Galaxy Aerospace
Airworthiness Expert

CALIBRATION TECHNICAL PROCEDURES

GAM/CL-TP

ISSUE 2

REVISION 0

DATE: 08 AUGUST 2024

GALAXY AEROSPACE SDN. BHD

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Galaxy Aerospace Airworthiness Expert	CALIBRATION TECHNICAL PROCEDURES	
	DOC REF. NO.	GAM/CL-TP
	ISSUE NO.	2
	REVISION NO.	0

DOCUMENT CHANGE RECORDS

No.	Issue No.	Revision No.	Date of Amendment	Affected Pages	Details of Amendment
1	1	0	01 JULY 2023	All	Initial issue of GAM/CL-TP
2	1	1	08 JULY 2024	1, 2, 3, 4, 6, 7, 8, 11, 30, 39, 40, 41, 42, 45, 51, 52, 53, 55, 56, 57, 59, 65, 66, 67, 68, 69, 70, 71, 73, 76, 79, 80,81	1.1 Procedure updated and added new procedure. 1.1.2-vii the word location removed and added serial number, status and remarks. Calibration device standard for hand torque tool single transducer Part no. updated. General mathematical model for pressure calibration and uncertainty due to readability for digital pressure gauge added. General mathematical model and additional uncertainty source added for dimensional calibration. Updated and added new reference, procedure and table for force verification. All calibration and verification method form section updated. Company new LOGO.

AUTHORIZATION APPROVALS

Electronic authorization approval is the preferred method for approving quality system documents. Signed hardcopies are only available upon request.

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Date: 26 AUGUST 2024	Date: 26 AUGUST 2024

CALIBRATION TECHNICAL PROCEDURES

INTRODUCTION
CL-TP-01

1. PERFORMING CALIBRATION

PURPOSE

The purpose of this Performing Calibration Procedure is to provide a procedure on how calibration work shall be performed in GAM CL starting from calibration request to returning the calibrated tools to customer.

SCOPE

This procedure applies to all tools which are covered within this CL-TP procedure that is sent to GAM CL for calibration.

1.1 PROCEDURE

1.1.1 Preliminary Acceptance Check

i. Read this entire procedure before beginning the calibration.

ii. Calibration shall be performed in an environment that conforms to Reference Standard.

iii. The tools that required to be calibrate/verification will hereafter be referred to as the Unit Under Test (UUT).

iv. Verify that the UUT is clean.

v. Visually examine the UUT for any condition that could cause errors in the calibration.

vi. If any of the requirements cannot be met, refer to the applicable manufacturer manual.

vii. If a malfunction occurs or a defect is observed while calibration is in progress, the calibration shall be discontinued and necessary corrective action taken; if corrective action affects a measurement function previously calibrated, the function shall be recalibrated before the remainder of the procedure implemented.

viii. Any finding found during the preliminary inspection, the finding shall be written in the remarks section of the Calibration Form and if no finding found NIL will be written down in the remarks section of the Calibration Form (refer the form section of each calibration method).

1.1.2 Acceptance

i. When the tool reaches calibration due, Store/Warehouse shall call for inspection by notifying Production Planner.

ii. PP shall perform scope applicability check and notify SV.

iii. If not within scope applicability, PP shall reject the tools.

iv. Tools within scope capabilities, PP shall register the incoming tools in the Calibration Records (GAM/CL-17) and produce the Work Order (GAM/CL-F18).

v. Place tools in the designated "**INCOMING**" area, preliminary acceptance check (refer 1.1.1) shall be carried out by Supervisor.

vi. During preliminary acceptance check, any discrepancies, defects, or findings SV shall advise the required action and liaise with PP to inform the operator for further instruction. Tools shall be labelled "Unserviceable" in accordance with the outcome of the report.

vii. PP fills out the details of the tools in Calibration Record (GAM/CL-F17). The record shall contain tools Part Number, serial number, calibration due date, status of the tool and special request from customer in remarks (if available).

viii. While waiting for further instructions, an additional '**UNSERVICEABLE**' label shall be issued and attached to the item signifying the defects or findings discovered. Item to be placed in the designated "**QUARANTINE**" area.

ix. If the tools are allowed to proceed for calibration stage, while waiting for its' turn, the item shall be placed at the designated "**HOLDING**" area.

1.1.3. Calibration Procedures

i. Technician shall perform calibration in accordance with Calibration Technical Procedure, Work Instructions and Work Order (GAM/CL-F18).

ii. Technician records the measurement and readings in the "Calibration Form" (refer the form section of each calibration method) with specific method of the tools.

1.1.4. Job Completion

i. Technician performing the calibration task shall sign in the "Calibration Form" (refer the form section of each calibration method) once he/she is satisfied with the work has been carried out in accordance with "Calibration Technical Procedure". The "Calibration Form" (refer the form section of each calibration method) then sent to SV.

ii. SV ensures that the "Calibration Form" (refer the form section of each calibration method) is completely signed, verify the correctness of the measurement results and other relevant data on the "Calibration Form" (refer the form section of each calibration method).

iii. SV closes the "Calibration Form "(refer the form section of each calibration method) and pass to WIC respectively.

iv. WIC verifies the "Calibration Form" (refer the form section of each calibration method). Once verified, WIC shall print out certificate (GAM/CL-F30) and acquire signature from SV.

v. PP collects all the paper works and prints out calibration sticker (GAM/CL-F41).

vi. PP closes Calibration Records (GAM/CL-17). Completed documents shall be scanned and properly distributed, attached to the component where required and place to "**OUTGOING**" before deliver to Store/Warehouse for further action.

vii. For unserviceable component, it is to be accompanied with '**UNSERVICEABLE**' label and placed to "**OUTGOING**" prior return to Store/Warehouse

1.1.5. Calibration Procedures Process Flow

PROCESS FLOW	DESCRIPTION	RESPONSIBLE PERSON	DOC. REF.
CALIBRATION REQUEST	• Stores/Warehouse call for inspection when tools are due for calibration. • PP receives request and data of tools and notify SV.	SI, PP	
SCOPE CHECK (NO → REJECTION; YES → TOOLS INCOMING)	• PP checks the scope applicability. • If outside GAM CL scope, reject the request. • If the tools are within scope, tools shall be place at "incoming" area for calibration.	PP	
REJECTION (→ RETURN TO STORE/WAREHOUSE) TOOLS INCOMING	• Register the component in "Calibration Records" and issue "Work Order" number. • Perform preliminary checks on tools. • Issue Workshop Documents - Calibration Form. • Assign technician for calibration work.	PP SV	▪ Calibration Records ▪ Work Order ▪ Calibration Form
WORK ORDER ISSUANCE PERFORM CALIBRATION	• Technician shall perform calibration in accordance with Calibration Technical procedure, Work Instructions and Calibration Form.	Technician	▪ Calibration Form
CLOSURE OF WORK ORDER, CALIBRATION FORM	• Upon completion of the task, the Technician fill and sign Calibration Form, then send to SV. • SV closes and sign the Calibration Form shall be verify by WIC.	Technician SV WIC	▪ Calibration Form
CALIBRATION CERTIFICATE	• WIC shall produce the calibration certificate, then pass to SV for signatory. • SV shall compile all calibration documents and pass to PP. • PP issue out Calibration Sticker and collects all calibration documents. • Calibration Record is completed.	WIC SV PP	▪ Calibration Certificate ▪ Calibration Form ▪ Calibration Sticker ▪ Calibration record
CALIBRATION STICKER	• All calibrated tools properly labelled and with completed documents shall be transferred to "Outgoing" area. • Completed documents shall be scanned and properly distributed, attached to the component where required.	PP	▪ Work Order ▪ Calibration Certificate ▪ Calibration Sticker
RETURN TO STORE/WAREHOUSE	• Calibrated tool returned to Store/Warehouse	SI	
RECORD SAFEKEEPING END	• Records to be kept and all the scanned copy of the document will be archived.	PP	▪ Work Order ▪ Calibration Certificate ▪ Calibration Form

2. FORMS

2.1. Calibration Sticker

GalaxyAerospace

CALIBRATION LABORATORY

CERT NO: ....

EQPT NO: ....

DUE DATE: ....

