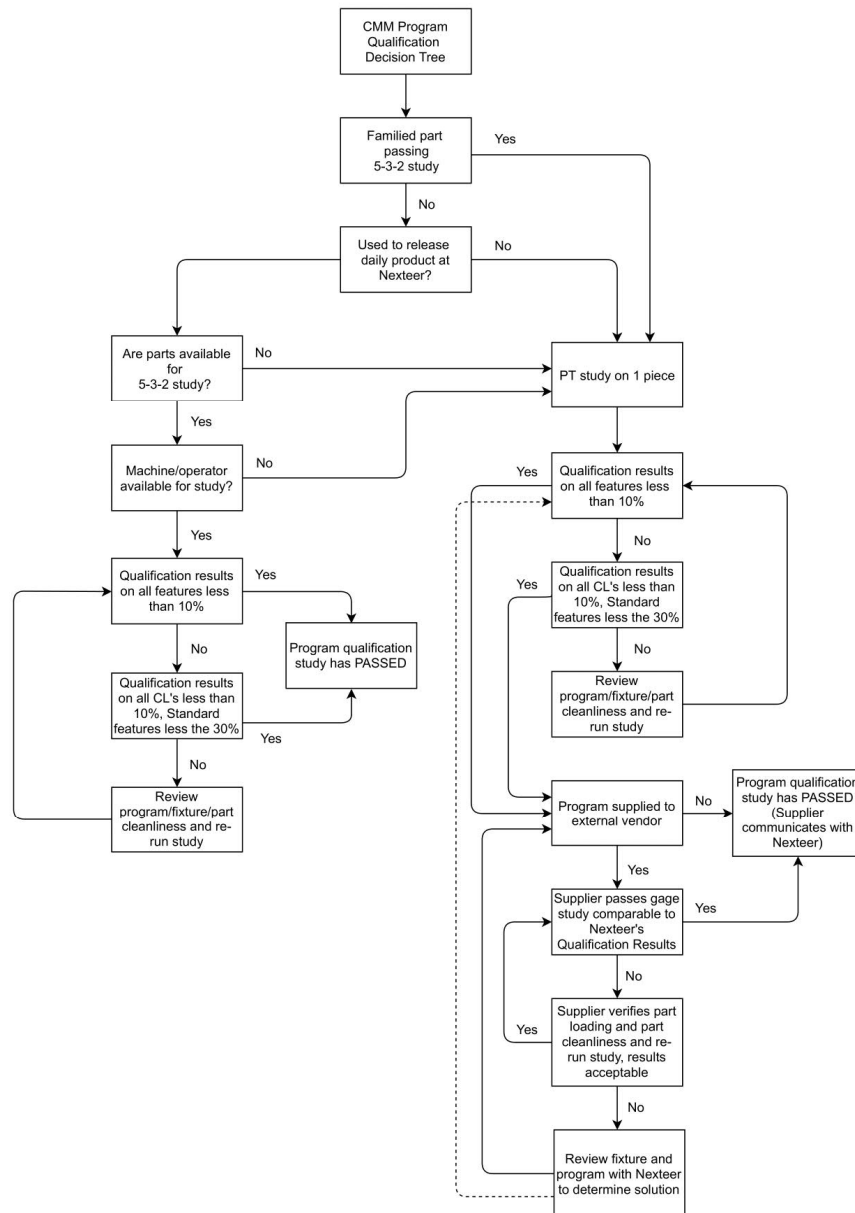


Table 1

Part Type or Inspection Type	MQ1 Gage Study Required	Number of Parts Required	MQ2 Plant Requirement (if MQ1 not ran on site)
Incoming Part (PPAP or Verification)	PT Study without unloading (unless fixture is known to affect part)	1 Part	1 Part from MQ1 Run with Correlation Review
Parts Produce Internal to Nexteer (When CMM is the Primary Gage)	5-3-2 Study (5 parts, 3 trials, 2 Operators) with load / unload	5 Parts	1 Part from MQ1 Run with Correlation Review
Parts Produce Internal to Nexteer (When CMM is not the Primary Gage)	PT Study without unloading (unless fixture is known to affect part)	1 Part	1 Part from MQ1 Run with Correlation Review
<b>Familied Gages</b>			
Pinions, Input Shafts, Drive Pulleys, Driven Pulleys, Other (Same Fixture Design Datums measured on part)	PT Study without unloading	1 Part	1 Part from MQ1 Run with Correlation Review
Ball Nuts, Ball Screws, Racks, Splines, Others	No Study * Verify Report Accuracy	1 Part	1 Part – Review Results

\* Specialty template program: Programming strategies, fixturing and probing remain the same, only modifying the nominals and tolerances within the Measurement Plan.

