DAIMLER

Prototype/Sheet Metal
Checking Fixture/Gage
Construction Standards

Daimler Trucks North America LLC
Corporate Quality Assurance
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March 2011

Forward

Quality Policy

Daimler Trucks North America LLC (DTNA) is committed to continually improve the performance of its brands in all aspects of our customers' expectations and experiences with our products, services and people, while maintaining our commitment to the environment and safety.

Purpose

To inform checking fixture/gage suppliers of the quality requirements of DTNA and all of its subsidiaries, divisions, and Business Units.

Scope

Includes all suppliers of prototype and production checking fixtures/gages to all DTNA subsidiaries and divisions.

Points of Contact

If you have questions concerning this manual or the DTNA quality procedures, contact the appropriate Business Unit Quality Department or the Corporate Quality Assurance Department.

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1.0 Purpose

These standards are intended as a guide for the construction of checking fixtures/gages for Daimler Trucks North America LLC (DTNA).

Checking fixtures/gages must:

- Have readily accessible features which allow dimensional data to be obtained and to provide conformance to design and manufacturing requirements.
- Provide consistent and accurate locating points to achieve maximum repeatability and reproducibility.
- Be accurately and economically constructed while exhibiting sufficient durability and stability for intended use.

2.0 Checking Fixture General Requirements

2.1 Manufacturer's Responsibilities

The fixture manufacturer is responsible for verifying and certifying that the checking fixture is constructed within tolerances unless otherwise specified.

DTNA is responsible for verifying that the checking fixture has been constructed to the same engineering release and change level as the part being inspected.

Checking fixtures/gages must be handled and stored appropriately to protect gage for function and cleanliness.

Shipping crates are required and included in the build cost of the fixture.

2.2 Identification/Certification Tags

Each fixture or gage shall have a metal Identification (ID)/Certification (Cert.) tag and a DTNA asset number tag installed by the construction source. It shall be mechanically fastened to the base of the fixture/gage. (See Fig. 2.2.A)

The ID/Cert tag must contain:

- Property of Daimler Trucks North America LLC
- Manufacturer Identification
- Part/Assembly Number
- Engineering Release Level
- Part/Assembly Description
- Certified By
- Certified Date

The Identification/Certification tag may contain:

- DTNA asset number

Upon request, DTNA will supply the metal asset number tag.

Example

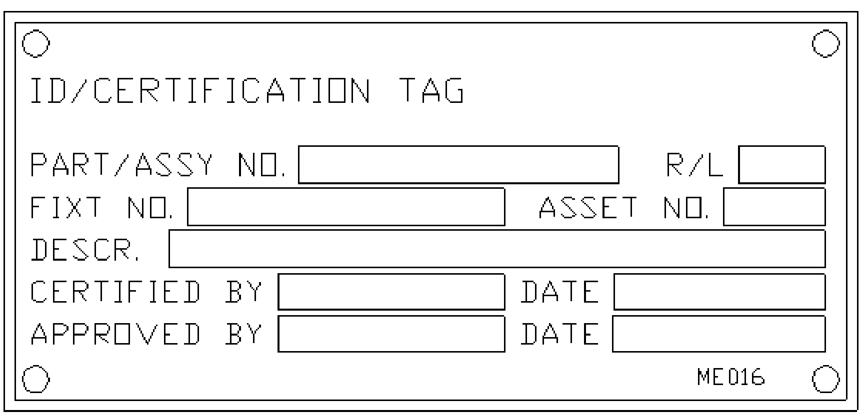


FIG. 2.2.A ID/CERTIFICATION TAG

3.0 Checking Fixture General Planning

Checking fixture planning, design, construction, certification, maintenance, and use should include consideration of the following elements:

- Determine required detail part, sub-assembly, and/or assembly to be checked.

- Review part prints, body layouts, and mock-up builds for control features:
    - Attaching surfaces
    - Sealing surfaces
    - Match areas
    - Trim lines
    - Gage holes/tooling holes
    - Openings
    - Hardware trim attaching surfaces

- Review previously successful fixture/gage design references.

- Determine checkpoint locations consistent with:
    - Concurrent engineering requirements
    - Locator documentation
    - Part datum selection
    - Initial Sampling Inspection Report (ISIR) measurement

- Consider allocation to:
    - Part/assembly suppliers
    - Die construction/tryout source
    - Prototype source

- Determine part position relative to fixture base. Part is preferably checked in truck position. Deviations from such should be considered only to maximize fixture/gage use or to reduce costs and should be in 90 degree increments from truck position. Manufacturing/QA Engineer must approve these fixture/gage deviations.

- Participate in selecting datum points and Primary Locating Points (PLP) in accordance with Geometric Dimensioning and Tolerancing (GD&T), and identifying Statistical Process Control (SPC) collection locations, if applicable.

- Determine checking method (feeler gage, go-nogo gages, or Coordinate Measuring Machine (CMM).

- Create concept or sketch to control design intent where applicable.