GAM/CL-F40

2.2. Calibration Certificate

Galaxy Aerospace

Issued By	GALAXY CALIBRATION LABORATORY GALAXY Aerospace (M) Sdn Bhd (1042262-D) Suite 11-14, Helicopter Centre, Sultan Abdul Aziz Shah Airport 47200 Subang, Selangor, Malaysia Tel: 03-77347226 Fax: 03-77347526

Customer

Work Order No:

CERTIFICATE NO

Date Of Issue

Instrument
Model
Part No
Serial No
Equipment Id
Capacity/Range
Date Of Receipt
Date Of Calibration
Recalibration Date

Instrument Conditions
Received
Returned

Environmental Conditions
Ambient Temperature
Relative Humidity
Recommended Date Due

(Specified By Customer)	The user should be aware there are many factors may cause this instrument to drift out of calibration limits prior to the stated recalibration date

REFERENCE STANDARD USED

MODEL	DESCRIPTION	SERIAL NO	CAL DUE	TRACEABILITY

The Standard instruments used in this calibration are traceable to either the National Standard maintained at the National Metrology Institute of Malaysia or other recognized International Standard Laboratories

CALIBRATED BY

APPROVED SIGNATORY

The results of calibration performed by Galaxy Calibration Laboratory apply to the particular equipment at the time of its test. They do not indicate or imply that Galaxy Calibration Laboratory approves, recommends or endorses the manufacturers or suppliers or users of such equipment that Galaxy Calibration Laboratory in any way guarantees the equipment's performance after calibration

Galaxy Aerospace

Instrument Condition When Returned

CALIBRATED	
TESTED	
REPAIRED	
VERIFICATION	

The report shall not be reproduced without the written approval of calibration Laboratory
Measurement Uncertainty: Refer to calibration results
The uncertainty calculation is based on the ISO Guide to the Expression of Uncertainty in Measurement
Note1: This calibration was performed according to ISO/IEC 17025:2017

CALIBRATION RESULTS

The item has been calibrated in accordance with pertinent reference and all data is within manufacturers or customer's requirement. The calibration measurement standards are traceable to National and Internal Standards

The expended uncertainties are based on estimate confidence probability of approximately at 95% and have a coverage factor of k=2 unless stated otherwise

CALIBRATION TECHNICAL PROCEDURES

HANDS TORQUE
CL-TP-02

1 PURPOSE

1.1 The purpose of this Hand Torque Tools Calibration Procedure is to establish procedure to identify and calibrate torque measuring equipment used for Galaxy Aerospace (M) Sdn. Bhd. Calibration Laboratory (GAM CL).

1.2 This document specifies this document is to specify requirements with which a laboratory must operate and demonstrate its competency to carry out calibration in accordance with ISO 6789-1:2017, ISO 6789-2:2017 and MS ISO/IEC 17025:2017.

1.3 Implementation of this calibration procedure ensures that the hand torque tool equipment used are properly identified and calibrated at appropriate intervals to maintain accuracy within specified limits.

2 SCOPE

2.1 This procedure lays down the specific requirements for calibration of torque indicating devices used in Calibration Laboratory (GAM CL).

2.2 Hand Torque Tools calibration that is within GAM CL capability are as follows:

Components	Type	Class	RANGE
Hand Torque Tools	Indicating Torque Tools Type I	A, B, C, D, E	4-50 in.lb 30-400 in.lb 80-1000 in.lb 20-250 ft.lb 60-600 ft.lb
	Setting Torque Tools Type II	A, B, C, D, E, F, G	

3 CALIBRATION DEVICE STANDARDS

Components	Range	Part Number
Transducer (4–in- 1)	4-50 in.lb.	2000-400-02
	30-400 in.lb.	
	80-1000 in.lb.	
	20-250 ft.lb.	
Single Transducer	60-600 ft.lb.	2000-12-02

4 REFERENCES

I. MS ISO/IEC 17025:2017 - General requirements for the competence of testing and calibration laboratories

II. ISO 6789-1:2017 - Assembly tools for screws and nuts

III. ISO 6789-2:2017 - Assembly tools for screws and nuts

IV. ISO GUM - Guide for determination of measurement uncertainty

V. SURETEST AND 600TL Model 5000-3 Torque Calibration System User Manual

VI. GAM/WI-CDI – Work Instruction for CDI Suretest 600TL Torque Calibrator

VII. GAM/CL/P – Calibration Laboratories Procedure

5 DEFINITIONS

5.1 Type A evaluation (of uncertainty)

Method of evaluation of uncertainty by the statistical analysis of series of observations

5.2 Type B evaluation (of uncertainty)

Method of evaluation of uncertainty by means other than the statistical analysis of series of observations.

5.3 Calibration system

Combination of a measurement device and the loading system for application of torque that acts as the measurement standard for the hand torque tool.

5.4 Measurement device

Working measurement standard provided either mechanically or by an electronic torque transducer and display.

5.5 Reference measurement standard

Measurement standard designated for the calibration of other measurement standards for quantities of a given kind in a given organization or at a given location.

5.6 Measurement error

Measured quantity value minus a reference quantity value.

5.7 Maximum permissible deviation

Maximum value of relative measurement deviation of the observed torque value on the torque measurement device is measured as a percentage of the target torque value on the torque tool.

5.8 Indicating torque tool (Type I)

Tool that indicates by means of a mechanical scale, dial or electronic display; the value of torque exerted by the tool at the output drive.

5.9 Setting torque tool (Type II)

Tool sensing torque transmitted by comparing the torque applied with a self-contained standard and signaling the transmission of the pre-selected value by a physical impulse, with or without audible signal, causing a temporary reduction in the torque applied.

5.10 Adjustable graduated torque tool (Type II, Class A, Class D and Class G)

Tool designed to be adjusted by the user, which has a scale or a display to assist adjustment.

5.11 Adjustable non-graduated torque tool (Type II, Class C and Class F)

Tool designed to be adjusted by the user with the aid of a torque measurement system.

5.12 Torque tool with fixed adjustment (Type II, Class B and Class E)

Tool not designed to be adjusted by the user, i.e., having a single setting.

6 CALIBRATION CONDITION

6.1 Calibration shall be carried out at a temperature of 20°C ± 2°C. Maximum relative humidity 65 % RH and shall be documented.

7 CLASSIFICATIONS

7.1 The hand torque tools to which this document applies are classified as follows.

7.1.1 Indicating torque tools Type I

I. Class A: Wrench, torsion, or flexion bar.

II. Class B: Wrench, rigid housing, with scale or dial or display.

III. Class C: Wrench, rigid housing and electronic measurement.

IV. Class D: Screwdriver, with scale or dial or display.

V. Class E: Screwdriver, with electronic measurement.

7.1.2 Setting torque tools Type II

I. Class A: Wrench, adjustable, graduated or with display.

II. Class B: Wrench, fixed adjustment.

III. Class C: Wrench, adjustable, non-graduated.

IV. Class D: Screwdriver, adjustable, graduated or with display.

V. Class E: Screwdriver, fixed adjustment.

VI. Class F: Screwdriver, adjustable, non-graduated.

VII. Class G: Wrench, flexion bar, adjustable, graduated.

8 REQUIREMENTS

8.1 Maximum permissible deviation

8.1.1 Each result for a torque tool, shall lie within the respective maximum permissible relative deviation for the type and class of that tool stated in Tables 3 and 4.

8.1.2 Where a manufacturer claims a smaller maximum permissible relative deviation than stated in Tables 3 and 4, each result shall lie within the claimed maximum permissible relative deviation.

8.1.3 For determining conformance with this subclause, the influence of the uncertainty of the torque tool and of the torque measurement device shall not be considered.

Table 3 — Maximum permissible relative deviation (Type I)

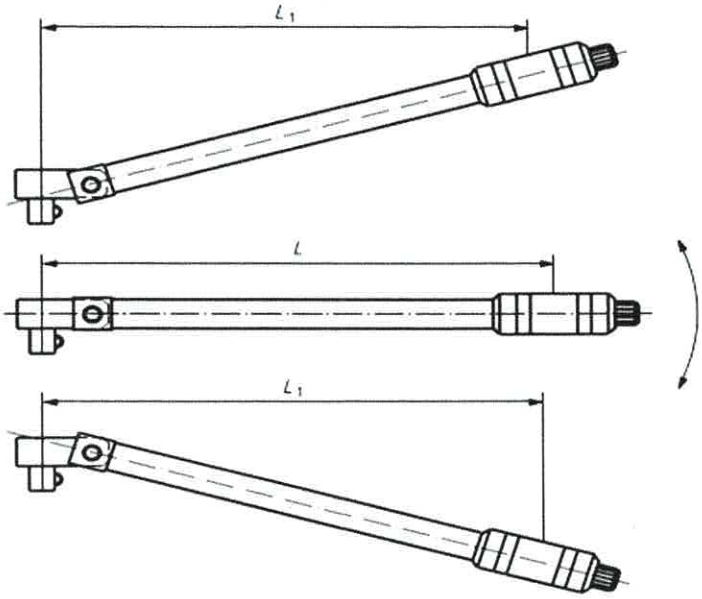
Class	Maximum torque value	
	≤10 N·m	>10 N·m
A and D	±6 %	
B, C and E	±6 %	±4 %
If a tool is operating in both directions, the maximum permissible relative deviation shall be met in each direction specified by the manufacturer.		

Table 4 — Maximum permissible relative deviation (Type II)

Class	Maximum torque value	
	≤10 N·m	>10 N·m
A, B and C	±6 %	±4 %
D, E, F and G	±6 %	
If a tool is operating in both directions, the maximum permissible relative deviation shall be met in each direction specified by the manufacturer.		