Table 2		
Study %	Data Range (Ave.) as a % of Part Print Tolerance *	Disposition of Gage
< 10%	< 3.3%	Accept
10 – 30%	3.3 – 10%	Conditional Acceptance **
> 30%	> 10%	Not Acceptable

\* The data range values shown are based on 3 trials with the number of parts times the number of appraisers > 10.

\*\* Decision should be based on the discretion of the NEiC. Those factors being:

- Importance of application measurement
- Standard machine repeatability
- Cost of measurement device
- Part temperature
- Calypso version/service pack/patch

- Fixture to fixture variation
- Probe calibration
- Cost of rework or repair
- Parts out of print specification
- CL Severity (Standard dimensions under 30% are acceptable)

### 3.22 Package Submission

All items and documentation relating to the CMM programming package must be submitted to the NEiC upon completion. Requirements vary depending upon the program intent.

#### 3.22.1 Production Program package shall include:

- CMM Program (after passing a Gage study)
- Probe configuration and documentation:
  - .pcf files
  - SolidWorks models and drawings
  - Calibration program/data
  - Probe configuration qualification setup form (07-1-5-F50)
  - Any additional documentation for Special probe setups (SWI)
- Fixture information (if fixture has been provided by an external CMM programming source):
  - Complete drawing package

#### 3.22.2 Non-Production Program package shall include:

- CMM Program (Gage study requirements should be reviewed by the NEiC)
- Probe configuration and documentation:
  - .pcf files
  - Pictures of the configuration(s)
  - Probe configuration qualification setup (Pictures or form (07-1-5-F50))
- Fixture information:
  - Picture(s) of the fixture setup on the CMM

## 4. Purchased CMM Program Requirements

### 4.1 Quoting Production Programs

#### 4.1.1 Quotes shall include a Job Number from the Nexteer CMM Job Tracker System.

**NOTE:** Jobs submitted for quotes should have a measurement plan outlined and/or a marked print, items shall be provided by the NEiC.

#### 4.1.2 Quotes shall include costs for the following:

- Programming and testing (which may include a fixture program if datum locators cannot be measured).
- Probe configuration design and documentation.
- Minimum of (2) full sets of probe configurations (unless otherwise noted by the NEiC).

- Performing a qualification study at the supplier's location (unless otherwise noted by the NEiC).

4.1.3 If requested by the NEiC, quotes may include costs for any of the following:

- One or more supplier designed and built fixtures (see Section 3.3 for more details).
- CMM Programming source to install and run a study at a Nexteer facility.
- Protecting/locking of the CMM Program as described in Section 3.18.

4.2 Quoting Non-Production Programs - Spot Checks or Quick Checks

4.2.1 Quotes shall include a Job Number from the Nexteer CMM Job Tracker System.

4.2.2 Quotes shall include costs for the following:

- Programming the part
- Part Setup

**NOTE:** Supplier must provide documentation, such as pictures of probes, fixturing, part orientation, etc. to allow recreation of the setup in future runs. Refer to section 3.21.2.

- Per piece or hourly charge (if multiple parts are required to be inspected)
- Part programs must be available upon request of the NEiC