- Address overall program timing requirements including procurement of long-lead items.
- Address fixture/gage certification procedures and requirements.
- Address Federal Motor Vehicle Safety Standards (FMVSS).
- Consider need to collect SPC data on assembly and CMM fixture in free-state based on engineering requirements (minimum use of clamps only to assure that assembly contact datums and assembly is stable).
- Select build materials to meet:
    - Durability requirements based on fixture use and conditions
    - Construction methods
    - Shape and area of checking requirement
    - Environmental conditions
    - Weight limitations as for apply-type gages
    - Prototype use and upgrade to production usage

4.0 Checking Fixture Fabrication Requirements

4.1 Material

Check fixture construction material should be reviewed and approved by DTNA Quality Assurance based on expected frequency of use and durability requirements.

Typical materials include:

- Grey fixture plank
- Red fixture plank
- Aluminum
- CRS steel
- Carbon fiber laminate

Bases are to be constructed of:

- Grey fixture plank
- Aluminum
- Steel
- Aluminum or fiberglass tubing

4.2 Orientation/Dimensions

Checking fixtures/gages should be fabricated such that the parts are set in truck position or some increment of 90 degrees from truck position. This is to ensure that parts may be easily set and squared for layout purposes. (See Fig. 4.2.A)

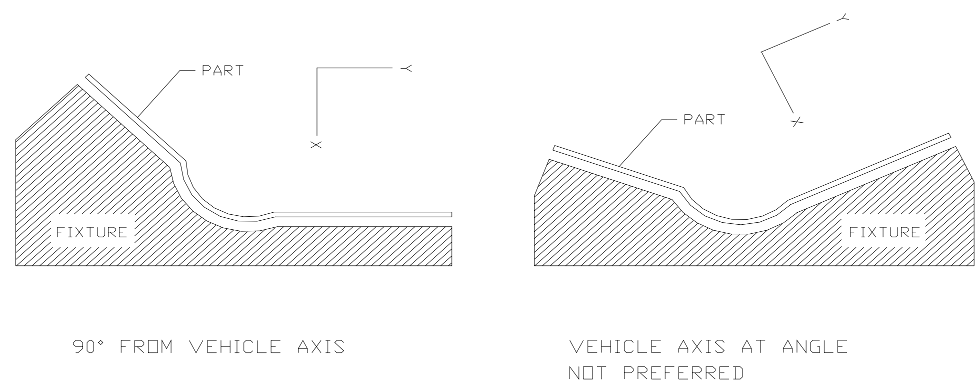


FIG. 4.2.A ANGULAR ORIENTATION

Checking fixtures/gages shall be designed to a male or female form as demonstrated in Fig.
4.2.B.

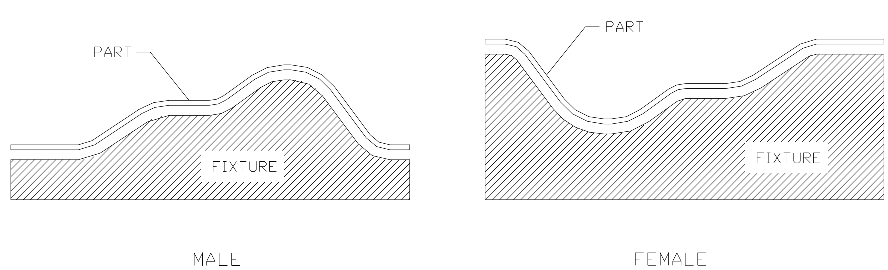


FIG. 4.2.B MALE AND FEMALE POSITIONS

The size of the base should be a minimum of 100 mm outside of the part perimeter and shall encompass all clamps (open or closed). Fixtures/gages are to be a minimum of 13.0 mm thick and all in line and sight check surfaces should be a minimum of 25 mm outside of the part perimeter. (See Fig. 4.2.C)

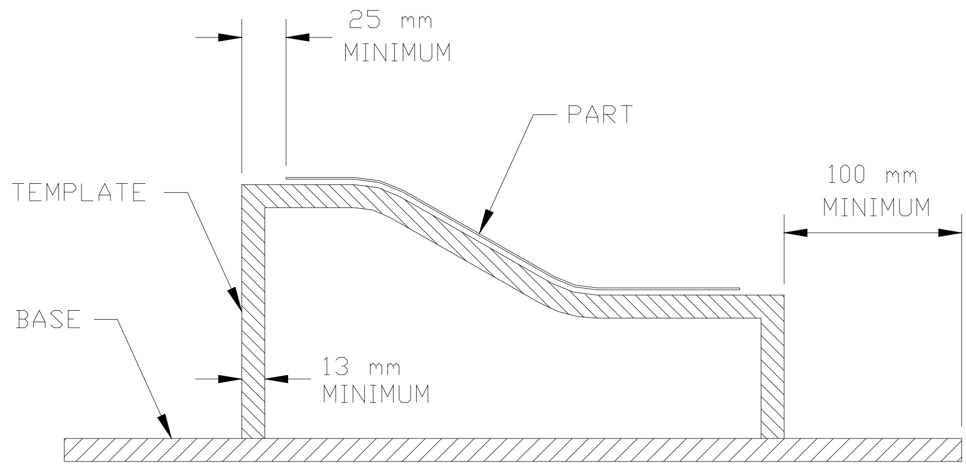
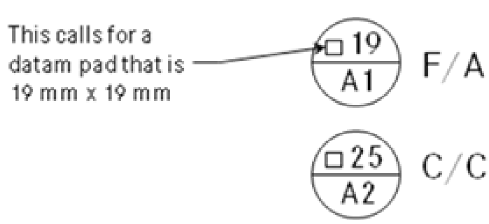