8.2 Effect of geometric changes.

8.2.1 All torque tools to be tested shall be tested for the influence on torque output due to changing geometry, such as but not exclusively flexible head ratchets (see Figure 1) and extension bars designed to be used to reduce operator effort (see Figure 2). The manufacturer shall communicate these influences on users through instruction sheets or the declaration of conformance.

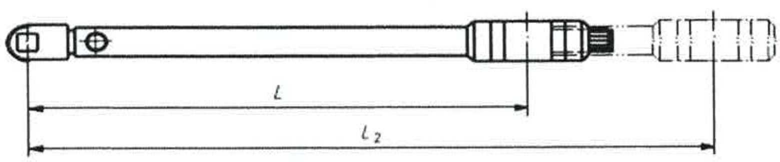


Key

L length

L_1 length reduced

Figure 1 — Example of a flexible head torque wrench



Key

L length

L_2 length extended

Figure 2 — Example of an extension bar

9 TORQUE MEASUREMENT

9.1 Torque measurement system

9.1.1 The torque measurement system shall be chosen to be suitable for the measurement of the specified range of the torque tool.

9.1.2 The maximum measurement error of the torque measurement device shall not exceed 1/4 of the claimed maximum permissible relative deviation of the torque tool at each target value.

9.1.3 The torque measurement device shall have a valid calibration certificate traceable to a national standard or to a calibration laboratory meeting the requirements of ISO/IEC 17025. Alternatively, the torque measurement device shall be calibrated by a laboratory maintaining the national measurement standard or according to ISO 6789-2:2017.

9.2 Application of torque

9.2.1 Each force applied to the tool shall be perpendicular to the axis of rotation.

9.2.2 The handle of the tool shall be allowed to move in all planes of rotation.

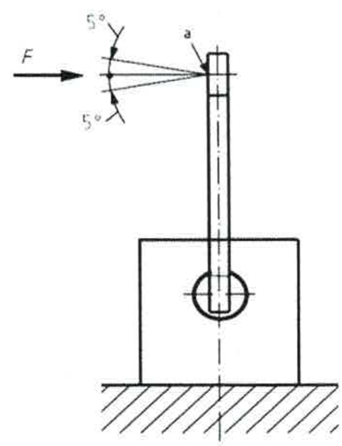
9.2.3 The connection between torque measurement system and torque tool shall permit self-alignment so that parasitic forces and moments are minimized.

9.2.4 The tool to be measured shall be oriented in accordance with Figures 3, 4 or 5.

I. In the case of Figures 3 or 4, the operating force, F, shall be applied within the angular deviation limits specified in the centre of the hand hold position of the grip or of the marked load point.

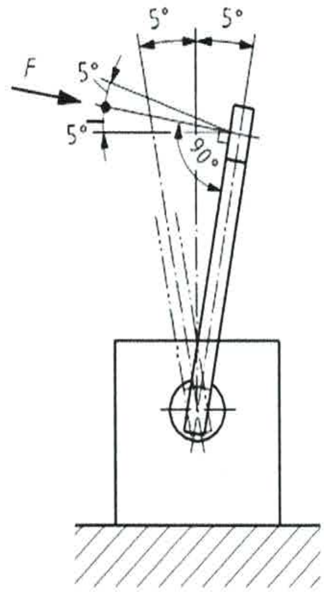
II. In the case of Figure 5, the operating torque shall be applied within the angular deviation limits specified.

III. Tools with flexible head shall be measured with the axis of rotation perpendicular to the axis of the tool.



a) Wrench in a vertical position

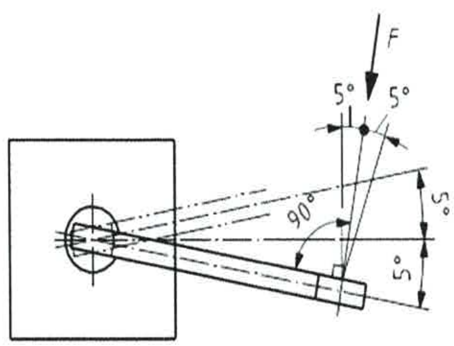
Key



b) Wrench in 5° offset

a Line contact, marked loading point or center of the hand hold position of the grip.

Figure 3 — Testing of a wrench in a vertical position (front view)

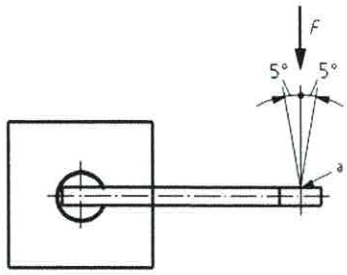


b) Wrench in 5° offset

Key

a Line contact, marked loading point or center of the hand hold position of the grip.

Figure 4 — Testing of a wrench in a horizontal position (top view)



a) Wrench in a horizontal position

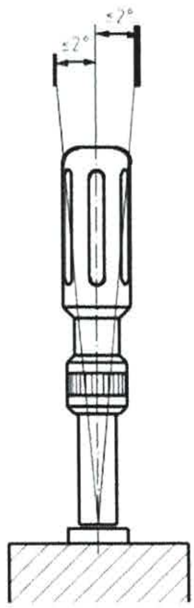


Figure 5 — Testing of a torque screwdriver and T-handle torque wrench in horizontal and vertical positions

9.2.5 Indicating torque tools (Type I) shall be loaded with an increasing torque until the target torque value is indicated on the torque tool. If the torque to be measured has been exceeded, then the measurement shall be repeated from the zero position. The time intervals between any two subsequent loadings shall be of the same duration. Slave pointers (memory indicators) shall not be used when taking the readings.

9.2.6 Setting torque tools (Type II) shall be loaded with a slowly and steadily increasing torque until attainment of the target torque is signalled by the torque tool. The target torque shall be reached after a minimum time as defined in Table 5.

Table 5 — Minimum time period for application of torque values

Applied torque value	<10 N·m	≥10 N·m <100 N·m	≥100 N·m <1 000 N·m	≥1 000 N·m
Minimum time to increase the torque from 80 % of target value to target value	0,5 s	1 s	1,5 s	2 s

For screwdrivers (Type II, Classes D, E and F), the time to increase the torque from 80 % of target value to target value shall be between 0,5 s and 1,0 s.

9.3 Measurement requirements

9.3.1 Prior to measurement, the torque measurement device and the torque tool shall be allowed to attain the ambient temperature.

9.3.2 Where the output drive is not permanently attached, the dimensions of the drive that affect the radial distance shall be recorded.

9.3.3 During measurement, analogue scales or dials shall be read in a perpendicular direction to minimize parallax errors.

9.4 Measurement sequence

9.4.1 General

I. Where the torque measurement device has not been continuously operating during the previous hour, three loadings to the maximum torque of the torque tool in the measurement direction are required and the torque measurement device shall then be set to zero.

II. Torque tools with electronic measurement shall be powered during the whole measurement sequence.

III. The measurement is carried out separately for each direction. For each direction of operation, the torque tool shall be preloaded three times at its maximum specified torque value without recording. The number of recorded measurements shall be according to Table 6.

IV. Torque tools which are covered by both classifications Type I and Type II shall be measured for both Types, unless the manufacturer has stated a preferred Type for this tool, in which case the maximum permissible relative deviation for the other Type also needs to be stated by the manufacturer.

Table 6 — Number of recorded measurements

Type of torque tool	Type I	Type II	Type II
Class of torque tool	All	A, D and G	B, C, E and F
Number of recorded measurements at each target torque value	5	5	10

9.4.2 Indicating torque tools, Type I

I. Indicating torque tools (Type I, all Classes) shall first be measured at the lowest specified torque value of the measurement range (see 5.1.3) then at approximately 60 % and finally at 100 % of the torque tool's maximum value.

II. For indicating torque tools (Type I, all Classes), after the three pre-loadings at the maximum torque of the tool, all load on the torque tool and the torque measurement system shall be removed. After a waiting period of at least 5 s, the pointer or electronic display of the torque tool and the torque measurement device shall be set to zero where such a facility exists. Then, the further number of recorded measurements shall be as specified in Table 6.

III. For indicating torque tools (Type I) with electronic display, the readings shall only be recorded after the display has stabilized.

9.4.3 Setting torque tools, Type II

I. Setting torque tools (Type II, Classes A, D and G) shall first be measured at the lowest specified torque value of the measurement range then at approximately 60 % and finally at 100 % of the torque tool's maximum value.

II. For setting torque tools (Type II, all Classes), after the three preloading at the maximum torque of the tool, all load on the torque tool and the torque measurement system shall be removed. After a waiting period of at least 5 s, the pointer or electronic display of the torque measurement device shall be set to zero where such a facility exists. Then, the further number of recorded measurements shall be as specified in Table 6.