## A. Appendix A - Part Type Naming List

Assist Mech	CIS	CIS (continued)
Assist Housing	Actuator Housing	Pinch Bolt
Assist Shaft Asm	Cardan Joint and Shaft Asm	Pivot Rivet
Ball Bearing Asm	Clamp Bolt	Rake Bracket
Bearing and Worm Shaft Asm	Coated Lower Shaft Asm	Rake Cam
Clamp Ring	Column Bearing Asm	Rake Spring
Eccentric Bearing Sleeve	Column Strg Shaft Asm	Retaining Clip
EPS Assist Asm	Column Asm	Shaft and Jacket Asm
EPS Assist Mech Asm	DCCV Housing	Shaft Tubular Plug
Gear and Lower Shaft Asm	EA Strap	Slip Clutch Assist Ring
Hex Retainer	EA Strap Eccentric Cam	Solid and Tubular Shaft Asm
Lower Assist Shaft	Female Tubular Shaft	Solid Lwr Strg Shaft Asm
Lower Assist Shaft Bushing	Female Tubular Shaft Asm	Solid Stg Shaft Asm
Lower Mounting Sleeve	Female Tubular Shaft Blank	Steering Column Shaft Asm
Mounting Bushing	Inner Cam	Strg Shaft Clamp Yoke Asm
Needle Bearing Asm	Inner Ring	Strg Shaft Stake Yoke
O Ring Seal	Inter Strg Shaft Asm	Support Housing
Plate Retaining Ring	Inter Strg Coated Shaft Asm	Tilt Housing
Retaining Ring	Inter Strg Shaft	Thrust Bearing Asm
Rotor Coupling	Inter Strg Shaft Asm	Tolerance Ring
Rotor Coupling Adapter	Inter Yoke Cardan JT Asm	Tube and Inter Strg Shaft Asm
Rotor Coupling Asm	Inter Strg and Col Shaft Asm	Tubular Shaft
Torsion Bar	Lead Screw	Tubular Steering Shaft
Torsional Retainer	Leadscrew Housing	Tubular Strg Shaft Asm
Upper Assist Shaft	Lock Sleeve	Tubular Yoke Cardan JT Asm
Upper Assist Shaft Asm	Lower Bearing Asm	Universal Joint Spider
Worm Gear Blank Asm	Lower Jacket	Upper and Lower Shaft Asm
Worm Gear Hub	Lower Overmold Shaft	Upper Jacket
Worm Gear Molded Asm	Lower Shaft	Upper Jacket Asm
Worm Gear Ring	Lower Strg Shaft	Upper Overmold Shaft
Worm Gear Trimmed Asm	Lower Strg Shaft Blank	Upper Shaft Stake Asm
Worm Isolator Asm	Male Spline Shaft Blank	Upper Strg Shaft
Worm Shaft	Male Tubular Shaft	Upper Strg Shaft Blank
Worm Shaft Blank	Male Tubular Shaft Asm	Weld Yokes Shaft Asm
Other	Male Tubular Shaft Blank	Yoke and Inter Strg Shaft Asm
	Mounting Bracket	Yokes
	Needle Bearing Asm	Other
	Outer Cam	
	Pin	

Driveline	Driveline (continued)	Driveline (continued)
-----------	-----------------------	-----------------------




Axle Bar Ball Retaining Sleeve Ball Retaining Ring Ball and Roller Retainer Ball Sleeve Asm Ball Spline Asm Bar Swage Clamp Bearing and Bracket Housing Asm Bearing Asm Boot Retaining Clamp Cross Groove Joint Asm Crossglide Joint Cage Crossglide Joint Inner Race Crossglide Joint Outer Race Crossglide IB Joint Asm Crossglide Joint Boot Adapter CG Joint Inner Race CG Joint Cage CG Boot Adapter CG Joint Outer Race Blank CG Joint Ball Retainer CG Joint Boot Adapter CG Joint Outer Race CG Joint Gasket CG Joint Boot Asm CV Joint Cage CV Joint Cage Race CV Joint Asm CV Joint Inner Race CV Joint Inner Race Blank CV Joint Outer Race CV Outer Race Blank Deflector Ring Disk Cross Groove Joint Asm Disk CG Joint Outer Race Disk CG Joint Boot Adapter Disk CG Joint Ball Retainer DO Joint Cage Blank DO Joint Cage DO Joint Inner Race	DO Joint Asm DO Joint Inner Race Blank DO Joint Retaining Ring Female DO Joint Outer Race Female Tripot Blank Female Tripot Housing Female Triglode Housing Grease Retainer Halfshaft Bar Blank Halfshaft Inboard Boot Halfshaft Boot Halfshaft Outboard Boot Hanger Bracket Halfshaft CV Joint Asm Halfshaft Bar Intermediate Shaft Inter Drive Shaft Bearing Asm Intermediate Shaft Slinger Inboard Shaft Inner TG Ball Inner Triglode Ball Joint Bar Shaft Asm Joint Retaining Ring Male DO Joint Outer Race Male Tripot Blank Male Triglode Blank Male Triglode Housing Blank Male Triglode Housing Male TG Housing Blank Male Tripot Housing Male TP Housing Blank Needle Roller O Ring Seal Outboard Shaft Outer Triglode Ball Protector Cap Race Retaining Ring Retainer and Housing Asm Retaining Ring Ring and Housing Asm	Shaft and Hsg Asm Spider Spacer Ring Swage Clamp TG Joint Spider TG Joint Spider Asm Triglode Bushing Tripot Bushing Tripot Joint Ball Tripot Joint Spider Tripot Joint Spider Asm Tripot Housing Tripot Housing Asm Tubular Tripot Housing Tubular Bar Shaft Asm Other
<b>EPS Electrical</b>	<b>HPS</b>	<b>HPS (continued)</b>
Backing Plate	Adjuster Plug	Pump Ring