FIG. 4.2.C CONSTRUCTION DIMENSIONS

4.3 Net Pads

A minimum of three net pads are required to set a part. All net pads shall be mechanically fastened to the fixture/gage in a manner which makes them easily removable. The surface net pads are to be installed at DTNA-specified datum points with clamps. They are to be inserted in the fixture with 3.0 mm C.R.S. and checked to math data and are the only points on which the parts are to be held and clamped without prior DTNA engineering approval. The surface datums are to be 25.0 mm x 25.0 mm unless otherwise indicated on the drawing.

Example:



4.4 Datum Locating/Gage Pins

All fixtures/gages should be provided with two locating pins, one primary (4-way locator) and one secondary (2-way locator), for locating the part on the fixture. The primary locating pin typically sets to a round locating hole and the secondary locating pin typically sets to a locating slot in the part. Datum locating pins can be round or tapered depending on part/assembly size, weight, SPC requirements, and activity preference. Datum holes designated as RFS (regardless of feature size) must be located with tapered pins. The preferred locating method will utilize plug gages and gage bushings. Fixed pins may be used for datums utilizing holes only with the approval of DTNA's Engineering. Both round and tapered pins shall be provided as required to suit Repeatability & Reproducibility and GD&T requirements.

Special attention should be paid to the orientation of locate holes. The fixture locate pin angle shall always correspond with the tooling locate pin angle which is typically in vehicle line position.

The pilot locating shank should be designed to be a minimum of 1 1/2 times the diameter of the shank.

All pins shall be attached to the fixture using cables and accessories.

4.4.1 Steel Specification

The following steels shall be used for fabrication of locating and gage pins:

- SAE 01 - Drill Rod - RC-60-62
- SAE 06 - Oil Harden - RC-45-50*
- SAE 4140 - Oil Harden - RC-48-50*
- SAE 6150 - Oil Harden -RC-40-44*

  *preferred

HRS Carburize - Harden .02" deep - Rockwell N-88-90

4.4.2 Locating Pins - Round

The pins should be made using commercial AGA handles, bushings, and plug blank if applicable (Carr-Lane or equivalent).

Ensure that a minimum of 10 mm of clearance exists between the handle and the part surface.

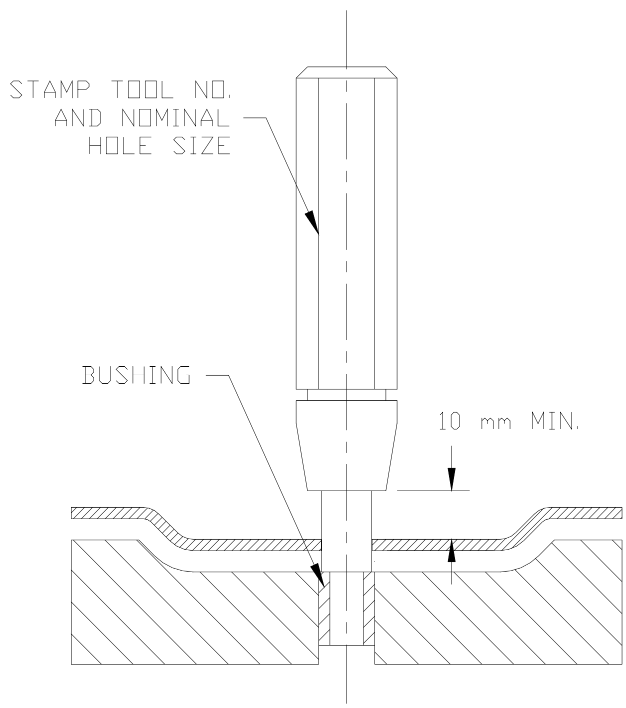


FIG. 4.4.A TYPICAL LOOSE ROUND LOCATING PIN

To determine the locating pin diameter, subtract 0.1 mm from the nominal hole size. Round locating pins shall have a construction tolerance of $^{+0.03}_{-0.00}$ mm

Example:

nominal hole size = 10.00 mm

10.00 - 0.1 = 9.90 mm

pin diameter = 9.90 $^{+0.03}_{-0.00}$ mm

4.4.3 Loose Locating Pins - Tapered

The pins should be made using AGA Standard handles and bushings (Carr-Lane or equivalent). All loose plug locators shall use pilot entry. If the under surface of the hole is not a datum, the maximum clearance around the hole should be 1.5 mm.