III. Setting torque tools (Type II, Classes A, D and G) shall be set to each target value starting from a lower value. If the target value is exceeded, the tool shall be set back to a lower value before re-adjustment to the target value.

IV. Setting torque tools (Type II, Classes C and F) shall be measured 10 times in succession at the lowest limit value or nominal torque pre-set value.

V. Setting torque tools (Type II, Classes B and E) shall be measured 10 times in succession at the nominal fixed value.

10 MEASUREMENT UNCERTAINTY

10.1 General Model of Measurement

10.1.1 The determination of the measurement uncertainty is generally carried out according to the following:

Model function			$y = f(x_1, x_2, \ldots, x_N)$
Standard uncertainty	$u(x_i)$	Standard uncertainty attributed to the input/influence quantity	
	c_i	Sensitivity coefficient	$c_i = \frac{\delta f}{\delta x_i}$
	$u_i(y)$	Contribution to the standard uncertainty attributed to the output quantity due to the standard uncertainty $u(x_i)$ of the input quantity x_i	$u_i(y) = c_i \cdot u(x_i)$
	$u(y)$	Standard uncertainty attributed to the output quantity	$u^2(y) = \sum_{i=1}^{N} u_i^2(y)$ $u(y) = \sqrt{\sum_{i=1}^{N} u_i^2(y)}$
Expanded uncertainty	$U(y)$	Expanded uncertainty	$U(y) = k \cdot u(y)$
	k	Coverage factor	$k = 2$ *for a measurand of largely normal distribution and a coverage probability of approximately 95%*

10.1.2 Uncertainty components of the torque calibration to be considered but not limited to:

I. Repeatability, w_{re}
II. Reproducibility, u_{rep}
III. Expanded measurement uncertainty Reference Torque Calibrator, w_{md}
IV. Resolution, w_{res}
V. Geometric effects of the output drive of the torque tool, w_{od}
VI. Geometric effects of the interface between the output drive of thetorque tool and the calibration system, w_{int}
VII. The length variation of the torque loading point, w_l

10.2 Sources of Uncertainty

10.2.1 Uncertainty due to Repeatability w_{rep}

I. Repeatability is the measurement precision under a set of repeatability conditions of measurement.

II. Reproducibility is the measurement precision where variable exist in the measurement process.

III. Calculating both repeatability uncertainty involves taking 'n' number of measurement, calculating the mean and standard deviation.

$$s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$$

IV. Uncertainty due to repeatability and reproducibility:

$$w_{rep} = \frac{s}{\sqrt{n}} \times \frac{100}{\bar{x}r}$$

V. The degree of freedom *v*, *v* = *n-1*

10.2.2 Uncertainty due to Standard equipment, w_{md}

I. This value should be taken from the standard calibration device certificate, for the corresponding measuring range or defined position, divided by the coverage factor (usually k=2).

$$w_{md} = \frac{W}{2}$$

II. The degree of freedom *v* will be taken from the ***t-table***, *v* = 50 where k=2

10.2.3 Uncertainty due to Resolution, w_{res}

10.2.3.1 Determination of the resolution, r, with analogue scales or dials

I. The torque value shall be read from the position of the active or moving cursor or pointer on a scale or dial. Slave pointers (memory indicators) shall not be used when taking the readings.

II. Where the pointer tip width is less than 1/5 of the scale or dial increment, the resolution is 1/5 of the scale or dial increment value. Where the pointer tip width is equal to or greater than 1/5 but less than 1/2 of the scale or dial increment, the resolution is 1/2 of the scale or dial increment value. Where the pointer tip width is greater than 1/2 of the scale or dial increment, the resolution is the scale or dial increment value.

$$w_{res} = \frac{r \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

III. The degree of freedom *v*, *v = 12.5*

10.2.3.2 Determination of the resolution, r, with micrometer scales

I. Where the torque tool utilizes a "micrometer" scale, a second set of scale marks appropriate to the main scale may be used to allow direct fractional reading of the torque value.

II. Where there is no secondary scale, its resolution is 1/2 of the main scale increment value. Where there is a secondary scale, the resolution is 1/2 of the secondary scale increment value.

$$w_{res} = \frac{r \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

III. The degree of freedom *v*, *v = 12.5*

10.2.3.3 Determination of the resolution, r, with digital scales or dials

I. For torque tools with a digital scale, dial or display the resolution, r, shall be determined as follows.

II. The value of r shall be a single increment of the last active digit, provided the display does not fluctuate by more than one digit when the device is at the lowest calibrated torque value. Where the values fluctuate by more than one digit when the device is at the lowest calibrated torque value, the value of r shall be a single increment of the last active digit plus one half of the fluctuation range.

$$w_{res} = \frac{r \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

III. The degree of freedom *v*, *v = 12.5*

10.3 Uncertainty due to reproducibility, u_{rep}

I. Reproducibility is affected by the ability to identify exactly the value at which loading should be stopped for indicating torque tools Type I and the ability of the mechanism to return in the same place each time after adjustment of the tool in the case of setting torque tools Type II. For both Type I and Type II tools, it includes parallax errors.

II. For torque tools of all types, the following method is described for the determination of reproducibility, b_{rep}. The tool shall be subjected to the loading sequence defined in ISO 6789-1:2017, 6.5, at the lowest specified torque value only and the values recorded. The sequence shall be performed four times and the torque tool shall be removed from the calibration system between each sequence. Where more than one operator performs such calibrations, the sequences will be distributed between operators.

$$b_{rep} = \max(X \text{ ri}) - \min(X \text{ ri})$$

$$w_{rep} = \frac{b_{rep} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

III. The degree of freedom v, reliability at 20% v = 12.5.

10.4 Uncertainty due to geometric effect of the output drive of the torque tool, w_{od}

I. Ratchets, hexagon and square drive outputs of the torque tool in particular have an influence since they can potentially run out of true and if not used in the same orientation each time, they can cause variation of reading. Interchangeable drive ends can also cause variation.

II. The following method is described for the determination of the output drive variation, bod. This value may be determined statistically for a sufficient number of specimen at least 10 of a model of tool and its determination does not need to be repeated each time for future calibrations of this model. Where the output drive is not capable of rotation, this variation shall be set to zero.

III. The torque tool is removed from the calibration system and the output drive is rotated by 60° (hexagonal drive output) or 90° (square drive output). Ten measurements are recorded for each of at least four positions distributed evenly over 360°, at the lower limit value of the measurement range, T_{min}, without changing the load application point.

$$b_{od} = max(\bar{x}_{\text{ri}}) - \min(\bar{x}_{\text{ri}})$$

$$w_{od} = \frac{b_{od} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

IV. The degree of freedom *v*, *v = 12.5*

10.5 Uncertainty due to geometric effects of the interface between the output drive of thetorque tool and the calibration system, w_{int}

I. Hexagon and square drive interfaces between the output drive of the torque tool and the calibration system have an influence since they can potentially run out of true and if not used in the same orientation each time, they can cause variation of reading.

II. The following method is described for the determination of the variation b_{int} due to the drive interface. This value may be determined statistically for a sufficient number of specimens at least 10 of a model of tool and its determination does not need to be repeated each time for future calibrations of this model.

III. The torque tool is removed from the calibration system and the drive interface is rotated by 60° (hexagonal drive output) or 90° (square drive output). Ten measurements are recorded for each of at least four positions distributed evenly over 360°, at the lower limit value of the measurement range, without changing the load application point.

$$b_{int} = max(\bar{x}_{\text{ri}}) - \min(\bar{x}_{\text{ri}})$$

$$w_{int} = \frac{b_{int} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

IV. The degree of freedom *v*, *v = 12.5*

10.6 Uncertainty due to the length variation of the torque loading point, w_{bl}.

I. Most torque wrenches have some variation in torque observed depending on the exact force loading point on the handle. This does apply to both indicating and setting wrenches, but not to torque screwdrivers of either type. For torque screwdrivers, the value of bl shall be set to zero.

II. Where the loading point is not marked on the torque tool and no manufacturer information is available, the dimension from the axis of rotation to the loading point used shall be documented.

III. The following method is described for the determination of the force loading point variation, bl. This value may be determined statistically for a sufficient number of specimens at least 10 of a model of tool and its determination does not need to be repeated each time for future calibrations of this model.

IV. Ten measurements are then recorded for each of two positions with changed force loading point, at the lower limit value of the measurement range, Tmin. The two force loading points shall be 10 mm on either side of the centre of the hand hold position or the marked loading point.