CEPS BRUSH MOTOR	Adjuster Spring	Pump Ring Blank
CEPS CIRCUIT CARD ASSEMBLY	Ball Bearing Asm	Pump Ring Dowel Pin
Circuit Card and Probe Hsg Asm	Blade and Cap Asm	Pump Rotor
Controller Cover	Boot Retaining Clamp	Pump Rotor Blank
EPS Controller Asm	Bushing and Housing Asm	R and P Strg Asm
EPS Logic Circuit Card Asm	Cap Retaining Spring	Rack Housing
EPS Power Circuit Card Asm	Carbon Steel Ball	Rack and Pinion Boot
EPS Powerpack Asm	Combination Pressure Valve	Rack Bearing Asm
Gear Wheel Retainer	Crimp Ring	Rack Bushing Asm
Hardware Controller Asm	Drive Shaft	Relief Spring Guide
Harness and Probe Hsg Asm	End Cover	Reservoir Baffle
Header Asm	Filler Tube Cap Asm	Reservoir Body
Lower Rotor Asm	Flow Control Spring	Reservoir Cap Cup
Male Terminal	Hyd Pump Housing Casting	Reservoir Cap Gasket
NCTS Circuit Card Asm	Hyd Pump Reservoir Asm	Reservoir Capstick
Probe Housing	Hydraulic Pump Asm	Reservoir Plate
Probe w Gear Wheels Housing Asm	Hydraulic Pump Core Asm	Reservoir Retaining Clip
Seal Plate	Indicator Blade	Retainer and Magnet
Sealing Patch	Inner and Outer Pole	Retaining Ring
Upper Rotor Asm	Inner Tie Rod Asm	Ring Insert
Other	Input Shaft Seal	Rod and Control Valve Asm
	Mounting Bushing	Sealing Plug
	MTO Gear Housing	Shipping Cap
	Needle Bearing Asm	Shipping Plug
	O Ring Damper	Shock Dampener Ring
	O Ring Seal	Spring Pin
	O Ring Union Fitting Asm	Steering Pinion
	Outer Tie Rod Asm	Steering Rack
	Pinion Asm	Steering Rack Blank
	Pinion Asm Retainer	Steering Rack Blank
	Pitman Shaft	Terminal and Coil Asm
	Pressure Plate	Thrust Plate
	Pressure Relief	Tie Rod End Clamp
	Pressure Valve Shield	Valve Body
	Pressure Valve Shield Blank	Valve Hsg and Valve Asm
	Pump Bushing	Worms
	Pump Housing	Other

PEPS	REPS	REPS (continued)
Adjuster Spring	Adjuster Plug	O Ring Isolator
Boot Retaining Clamp	Adjuster Spring	O Ring Seal

Clamp Ring	Assist Cover	Outer Tie Rod Asm
Eccentric Rack Bearing	Assist Drive Belt	Pinion and Input Shaft Asm
ERB Pin	Assist Housing	Pinion Bearing Retainer
Inner Tie Rod Asm	Ball Nut	R and P and Motor Housing Asm
Input Shaft	Ball Pinion Bearing Asm	R and P Housing Asm
Input Shaft Seal	Ball Bearing Asm	Rack and Pinion Boot
Needle Bearing Asm	Ball Nut and Bearing Asm	Rack and Pinion Housing
Outer Tie Rod Asm	Ball Nut Blank	Rack Bearing Asm
Rack and Pinion Boot	Ball Nut Housing	Rack Housing
Rack Bearing Asm	Ball Return Lower Guide	Rack Support Bushing
Rotor Coupling	Ball Return Upper Guide	Retaining Nut
Rotor Coupling Asm	Ball Return Guide Retainer	Retaining Ring
Rotor Coupling Adapter	Ball Screw and Rack	Sealing Plug
Steering Pinion	Ball Screw and Rack Blank	Sensor Cover
Tie Rod End Clamp	Ball Screw and Ball Nut Asm	Steering Pinion
Torsion Bar	Bearing and LHD Housing Asm	Steering Rack
Other	Boot Retaining Clamp	Steering Rack Asm
	Controller Cover	Threaded Dust Cover
	Chrome Alloy Ball	Tie Rod End Clamp
	Diamond Seal	Torsion Bar
	Dive Pulley	Travel Stop
	Driven Pulley	Wave Isolator
	Eccentric Rack Bearing	Other
	EPS Assist Mech Asm	
	EPS Rack Assist Asm	
	Expanding Rack Bearing	
	Gear Asm	
	Header	
	Heat Shield	
	Idler Cam Asm	
	Inner Tie Rod Asm	
	Input Shaft	
	Input Shaft Seal	
	Metric Hex Nut	
	Motor	
	Motor Sensor Cover	
	Mounting Bushing	
	Needle Bearing Asm	