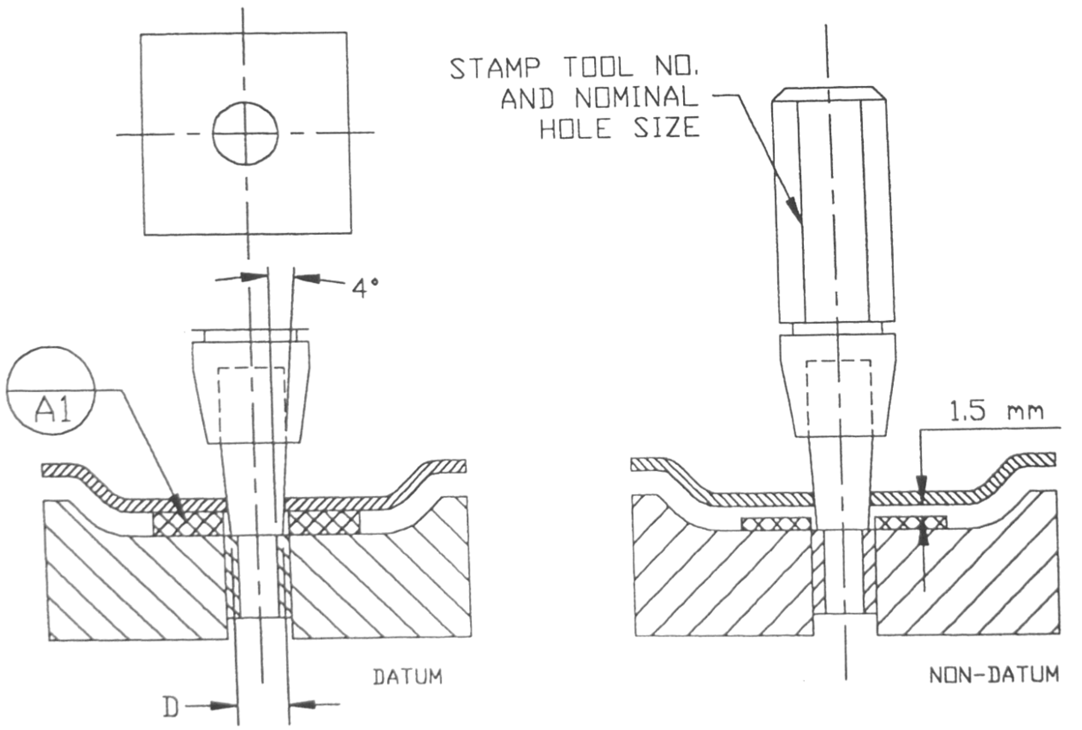


FIG. 4.4.B TYPICAL LOOSE TAPERED LOCATING PIN

To determine the tapered pin diameter, subtract 0.5 mm from the smallest hole diameter.

Tapered locating pins shall have a construction tolerance of ${}^{+0.00}_{-0.13}$ mm

Example: hole size on print = $16.00\,{}^{+0.03}_{-0.15}$ mm

= 16.00 – 0.15 mm

= 15.85 mm

15.85 – 0.5 = 15.35 mm

tapered pin diameter = $15.35\,{}^{+0.00}_{-0.13}$ mm

Notes: This diameter corresponds to dimension D on Fig. 4.4.B.
The total taper for the pin should be 8 degrees unless otherwise specified.

4.4.4 Tapered Locating Pins - Fixed Spring Loaded

Pins should be designed so that they restrict the part movement in the directions specified on the drawing. (See Fig. 4.4.C)

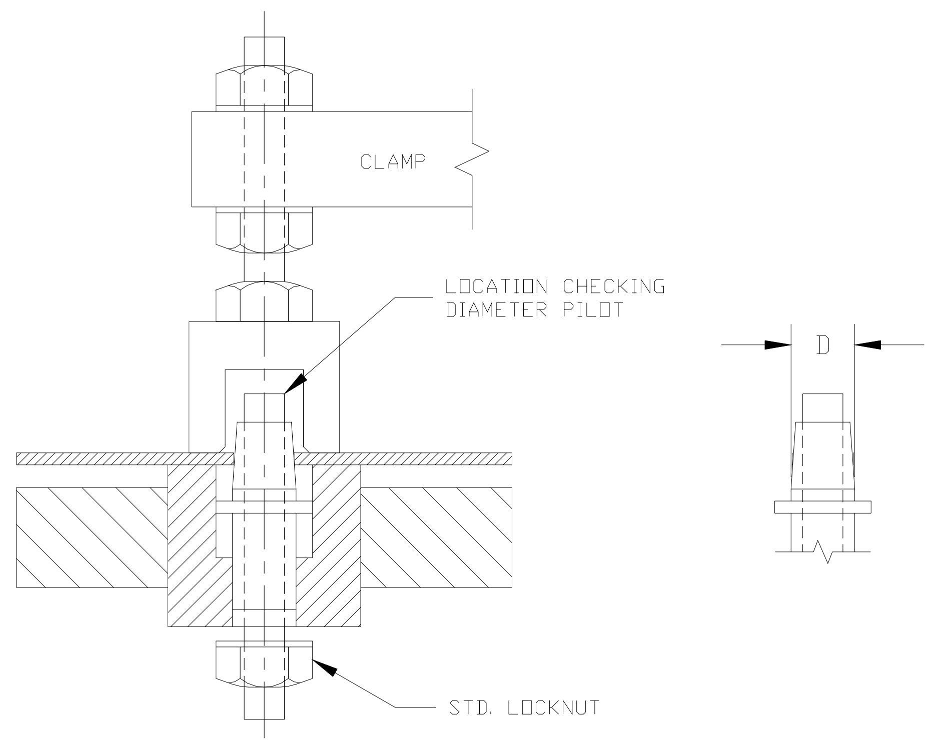


FIG. 4.4.C TYPICAL FIXED SPRING LOADED LOCATING PIN

To determine the tapered pin diameter, add 0.5 mm to the largest hole diameter. Tapered fixed spring loaded locating pins shall have a construction tolerance of $^{+0.13}_{-0.00}$ mm.