V. The mean value of the 10 values at the longest lever length are subtracted from the mean value of the measurements of the shortest lever length and this value is defined as the force loading point variation.

$$b_l = \bar{x}\ short - \bar{x}\ long$$

$$w_l = \frac{b_l \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$$

VI. The degree of freedom *v*, *v = 12.5*

10.7 Determination of the relative standard measurement uncertainty, *w*.

I. The relative standard measurement uncertainty, *w*, assigned to the torque tool at each calibration point is given for uncorrelated input quantities.

$$w = \sqrt{\left(\frac{W_{md}}{2}\right)^2 + {w_{re}}^2 + {u_{rep}}^2 + {w_{res}}^2 + {w_{od}}^2 + {w_{int}}^2 + {w_l}^2}$$

II. Proposed distribution and corresponding standard uncertainty.

Quantity	Evaluation of standard uncertainty	Distribution function	Relative standard measurement uncertainty, *w* in %
Repeatability	Type A	Normal	$w_{re} = \frac{s}{\sqrt{n}} \times \frac{100}{\bar{x}r}$
Reference Torque Calibrator	Type B	Normal	$w_{md} = \frac{W}{2}$

Resolution of the torque tools	Type B	Rectangular	$u_{res} = \frac{r \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$
Reproducibility	Type B	Rectangular	$u_{rep} = \frac{b_{rep} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$
Geometric effects of the output drive of the torque tool	Type B	Rectangular	$w_{od} = \frac{b_{od} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$
Geometric effects of the interface between the output drive of thetorque tool and the calibration system	Type B	Rectangular	$w_{int} = \frac{b_{int} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$
The length variation of the torque loading point	Type B	Rectangular	$w_{l} = \frac{b_{l} \times 0.5}{\sqrt{3}} \times \frac{100}{\bar{x}r}$
Combined standard uncertainty	$w = \sqrt{\left(\frac{W_{md}}{2}\right)^2 + {w_{re}}^2 + {u_{rep}}^2 + {w_{res}}^2 + {w_{od}}^2 + {w_{int}}^2 + {w_{l}}^2}$		

10.8 Determination of the relative expanded measurement uncertainty, *W*.

I. The relative expanded measurement uncertainty, *W*, of the calibration result for the torque tool is calculated from the standard measurement uncertainty by multiplication by the coverage factor, k. The default value of k = 2. A check shall be made in order to ensure a confidence interval of approximately 95 %. The value for w shall first be rounded to three decimal places.

$$W = k \times w$$

10.9 Determination of the relative measurement uncertainty interval, *W'*.

The relative uncertainty interval, *W'*, of a calibration including all systematic and random components shall be calculated.

$$W' = |\overline{as}| + W + |b_{ep}|$$

where:

$\overline{as}$: the mean value of relative measurement error at each calibration torque.

W : the relative expanded measurement uncertainty

b_{ep} : the Stated relative measurement error of the measurement device.

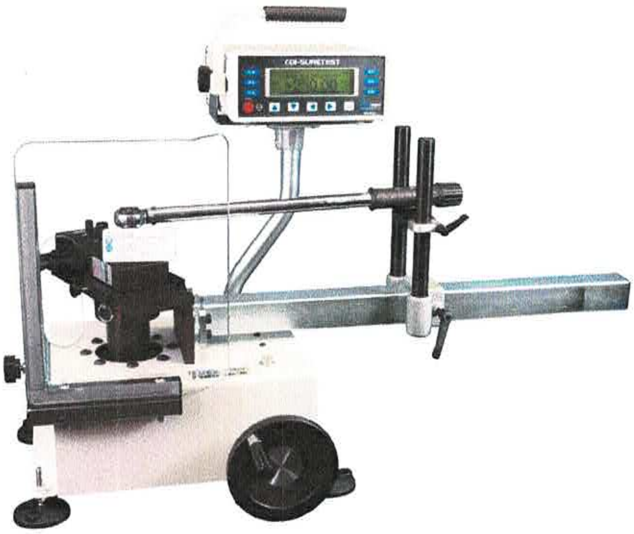
$$b_{ep} = \frac{b_{e,max}}{X_r} \times 100 \text{ in } \%$$

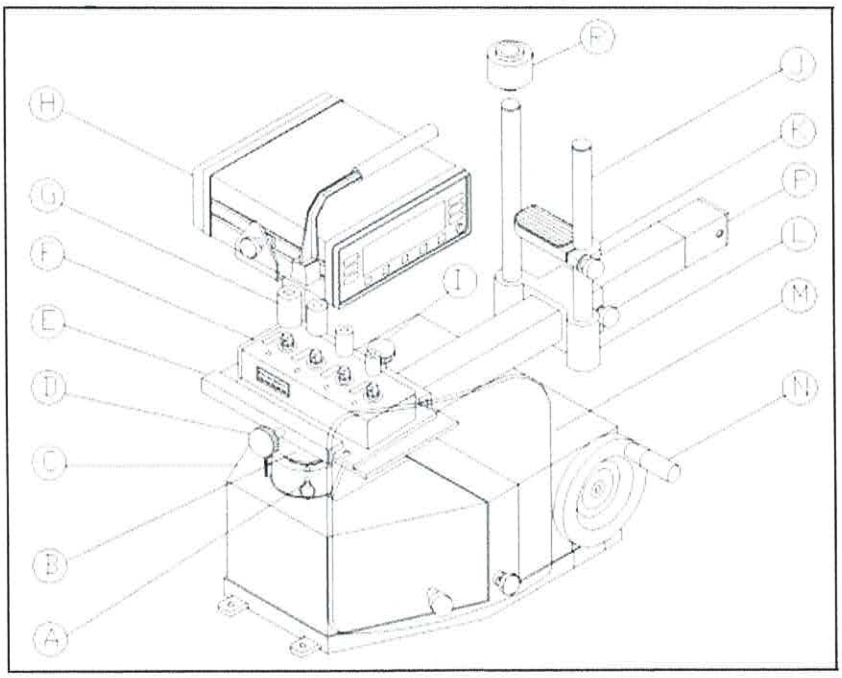
11 Calibration System Standards

11.1 Torque Transducer

Components	Range	
Transducer (4–in- 1)	4-50 in.lb.	
	30-400 in.lb.	
	80-1000 in.lb.	
	20-250 ft.lb.	
Single Transducer	60-600 ft.lb.	

11.2 Calibration system - CDI SURETEST MODEL 5000-3





Item	Description	Item	Description
A	Quick release pin (Transducer)	I	Top thumb screw
B	4-in-1 Transducer Standoff	J	Tube, Load (Part of rest assembly)
C	600TL (Manual Loader)	K	Rest, Adjustable
D	Side thumb screw	L	Reaction Slide Assembly
E	4-in-1 Adapter Bracket	M	Safety shield
F	Multiple Transducers	N	Hand Crank
G	Drive Adaptors	P	Extendable Reaction Bar
H	SURETEST	R	Linear Bearing Assembly

11.3 Safety Procedure

Note: All safety procedure highlighted in this Section is labelled as ***WARNING***, derived from Equipment Manual - SURETEST AND 600TL Model 5000-3 Torque Calibration System User Manual.

WARNING indicates a potential hazard which, if not avoided, could result in death or serious injury to the operator or to bystanders.

11.3.1 Risk of electric shock and fire.

I. For indoor use only. Do not expose charger to rain or snow. Do not use in damp locations.

II. Replace defective cord immediately. Return to qualified service centre for replacement. Electric shock or fire can cause injury.

11.3.2 Flying particles can discharge when applying torque.

I. Users and bystanders must wear safety goggles.

II. Always wear safety goggles when applying torque.

III. Do not use this equipment with the power off. Always turn on the indicator and loader so the torque and load values are indicated on the display. The safety relays only work when the power is on. Flying particles can cause injury.

11.3.3 Risk of entanglement.

I. When starting power tools, check for obstacles near your hand and anticipate the reaction force by gripping the tool firmly.

II. Do not wear loose clothing and jewellery while operating a power tool. Loose clothes and jewellery can be caught in moving parts.

III. Keep body parts away from rotating parts.

IV. Wear a protective hair covering to contain long hair and prevent contact with moving parts.

V. Do not overreach. Keep proper footing and balance at all times. Entanglement can cause injury.

11.3.4 Improper use can cause breakage.

I. Read instructions before operating.

II. Follow manufacturer's instructions, safety precautions, and specifications when operating tools. Broken equipment can cause injury.

11.3.5 Additional Warnings

I. Make sure all components, including adaptors, extensions, drivers and sockets are rated to match or exceed the torque or load being applied.

II. Be sure the capacity of the ***5000-3*** system matches or exceeds each application before performing a procedure.

III. Do not use the ***5000-3*** system if it makes unusual noises, has loose parts, or shows any other sign of damage. Have repairs performed at a ***CDI Service Center*** before use.

IV. Do not use chipped, cracked, or damaged sockets and accessories.

V. Do not remove any labels. Replace any damaged label.

VI. Follow good, professional tool practices:

** *Pull on a wrench handle* ** ***do not push*** ** and adjust stance to prevent a possible fall.

** ***Do not use extensions***, such as a pipe, on a wrench handle.

VII. When using ratchets, make sure the direction lever is fully engaged in the correct position.

VIII. Never attempt to test an impact tool on this instrument.

IX. Always position the 40" arm over the front of the stand as shown. Never extend the test arm behind the stand. The stand will tip over when weights are applied.