## B. Appendix B - Title Block Information

		STAMP OR ETCH ON ALL DETAILS THE DRAWING AND DETAIL NUMBER, AND THE LATEST APPLICABLE REVISION SYMBOL. IF ROOM PERMITS, STAMP OR ETCH THE VENDORS INITIALS AND DATE OF MANUFACTURE.  <b>DO NOT SCALE DRAWING</b> 1 PLACE DECIMALS $\pm 0.25$ MM 2 PLACE DECIMALS $\pm 0.13$ MM 3 PLACE DECIMALS $\pm 0.13$ MM ANGLES $\pm 0.30^\circ$ REMOVE ALL SHARP EDGES	
		 <small>THIS DOCUMENT IS PROTECTED BY COPYRIGHT AND NOTHING IN THE DOCUMENT SHALL GRANT A LICENSE OR ANY OTHER RIGHTS TO THE DOCUMENT OR THE INFORMATION CONVEYED THEREIN; THE REPRODUCTION, DISTRIBUTION, AND UTILIZATION OF THIS DOCUMENT OR ITS RELATED CAD DATA, AS WELL AS COMMUNICATION OF ANY CONTENT TO OTHERS, WITHOUT THE EXPRESS WRITTEN AUTHORIZATION IS PROHIBITED.</small>	
		2	
			3
		4	
PART NO.	PART NO.	DESIGN APPROVED 5	DRAWN BY 6
		CHECKED BY 7	SCALE 8
		DATE 9	DATE 10
PREFIX - DRAWING NUMBER - SHEET TYPE - SHEET NUMBER			
1			

11  
Supplier Name and Job #

## 1. PREFIX – DRAWING NUMBER – SHEET TYPE – SHEET NUMBER

- **PREFIX:** PE (Probe Element) or PC (Probe Configuration) type drawing
- **DRAWING NUMBER:** Provided by the NEiC
- **SHEET TYPE:** Not Utilized
- **SHEET NUMBER:** Not Utilized

Probe Element Example: PE-34001234

Probe Configuration Example: PC-34405896

## 2. TYPE

- For PE drawing this shall be Element Type (see Section 3.6)  
**Example:** Connection Bar
- For PC drawings this shall be Part Type (see Appendix A)  
**Example:** R&P Housing

## 3. FEATURE

- For PE drawings this can be length, angle and/or diameter  
**Example:** 320.0mm x 23.5 deg
- For PC drawings this shall be the major feature being measured  
**Example:** Mounting Bore Face

## 4. ALIAS

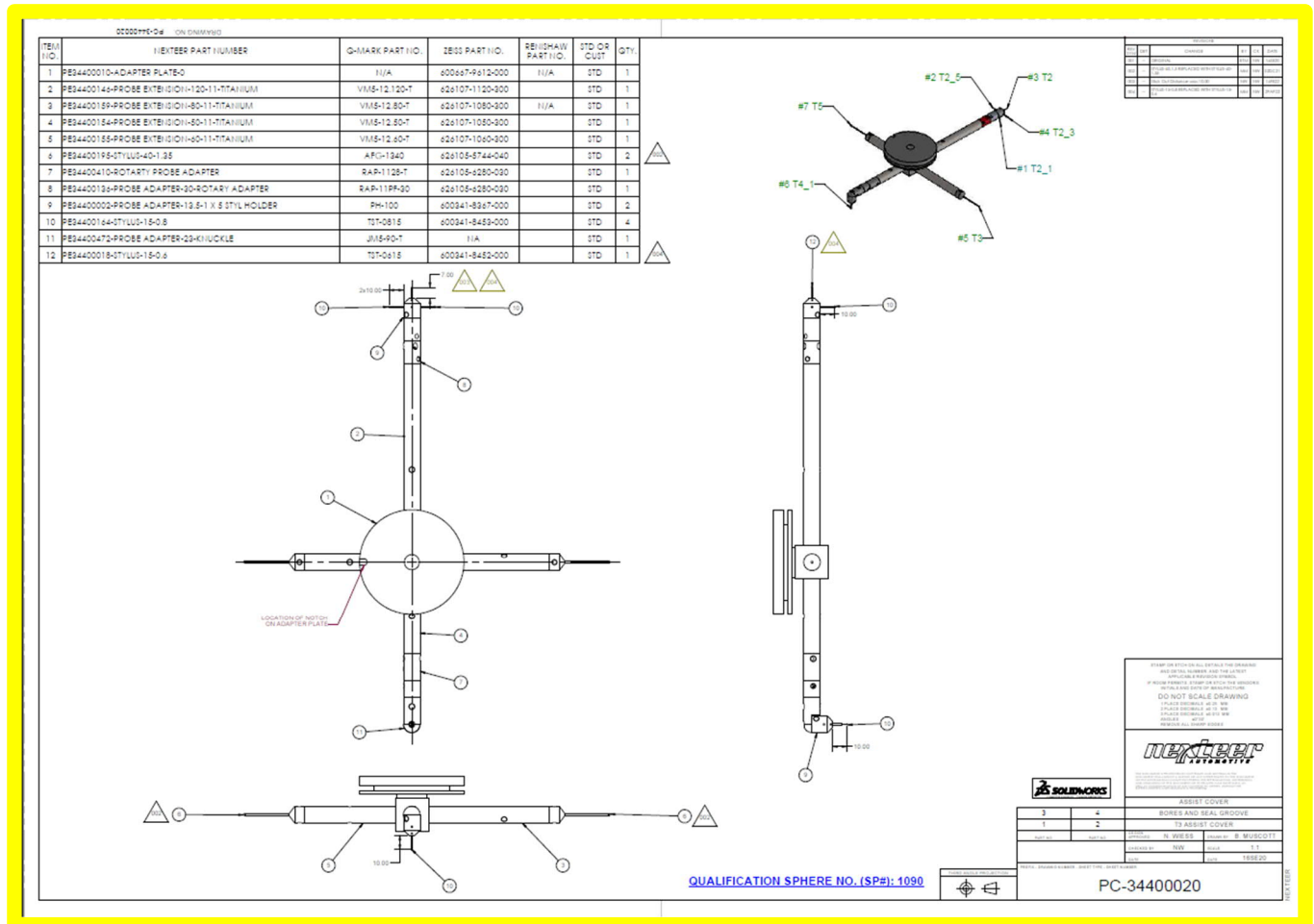
- For PE drawings this shall be the alias id of the probe element
- For PC drawings this shall be the alias id of the probe configuration