Example: hole size on print = $12.00\,^{+0.03}_{-0.15}$ mm

= 12.00 + 0.03 mm

= 12.03 mm

12.03 + 0.5 = 12.53 mm

tapered pin diameter = $12.53\,^{+0.13}_{-0.00}$ mm

Notes: This diameter corresponds to dimension D on Fig. 4.4.C.
The total taper for the pin should be 8 degrees unless otherwise specified.

4.4.5 Gage Pins and Hole Tolerances (non-datum)

Use GD&T instructions to determine which holes will be plug checked and which will be sight checked.

The gage pins should be made using standard AGA gage handles and bushings (Carr-Lane or equivalent), specifying Carr-Lane step-plug gage pin whenever possible.

The punch supplier should be contacted for design assistance regarding irregular shaped holes.

The pins shall have a chamfer distance of ten percent of the pin diameter and at an angle of 90 degrees to prevent part movement on the gage. (See Fig. 4.4.D)

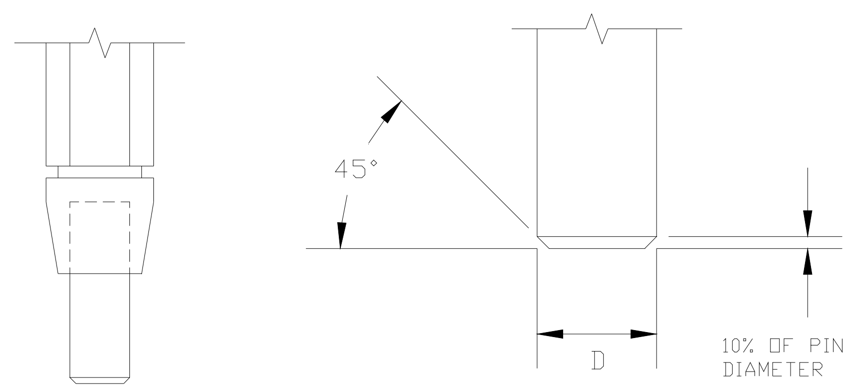


FIG. 4.4.D TYPICAL GAGE PIN

To determine the gage pin diameter, subtract the geometric tolerance limit from the minimum hole diameter. Gage pins shall have a construction tolerance of $^{+0.03}_{-0.00}$ mm.

Example:	hole size on print	=	10.00 $^{+0.03}_{-0.15}$ mm
	smallest hole diameter	=	10.00 - 0.15
		=	9.85 mm
	geometric tolerance limit	=	0.5 mm
	9.85 – 0.5	=	9.35
	Gage pin diameter	=	9.35 $^{+0.03}_{-0.00}$ mm

4.4.6 Detail Blocks

Use detail blocks for positive location of non-round loose pins.

Use standard stock sizes.

See Fig. 4.4.E

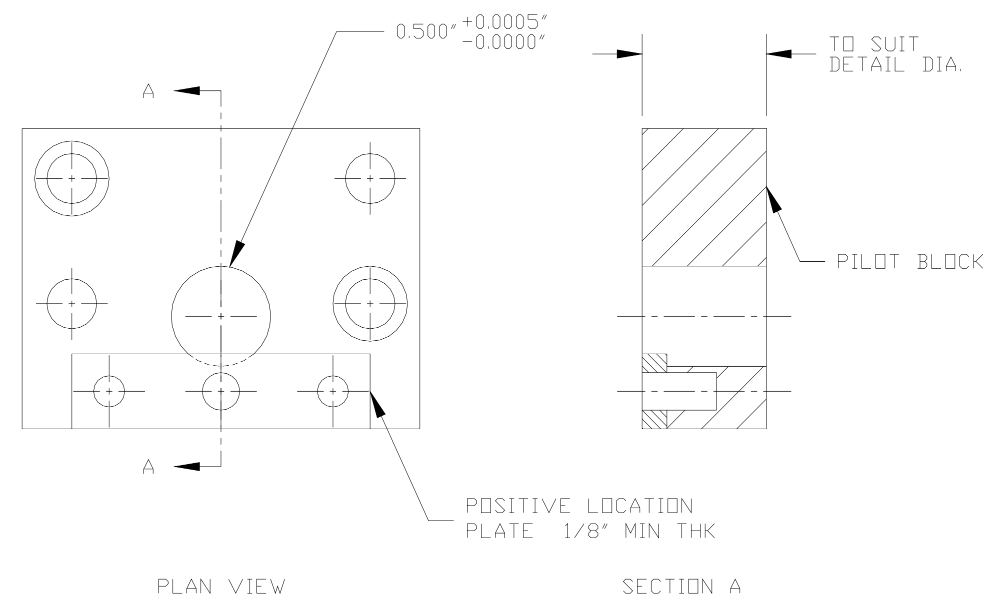


FIG. 4.4.E EXAMPLE OF A DETAIL BLOCK

4.5 Clamping

All surface datums are to be clamped and the area of the fixture where the clamp is mounted must be reinforced for strength and fastening purposes.