X. Always be alert to the potential for personal injury that may be caused by excessive torque applications, careless handling of heavy weights, and out-of-balance or unsafe weight distribution.

12. FORMS

I. GAM/CL-F17: Calibration Records

II. GAM/CL-F19: Delivery Order

III. GAM/CL-F32: Torque Wrench Tools Calibration Form

Galaxy Aerospace

CALIBRATION FORM
TORQUE WRENCH TOOLS

Work Order No.	

UNIT UNDER CALIBRATION

EQUIPMENT/TOOL ID:	
ITEM DESCRIPTION:	
MODEL NO:	
MANUFACTURER BY:	
SERIAL NO:	
SIZE/RANGE/CAPACITY:	
READABILITY:	
RESOLUTION:	
THERMAL EXPANSION	

STANDARD(S) EQUIPMENT USED

ITEM DESCRIPTION:	
PART NO:	
SERIAL NO:	
UNCERTAINTY:	
DRIFT:	

CALIBRATION SUMMARY

CALIBRATION DATE:			CERTIFICATE NO:		
CALIBRATION VALID UNTIL:			CONDITION OF THE TOOL:	BEFORE	AFTER
TEMPERATURE:	Min °C	Max °C			
HUMIDITY:	Min % rh	Max % rh			

UNITS:	N.m	cN.m	N.cm	kgf.cm	kgf.m	gf.m	lbf.ft	lbf.in	ozf.in	

(ACTUAL)

TARGET VALUE	REFERANCE VALUE Xa	REFERENCE VALUE Xr	MEASUREMENT ERROR Xa - Xr	RELATIVE MEASUREMENT ERROR a s %
Xa = at min T max				
		Xr =		a =
Xa= at 60% T max				
		Xr =		a =
Xa= at 100% T max				
		Xr =		a =

Remarks/Comments

	Name & Signature	Date	Company Stamp Holder
Calibrated By:			
Certified By:			

Page 1 of 1 GAM/CL-F32 REV 1 (08/24)

CALIBRATION TECHNICAL PROCEDURES

PRESSURE
CL-TP-03

1 PURPOSE

1.1 The purpose of this Pressure Calibration Procedure is to establish procedure to identify and calibrate pressure measuring equipment used for Galaxy Aerospace (M) Sdn. Bhd. Calibration Laboratory (GAM CL).

1.2 This document specifies this document is to specify requirements with which a laboratory must operate and demonstrate its competency to carry out calibration in accordance with ISO DKD-R 6-1 and MS ISO/IEC 17025:2017.

1.3 Implementation of this calibration procedure ensures that the pressure measuring equipment used are properly identified and calibrated at appropriate intervals to maintain accuracy within specified limits.

2 SCOPE

2.1 This procedure lays down the specific requirements for calibration of torque indicating devices used in Calibration Laboratory (GAM CL).

2.2 Pressure measuring equipment calibration that is within GAM CL capability are as follows:

Components	Type	RANGE
Pressure Measuring Equipment	Pressure Gauge	0 – 135 bar 0 – 350 bar 0 – 700 bar

3 CALIBRATION DEVICE STANDARDS

Components	Range	Part Number
Pressure Module	0 – 135 bar	PM620-17G
	0 – 350 bar	PM620-20A
	0 – 700 bar	PM620-22A

4 REFERENCES

I. MS ISO/IEC 17025:2017 - General requirements for the competence of testing and calibration laboratories
II. Guideline DKD-R 6-1 - Calibration of Pressure Gauges
III. Druck DPI612 - Portable Pressure Calibrator User Manual – 109M4017
IV. ISO GUM - Guide for determination of measurement uncertainty
V. GAM/WI-DPI 612/01- Work Instruction for DPI 612 Pressure Calibrator.
VI. GAM/CL/P – Calibration Laboratories Procedure

5 DEFINITIONS

5.1 For the purpose of this procedure, the term and definition are given in JCGM publication.

6 CALIBRATION CONDITION

6.1 Calibration shall be carried out at a temperature of 20°C ± 2°C. Maximum relative humidity 65 % RH and shall be documented.

7 CALIBRATION CAPABILITY

7.1 The handling of a calibration order requires the calibration capability (suitability) of the calibration item, i.e. the current status of the calibration item should meet the generally recognized rules of technology as well as the specifications according to the manufacturer's instructions. The calibration capability must be ascertained by means of external inspections and functional tests.

7.1.1 External inspections cover, for example:

I. visual inspection for damage (pointer, threads, sealing surface, pressure channel)

II. contamination and cleanness

III. visual inspections regarding labelling, readability of indications

IV. checking whether the documents required for calibration (technical data, operating instructions) are available.

7.1.2 Functional tests cover, for example:

I. Leak tightness of the calibration item's line system.
II. Electrical operational capability.
III. Proper function of the control elements (e.g. zero adjustability).
IV. Adjusting elements in defined position.
V. Error-free execution of self-test and/or self-adjustment functions; if necessary, internal reference values are to be read out via the EDP interface.
VI. Torque dependence (zero signal) due to mounting.

8 CALIBRATION METHOD

8.1 The pressure gauge is to be calibrated as a whole (measuring chain), if possible. And the required mounting position is to be considered.

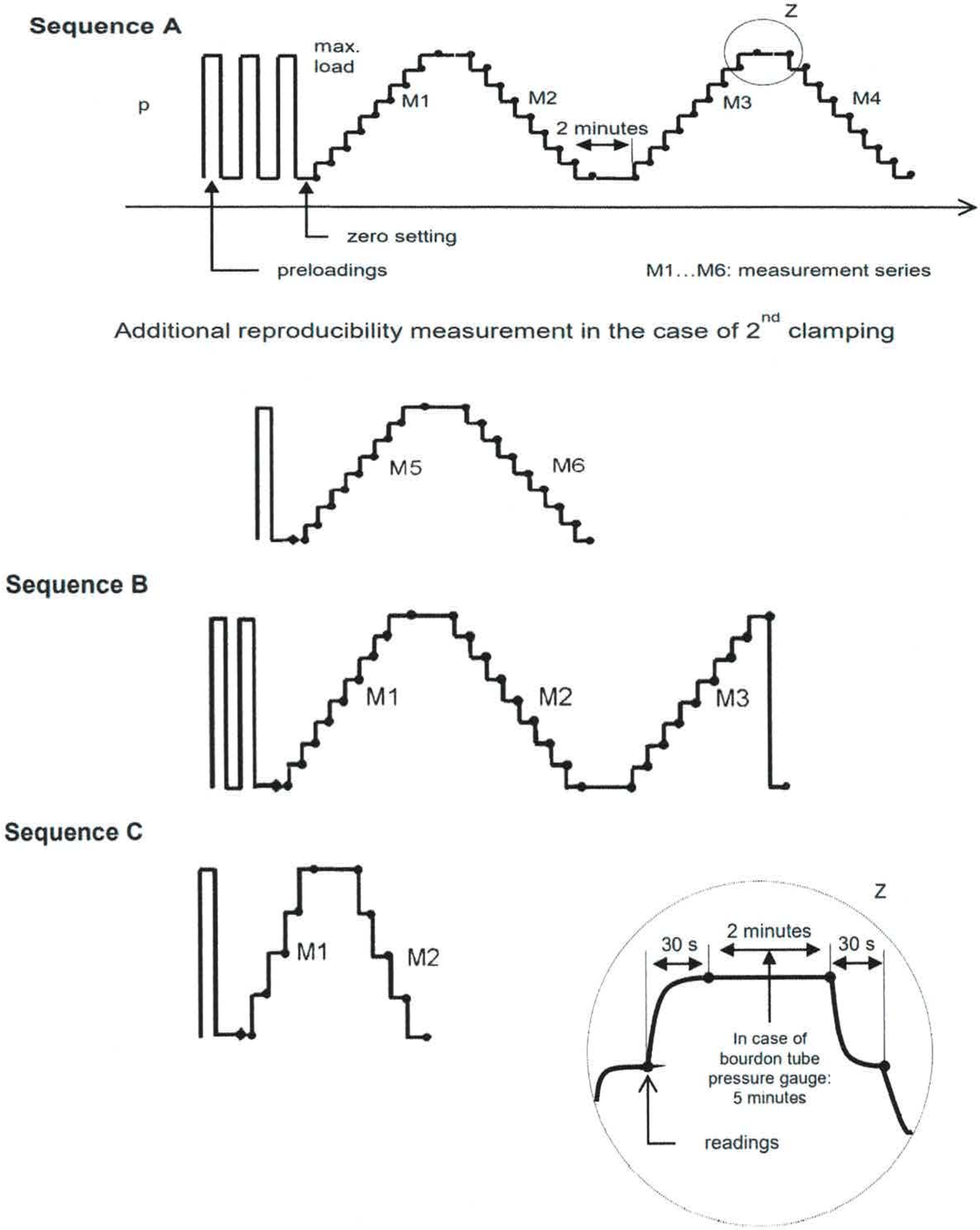
8.2 The calibration is to be carried out at equally distributed measurement points across the calibration range.