## 5. DESIGN APPROVED

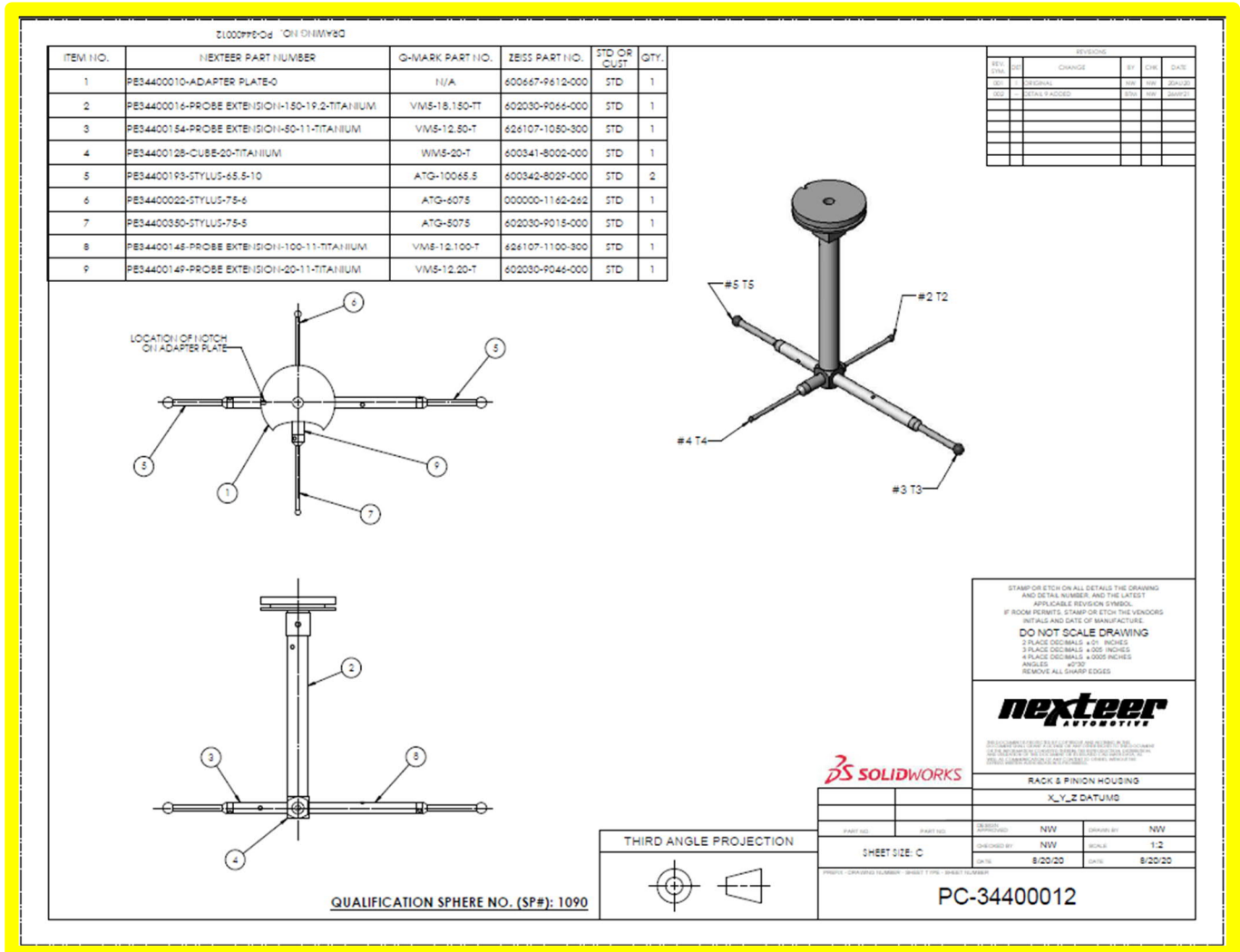
- 
- The initials of the Nexteer Manufacturing Engineer shall be entered  
**Example:** MEG
6. DRAWN BY
    - The initials of the designer  
**Example:** BTM
  7. CHECKED BY
    - The initials of the checker  
**Example:** BJK
  8. SCALE
    - The scale of the drawing  
**Example:** 1:1
  9. DATE
    - The date the drawing was checked  
**Example:** 08MY20
  10. DATE
    - The date the drawing was completed  
**Example:** 08MY20
  11. SUPPLIER NAME AND JOB #
    - Sheets drawn by persons other than Nexteer personnel shall have the supplier's name and job number shown outside the right vertical border  
**Example:** Nick Weiss Metrology Services – Job 12345