Clamps that have spring loaded pressure feet or spring plungers should be used (approximately 8 lbs. of pressure).

Use light duty push clamps in preference to swing clamps in order to achieve unidirectional forces when attempting to net in two directions simultaneously.

Use light duty clevis type toggle clamps if the design dictates, keeping in mind the following precautions:

Clamp pivot axis must be a co-planar with pressure foot contact surface.

- If the clamp pivot point is not properly located, clamp forces will be multidirectional causing possible part distortion.
- Use spring loaded turn clamps where clamps must clear through cutouts or other features.

Use heavy duty clamps only when instructed.

For clamp location, a tolerance of ± 15 degrees from the normal to the part surface should be held.

When clamping into a corner, bisect the angle and include an anti-rotational device.

Mount the clamp and the datum locator on a common support to reduce external stress on the datum locator and/or check details. Mount the clamp and datum locator separately only if it is not feasible to mount them on a common support.

Clamps are intended to help stabilize the part on the fixture/gage. They are not intended to take twist out of the part or deform it into nominal position. The use of clamps should always be kept to a minimum. Any additional clamping must be noted on the part drawing (e.g. restrain part using “X” clamps at the following locations).

Clamp identification numbers should clearly identify clamping sequence.

4.6 Trim/Scribe Lines

Trim lines and certain flange break lines are to be flush checked and feeler checked. Scribed lines on the fixture/gage may be used to check part trim lines at the direction of DTNA Manufacturing Engineering / Quality Assurance.

Scribe lines shall be provided in vehicle line position at 100 mm intervals. Scribe lines shall also be provided around all trim edges and hole perimeters. Center lines shall be scribed for all holes. Trim edges and hole perimeters shall be provided with ± 3.0 mm offset scribe lines (See Fig. 4.6.A).

Use sight checks to identify part features, holes, slots, etc. that are not dimensionally critical.

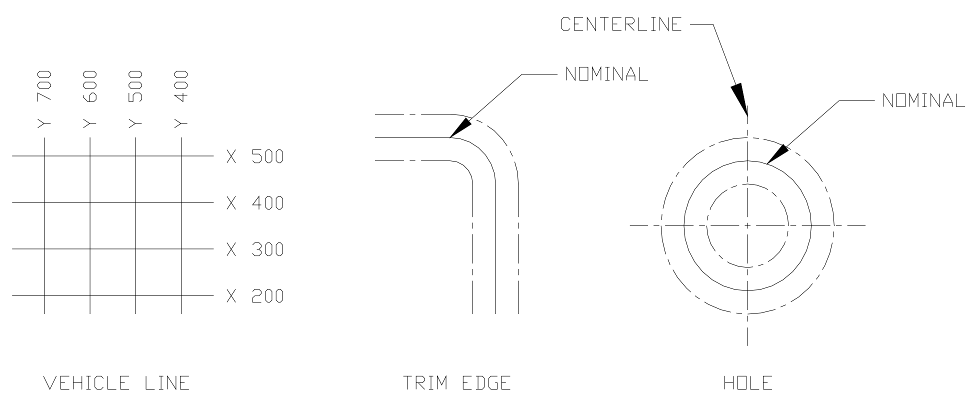


FIG. 4.6.A EXAMPLES OF SCRIBE LINES

4.7 Templates

Templates are intended to check important surfaces and critical areas of the part (e.g. weld joints, cross sections critical for water seal, etc.). They can be loose, stationary, or swinging depending upon use.

All templates shall be constructed of steel with the nominal gap stamped near the measurement surface.

Lightening holes should be used where applicable to reduce the weight of the template.

4.7.1 Fixed/Swing Templates

For fixed or swing templates mounted onto the fixture/gage, use 1/4" CRS. Aluminum may be used for large templates upon approval from DTNA Manufacturing Engineering.

Fixed templates should be machined and mounted normal to body lines and normal to surface part features (See Fig. 4.7.A).

Bevel non-check edges to minimum 1.5 mm land.