8.3 Depending on the desired measurement uncertainty, one or more measurement series are necessary (see Table 1 or Figure 2, respectively).

Table 1

Sequence		A	B	C
Desired measurement uncertainty in percentage of the measurement span (*)		<0.1	0.1…0.6	>0.6
Minimum number of measurement points with zero points up/down		9	9	9
Numbers of preloading		3	2	1
Load change + waiting time. (**) seconds		>30	>30	>30
Waiting time at upper limit of the measurement range minutes		2	2	2
Number of measurement series	Up	2	2	1
	Down	2	1	1

Figure 2



8.4 If the calibration item's behaviour regarding the influence of the torque is not sufficiently known during mounting, the reproducibility must be determined by additional clamping. In this case, the value of the torque is to be documented.

8.5 The height difference between the reference heights of the standard and the calibration item is to be minimised; otherwise, the correction is to be calculated.

8.6 The comparison of the measured value between calibration item and reference or working standard is feasible in two ways:

I. Adjustment of the pressure according to the indication of the calibration item.

II. Adjustment of the pressure according to the indication of the standard.

8.7 The preloading time at the highest value and the time between two preloadings should at least be 30 seconds. After preloading and after steady conditions have been reached, the indication of the calibration item is set to zero – provided that this is supported by the calibration item.

8.8 The zero reading is carried out immediately afterwards. As to the pressure step variation of a measurement series, the time between two successive load steps should be the same and not shorter than 30 seconds, and the reading should be performed no earlier than 30 seconds after the start of the pressure change. Especially Bourdon tube pressure gauges have to be slightly tapped to minimize any frictional effect of the pointer system. The measured value for the upper limit of the calibration range is to be registered before and after the waiting time.

8.9 The zero reading at the end of a measurement series is carried out at the earliest 30 seconds after the complete relief.

9 MEASUREMENT UNCERTAINTY

9.1 General Model of Measurement

9.1.1 The determination of the measurement uncertainty is generally carried out according to the following:

Model function			$y = f(x_1, x_2, \dots, x_N)$
Standard uncertainty	$u(x_i)$	Standard uncertainty attributed to the input/influence quantity	
	c_i	Sensitivity coefficient	$c_i = \frac{\delta f}{\delta x_i}$
	$u_i(y)$	Contribution to the standard uncertainty attributed to the output quantity due to the standard uncertainty $u(x_i)$ of the input quantity x_i	$u_i(y) = c_i \cdot u(x_i)$
	$u(y)$	Standard uncertainty attributed to the output quantity	$u^2(y) = \sum_{i=1}^{N} u_i^2(y)$

			$u(y) = \sqrt{\sum_{i=1}^{N} u_i^2(y)}$
Expanded uncertainty	$U(y)$	Expanded uncertainty	$U(y) = k \cdot u(y)$
	k	Coverage factor	$k = 2$ *for a measurand of largely normal distribution and a coverage probability of approximately 95%*

9.1.2 General mathematical model for pressure gauge.

$$\Delta p_{up/down} = p_{ind,up/down} - p_{standard} + \sum_{i=1}^{2} \delta pi$$

$$= p_{ind,up/down} - p_{standard} + \delta p_{zero\ deviation} + \delta p_{repeatability}$$

Where:

$\Delta p_{up/down}$ = output quantity deviation index up/down of pressure gauge.

$p_{ind,up/down}$ = indication index up/down of pressure gauge.

$P_{standard}$ = value of the reference standard.

$\delta p_{zero\ deviation}$ = influence quantity of zero deviation.

$\delta p_{repeatability}$ = influence quantity of repeatability.

$$\Delta p_{mean} = p_{ind,mean} - p_{standard} + \sum_{i=1}^{3} \delta pi$$

$$= p_{ind,mean} - p_{standard} + \delta p_{zero\ deviation} + \delta p_{reapeatability} + \delta_{hysteresis}$$

Where:

Δp_{mean} = output quantity deviation mean of pressure gauge.

$p_{ind,mean}$ = indication index mean of pressure gauge.

$p_{standard}$ = value of the reference standard.

$\delta p_{zero\ deviation}$ = influence quantity of zero deviation.

$\delta p_{repeatability}$ = influence quantity of repeatability.

$\delta p_{hysteresis}$ = influence quantity of hysteresis.

$$p_{ind,mean} = \frac{p_{ind,up} + p_{ind,down}}{2}$$

Where:

$p_{ind,mean}$ = indication index mean of pressure gauge.

$P_{ind,up}$ = indication value of the up reading pressure gauge.

$P_{ind,down}$ = indication value of the down reading pressure gauge.

9.2 Uncertainty components of the pressure calibration to be considered but not limited to:

I. Repeatability, u_{rep}

II. Uncertainty due to Standard equipment, u_{std}

III. Uncertainty due to Accuracy of Standard Equipment drift, u_{dri}

IV. Resolution, u_{res}

V. Hysteresis, u_{hy}

9.3 Sources of Uncertainty

9.3.1 Uncertainty due to Repeatability

I. Repeatability is the measurement precision under a set of repeatability conditions of measurement.

II. Calculating repeatability uncertainty involve taking 'n' number of measurement, calculating the mean and standard deviation.

$$s = \frac{|I1 - I2|}{2}$$

III. Uncertainty due to repeatability:

$$u_{rep} = \frac{s}{\sqrt{3}}$$

IV. The degree of freedom *v*, *v* = *n-1*

9.3.2 Uncertainty due to Standard Equipment

I. Uncertainty of standard equipment is mentioned on the calibration certificate along with the k value.

II. Uncertainty due to Standard Equipment:

$$u_{ref} = u_{ref} = \frac{a}{k}$$

III. The degree of freedom *v, v = 50*

9.2.4 Uncertainty due to reference drift, u_{dri}

I. This value should be taken from the history of the calibration device certificate, where the worst drift value will be taken for calculation uncertainty.

II. The value a taken from worst drift from the history of the calibration device certificate.

$$u_{dri} = \frac{a}{\sqrt{3}}$$

III. The degree of freedom *v, v = 12.5*

9.2.5 Uncertainty due to Resolution

I. Uncertainty due to Resolution, u_{res} can be measured by finding the least significant digit at measurement system or equipment and observe the smallest incremental change.

II. For digital indicating device, after determining whether the instrument counts or rounds the last digit; divide the resolution by 1 for counted values or 2 for rounded values.

III. For analog indicating device, resolution of the indicating device is obtained from the ratio of the pointer width to the centre distance of two adjacent graduation lines (scale interval). 1/2, 1/5 or 1/10 is recommended as ratio. If the ratio shall be 1/10 (i.e. the estimable fraction of a scale interval), the scale spacing must be 2.5 mm or greater.

IV. Uncertainty due to resolution, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ Changing\ Pressure}{\sqrt{3}}$$

V. Uncertainty due to readability for digital pressure gauge, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ UUT}{\sqrt{12}}$$

VI. The degree of freedom *v, v = 12.5*

9.2.6 Uncertainty due to Hysteresis

I. Hysteresis is the difference between Down Cycle reading and UP cycle reading.

II. Uncertainty due to hysteresis, u_{hy} can be calculated as follows:

$$u_{hy} = \frac{Down\,reading - Up\,Reading}{\sqrt{3}}$$

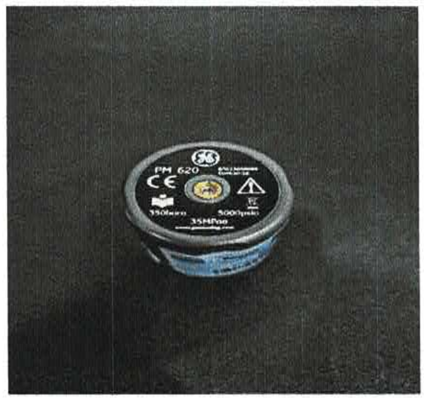
III. The degree of freedom *v*, *v = 12.5*

9.3 Proposed distribution and corresponding standard uncertainty

Quantity	Evaluation of standard uncertainty	Distribution function	Standard uncertainty, u
Repeatability	Type A	Rectangular	$u_{rep} = \frac{\|I1 - I2/2\|}{\sqrt{3}}$
Resolution of the torque tools	Type B	Rectangular (analogue)	$u_{res} = \frac{r}{\sqrt{3}}$
		Step (digital)	$u_{res} = \frac{r}{\sqrt{12}}$
Standard Equipment	Type B	Normal	$u_{ref} = \frac{U}{k}$
Reference Drift	Type B	Rectangular	$u_{dri} = \frac{a}{\sqrt{3}}$
Hysteresis	Type B	Rectangular	$u_{hys} = \frac{h}{\sqrt{3}}$
Combined standard uncertainty	$u_c = \sqrt{u_{rep}^2 + 2u_{res}^2 + u_{std}^2 + u_{acc\,std} + u_{hys}}$		
Expanded uncertainty	$U = k \cdot u_c, k = 2$		