## C. Appendix C - Probe Configuration Drawing Examples

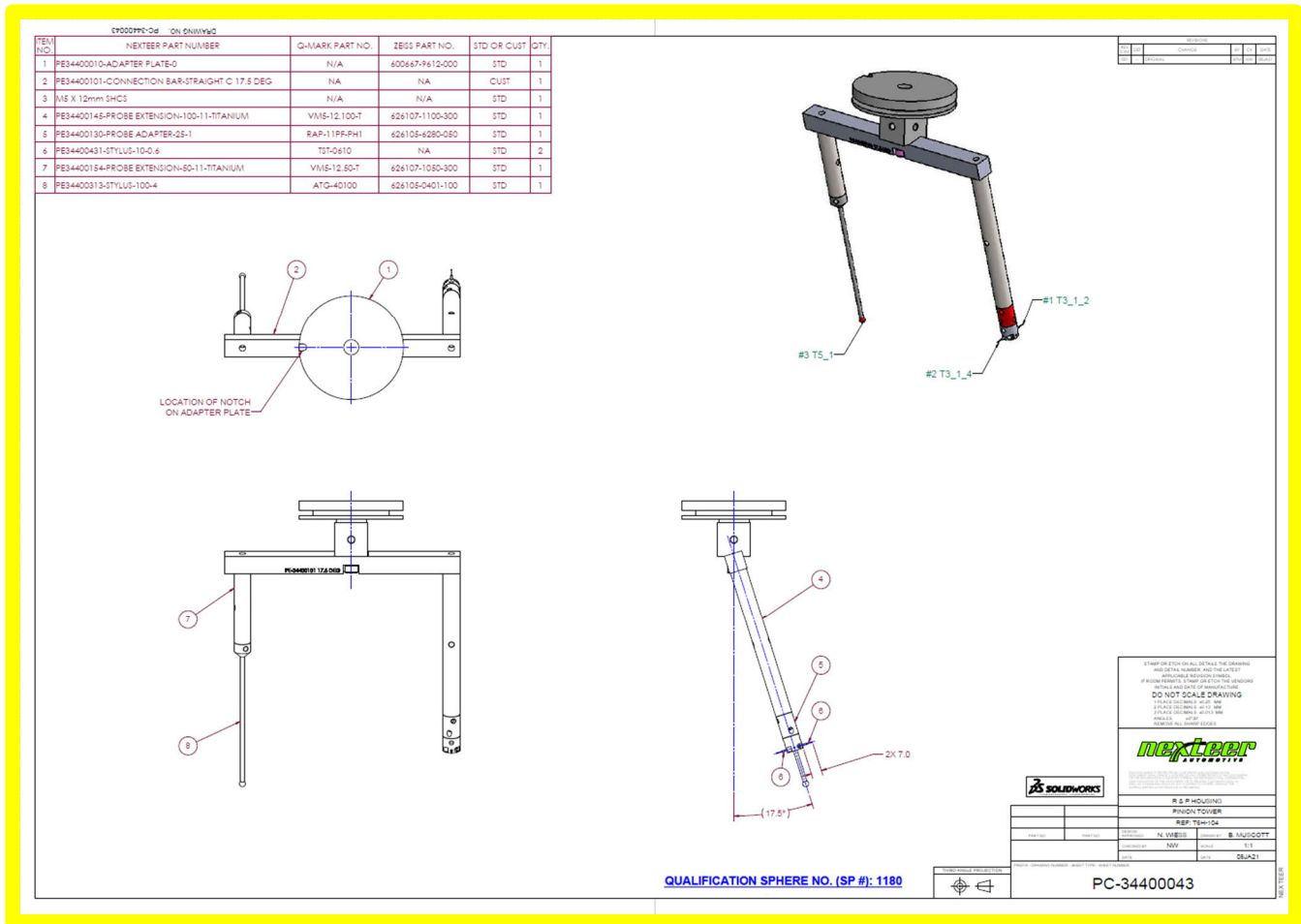
### Example 1 of 3:



Example 2 of 3:

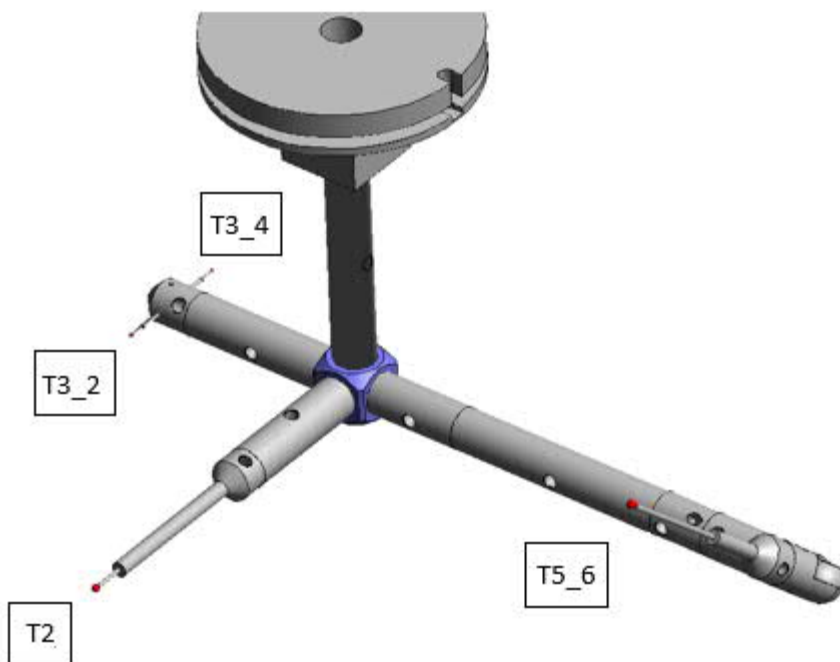
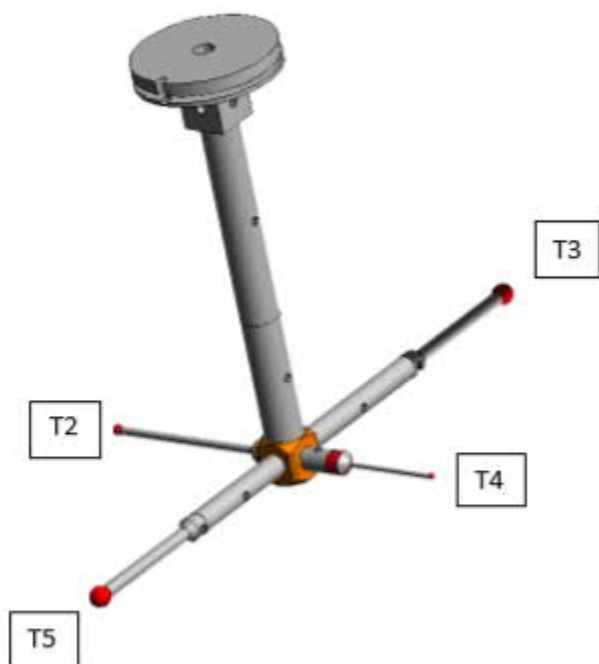


Example 3 of 3:





D. Appendix D - Probe Tip Naming Examples



## RECORD OF REVISIONS

[illegible]