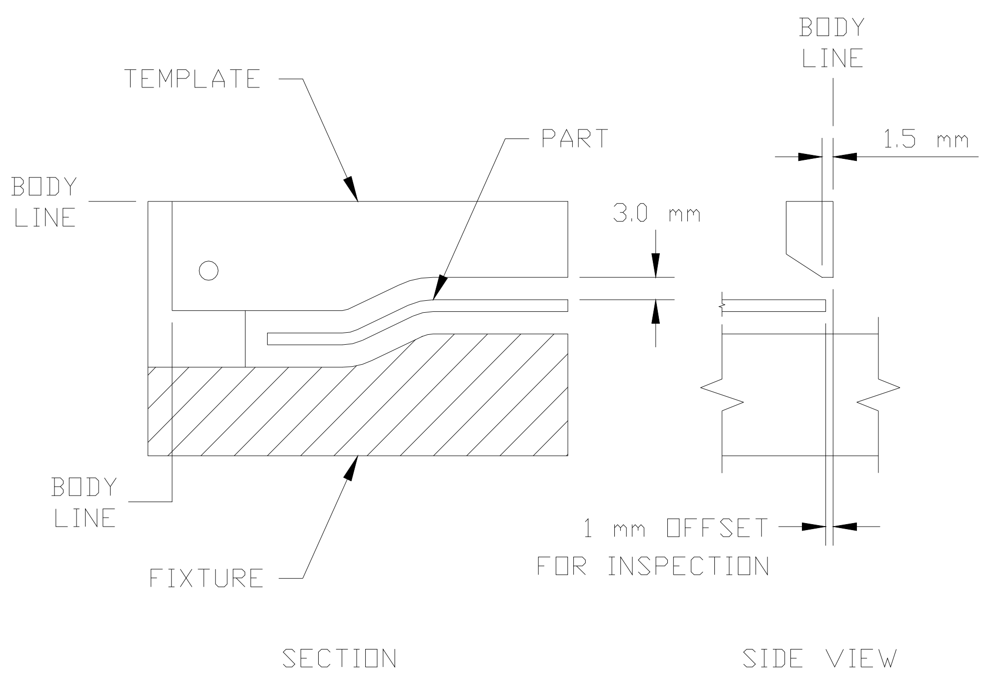


FIG. 4.7.A EXAMPLE OF A SWING TEMPLATE

4.7.2 Loose/Hand Applied Templates

For loose or hand applied templates use 3/16" SAE 01 - gage stock (ground flat stock), available in 1/16", 1/8", 3/16" x 10", and 3/16" x 36".

Locating provisions shall be used where applicable for repeatability requirements.

5.0 Geometric Dimensioning & Tolerancing Standards

Geometric Dimensioning and Tolerancing (GD&T) is a standardized tolerancing method which dimensions parts such that both product design needs and manufacturing capabilities can be satisfied. GD&T relies on establishing part datums from which all part dimensions are referenced.

Manufacturing/Gage engineer uses GD&T part datums:

- for part locating in fixture/gages
- as check points

Choice of part features or points to be checked must consider GD&T datums. Selection of datums as actual check points is dependent on each specific part or assembly to be checked and its associated manufacturing process. Part datums should be surfaces parallel to body line or with a minimum of angle. Selected points must be consistent with statistical process control (SPC) requirements as established by concurrent engineering.

Check fixture/gage construction must comply with GD&T practices for locating part in fixtures/gages.

For additional geometric dimensioning and tolerancing information, consult DTNA drafting standards and GD&T training manuals.

5.1 Symbols

ASME Y14.5-2009 Dimensioning and Tolerancing establishes uniform practices and interpretation of GD&T symbols, dimensioning, tolerancing, and related requirements for use on DTNA engineering drawings.

5.2 Tolerances for Checking Fixtures/Gages

General fabrication	-	± .15 mm (x.x) unless otherwise specified.
General machining	-	± 0.12 mm unless otherwise specified.

5.2.1 Final Assembly Gage Tolerances:

Locators	-	± 0.05 mm
Datum Nets	-	± 0.05 mm
Locating nets	-	± 0.07 mm
In-line check - trim line	-	± 0.20 mm
Feeler and Flush	-	± 0.15 mm
In-line check - flush	-	± 0.13 mm
Clear	-	± 0.25 mm
Trim Scribe	-	± 0.25 mm
SPC bushing	-	± 0.10 mm direction of dimensional product audit
SPC bushing	-	± 0.25 mm direction not used for product audit (for process monitoring only)

5.2.2 Shims

Use of loose shims is NOT permissible for check details or locating datums.

Exception: To salvage details in error, mechanically attached spacers are permissible only with Manufacturing/Gage Engineer’s prior approval.

6.0 Checking Fixture Documentation Requirements

6.1 Repeatability and Reproducibility (R & R)

A fixture/gage R & R study shall be performed on all fixtures per DTNA specifications. Studies shall be conducted using digital hand tools or layout machines. The number and position of points in the study shall be a representative sample of all points checked on the part. An illustration of the part showing the points which were checked and their coordinate locations shall be included with the R & R report. The Percent Measurement Variation (PMV) requirement for all DTNA checking fixtures is targeted for less than 20% and should not exceed 30%.

6.1.1 Repeatability and Reproducibility Procedure (5 parts, 3 times each, 2 operators)

1. Select the critical points which need to be checked for fixture/gage repeatability and reproducibility.

2. Select two operators (referred to as Operator A and Operator B) to take measurements; select a separate person to record actual measurements onto the Checking Fixture R & R Data Sheet.

3. Select a part to be used for measurement purposes

4. Operator A is to set up the part on the fixture, following the Feature Sheet Set-up procedure.

5. Operator A is to measure the critical points as decided upon in Step 1 and record the data on the Checking Fixture R & R Data Sheet.

6. Remove part for the fixture/gage.

7. Operator B is to set up the part on the fixture, following the Feature Sheet Set-up procedure.

8. Repeat steps 5-6.

9. Repeat steps 3-8 for four additional parts (5 total parts.)

10. Calculate Gage R & R values.

6.1.2 Understanding the R & R Calculation

See the following example of an R & R Data Sheet.

- Tolerance Span: the overall width of the tolerance

  Example: ± 2.0 has a tolerance span of 4.0

- Average: the sum of the individual measurements, x_i, divided by the total number of measurements, n. Average is denoted by x.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

- Standard Deviation: describes how far the individual measurements are spread out from the mean (average) of the distribution. The Data Sheet calculates sample standard deviation (by using the n-1 factor). Sample standard deviation (S) is defined by the following equation:

$$S = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{n-1}}$$

- Percent Measurement Variation (PMV): describes the potential of a fixture/gage being capable or the percentage of the tolerance which is being used. Values of 30 or less are desirable. PMV is defined by the following equation:

$$PMV = \frac{6 * S}{\text{Tolerance Span}} * 100\%$$

- PMV (All): this takes into account all sources of variation; operator setup, differences in operators and differences in measuring instruments.

$$PMV = \frac{6 * S_{ALL}}{\text{Tolerance Span}} * 100\%$$

Gage R & R Study 5-3-2 Worksheet

(5 parts, 3 times each, 2 operators)

Date:

Gage Number:
Gage Cert. Level:
Gage Cert. Date:
Gage Build Source:

Part Number:
Part Name:
Characteristic:
Engineering Level:

Operators: A B

Tolerance: Number of Parts: 5 No Operators: 2 Number of Trials: 3

Operator	Trial Number	Part 1	2	3	4	5		Average
A	1							
	2							
	3							
	Average						X-bar	
	Range						R-bar	

Operator	Trial Number	Part 1	2	3	4	5		Average
B	1							
	2							
	3							
	Average						X-bar	
	Range						R-bar	
Part Average							Rp	

USER INPUT

CALCULATED

Equipment Variation:		R & R		%EV	Enter Tol.	%EV-TV		R-Bar	
Appraiser Variation:		Part Var:		%AV	Enter Tol.	%AV-TV		X-Dif	
$\sigma_{repeatability}$		Total Var:		%RR	Enter Tol.	%RR-TV		UCLr	
$\sigma_{reproducibility}$		$\sigma_{R\&R}$		Notes		%PV-TV		LCLr	0.00
		σ_{TV}		NDC	#VALUE!	Min %RR		Max Range	
		Criteria <	30%			Pass/Fail	#VALUE!	Stable?	

6.2 Drawings

It is the responsibility of the supplier to submit a complete set of drawings prior to construction for each fixture/gage. Drawings shall be sufficiently detailed to fabricate a new fixture if necessary. The drawings shall be provided with a method of confirming and updating the design level of the fixture.

6.3 Certification

All fixtures/gages shall be certified to ensure that they are within their specified tolerances. The certification shall be performed with the fixture/gage in completely assembled state. Certification shall be conducted prior to Engineering Trials.

An inspection report shall be issued to the supplier upon completion. The cover sheet of the inspection report shall include the part number, date of inspection, design level of the part, and fixture set up method. The body of the report shall include illustrations of the area being measured, design nominals, and deviations from nominal in metric units. The report shall clearly differentiate between set points and measurement points when checking tangents or surfaces.

It is the responsibility of the supplier to ensure that fixture design is correct and inspection is sufficient. Fixture inspections shall be performed whenever a fixture is modified in any way that might affect the accuracy of the fixture. Inspections shall be performed after any gage modifications, repairs, or design level changes. In these cases only the area that was changed needs to be confirmed, not the entire fixture.

6.4 Maintenance

It is the responsibility of the supplier to maintain their fixtures in good working order. Fixtures shall be clean and properly painted with no missing, broken, or chipped areas. The fixture/gage drawings and inspection reports shall serve as a history of all changes and modifications to the fixture.

6.5 Set Up Procedure (Feature Sheet)

Fixtures are to be provided with a set up procedure which shall be mechanically fastened to the fixture. Procedure is plastic engraved. The set up procedure shall be a detailed description of the method used for setting the part in the fixture for measurement. The procedure shall include sequences for installing locate pins and engaging clamps where applicable.

6.6 Specification

A checking fixture/gage specification containing all design build criteria shall be completed by DTNA's Design Engineering, Manufacturing Engineering, Quality Engineering, tooling supplier and checking fixture supplier, and approved before the fixture/gage is sent out for final design and build.

7.0 Part Buy-Off Procedure

The following summary identifies specific requirements for "Part Buy-Off" for all DTNA component parts and assemblies. These requirements are associated with all parts received by DTNA either from internal or external sources. Deviations to this outline must be presented by the supplier and approved by DTNA's Quality Engineer.

- Parts and assemblies must be "Bought-Off" on an approved checking fixture or CMM holding fixture.
- The Quality Engineer will review the part to ensure proper Engineering change level and part characteristics are incorporated into the part or assembly prior to part buy-off.
- Tolerances shall be defined on part drawings.
- Initial Sampling Inspection Report (ISIR) approval may be required for part shipment.
- Variable data for the first sample must be submitted to DTNA prior to part or assembly buy-off. (Vendor ISIR)
- Additional CMM requirements will be determined based on stability of 30 part capability study.

If you have any questions, comments or concerns regarding part buy-off please contact the responsible Quality Engineer.