10 Calibration System Standards

10.1 Pressure Module

Components	Range	
Pressure Module PM620-17G	0 – 135 bar	
Pressure Module PM620-20A	0 – 350 bar	
Pressure Module PM620-20A	0 – 700 bar	

10.2 Druck DPI612 (hFlexPro)

Item	Description	Item	Description
1	ON/OFF button	9	Pressure connection for a relief valve (PRV)
2.1	Volume adjuster wheel with fold-in handle	10	Pressure and electrical connections for a PM620 module
4	Test port	11	Hydraulic refill valve
5	Pneumatic pressure release valve	12	Hand straps
6	CH1 connectors	13	+5 V DC power input socket
7	Isolated CH2 connectors	14	USB type A connector
8	Liquid Crystal Display (LCD)	15	USB mini-type B connector

10.3 Safety Procedure

I. Reference: Druck DPI612 User Manual

II. Read and obey all the operator's local health and safety regulations and safe working procedures or practices when doing a procedure or task.

10.4 General

Use only the approved tools, consumable materials and spares to operate and maintain the equipment.

I. Use equipment only for the purpose for which it is provided.

II. Wear all applicable Personal Protective Equipment (PPE).

III. Do not use sharp objects on the touchscreen.

IV. Observe absolute cleanliness when using the instrument.

V. Severe damage can be caused if equipment connected to this instrument is contaminated.

VI. Connect only clean equipment to the instrument. To avoid any contamination, an external Dirt Moisture Trap is recommended.

VII. Some liquid and gas mixtures are dangerous. This includes mixtures that occur because of contamination. Make sure that the equipment is safe to use with the necessary media.

VIII. Read and obey all applicable WARNING and CAUTIONS signs.

10.4.1 Make sure that:

I. All work areas are clean and clear of unwanted tools, equipment and materials.

II. All unwanted consumable materials are disposed in accordance with local health and safety and environmental regulations.

III. All equipment is serviceable.

10.5 Warnings

I. Do not ignore the specified limits for the instrument or its related accessories. This can cause injuries.

II. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

III. Do not use the instrument in locations with explosive gas, vapour or dust. There is a risk of an explosion.

11 FORMS

I. GAM/CL-F17: Calibration Records

II. GAM/CL-F19: Delivery Order

III. GAM/CL-F31: Pressure Gauge Calibration Form

Galaxy Aerospace

CALIBRATION FORM
PRESSURE GAUGE

Work Order No.	

UNIT UNDER CALIBRATION

EQUIPMENT/TOOL ID:	
ITEM DESCRIPTION:	
MODEL NO:	
MANUFACTURER BY:	
SERIAL NO:	
SIZE/RANGE/CAPACITY:	
READABILITY:	
RESOLUTION:	
THERMAL EXPANSION	

STANDARD(S) EQUIPMENT USED

ITEM DESCRIPTION:	
PART NO:	
SERIAL NO:	
UNCERTAINTY:	
DRIFT:	

CALIBRATION SUMMARY

CALIBRATION DATE:			CERTIFICATE NO:		
CALIBRATION VALID UNTIL:			CONDITION OF THE TOOL:	BEFORE	AFTER
TEMPERATURE:	Min °C	Max °C			
HUMIDITY:	Min % rh	Max % rh			

UNITS:	Bar	Psi	kg/cm²	kPa	mmH2O	inH2O	mmHg	inHg	Mbar	MPa	

(ACTUAL)

Nominal Value	Reference Value	UUT Increasing			UUT Decreasing			Correction		Repeatability		Hysteresis
		I1	I2	Mean	D1	D2	Mean	Increasing	Decreasing	Increasing	Decreasing	

Remarks/Comments

	Name & Signature	Date	Company Stamp Holder
Calibrated By:			
Certified By:			

Notes:

1. Correction Column for Increasing - Reference Pressure Minus (-) UUT Increasing Mean
2. Correction Column for Decreasing - Reference Pressure Minus (-) UUT Decreasing Mean
3. Repeatability Column for Increasing - (I1-I2)/2
4. Repeatability Column for Decreasing - (D1-D2)/2
5. Hysteresis Column - UUT Mean Increasing Minus (-) UUT Mean Decreasing

Page 1 of 1 GAM/CL-F31 REV 1 (08/24)

CALIBRATION TECHNICAL PROCEDURES

DIMENSIONAL

CL-TP-04

1 PURPOSE

1.1 The purpose of this Dimensional Calibration Procedure is to establish procedure to identify and calibrate dimensional measuring equipment used for Galaxy Aerospace (M) Sdn. Bhd. Calibration Laboratory (GAM CL).

1.2 This document specifies this document is to specify requirements with which a laboratory must operate and demonstrate its competency to carry out calibration in accordance with ASME B89.1.14-2018, ASME B89.1.13-2013, JIS B 7502:2016 and MS ISO/IEC 17025:2017.

1.3 Implementation of this calibration procedure ensures that the pressure measuring equipment used are properly identified and calibrated at appropriate intervals to maintain accuracy within specified limits.

2 SCOPE

2.1 This procedure lays down the specific requirements for calibration of torque indicating devices used in Calibration Laboratory (GAM CL).

2.2 Pressure measuring equipment calibration that is within GAM CL capability are as follows:

Components	Type	RANGE
Dimensional Measuring Equipment	Caliper	0.5000 mm – 100.0000 mm 25.000 mm – 200.000 mm 0.0625 inch – 2.000 inch 1.000 inch – 8.000 inch 0 mm – 300 mm
	Micrometer	0.5000 mm – 100.0000 mm 25.000 mm – 200.000 mm 0.0625 inch – 2.000 inch 1.000 inch – 8.000 inch 0 mm – 300 mm

3 CALIBRATION DEVICE STANDARDS

Components	Range	Part Number
Gauge Block	0.5000 mm – 100.0000 mm	516-950-10
	25.000 mm – 200.000 mm	516-1115-10
	0.0625 inch – 2.000 inch	516-934-16
	1.000 inch – 8.000 inch	516-126-16
Caliper Checker	0 mm – 300 mm	C1103010300
Pin Gauge	10 mm	PING-G10-10.00
Optical Flat	45 mm (0.2 µm)	158-117
Optical Parallel	25.00, 25.12, 25.25, 13.37mm,	MTY157-904

4 REFERENCES

I. MS ISO/IEC 17025:2017 - General requirements for the competence of testing and calibration laboratories

II. ASME B89.1.14-2018-Caliper

III. ASME B89.1.13-2013-Micrometers.

IV. JIS B 7502:2016

V. ISO GUM - Guide for determination of measurement uncertainty

VI. GAM/CL/P – Calibration Laboratories Procedure

5 DEFINITIONS

5.1 For the purpose of this procedure, the term and definition are given in JCGM publication.

6 CALIBRATION CONDITION

6.1 Calibration shall be carried out at a temperature of 20°C ± 1°C. Maximum relative humidity 65 % RH and shall be documented.

7 CALLIPERS

7.1 Calibration Device Standards

Components	Range	Part Number
Gauge Block	0.5000 mm – 100.0000 mm	516-950-10
	25.000 mm – 200.000 mm	516-1115-10
	0.0625 inch – 2.000 inch	516-934-16
	1.000 inch – 8.000 inch	516-126-16
Caliper Checker	0 mm – 300 mm	C1103010300
Pin Gauge	10 mm	PING-G10-10.00

7.2 Pre-Calibration

7.2.1 Ensure that calliper function as normal before calibration.

7.2.2 Check the measuring jaws/scale/pointer/beam are all in satisfactory condition before proceeding with calibration.

7.2.3 Clean the surfaces on the calliper using alcohol and stabilize the IUT inside the calibration environment for at least 2 hours.

7.2.4 Closing the jaws tightly and holding the calliper to a light source. If you do not see light breaking through at any point along the jaw boundary proceeding for calibration.

7.2.5 Zero the measuring jaws and depth gauge adjust as necessary.

7.3 Calibration Method

7.3.1 Partial surfaces contact error E (maximum permissible error, EMPE)

I. Place the specified length of Calliper Checker between the measuring faces for external measurements.

II. Measure at root, middle and tip side of the faces.

III. Take minimum of three test points.

7.3.2 Repeatability of Partial surface contact error R (maximum permissible error RMPE)

I. This measurement is the closeness of agreement between the results of successive measurements of same measurand.

II. Place the specified length of Calliper Checker between the measuring faces for external measurements.

III. Measure at any position on the jaws under same condition of measurements.

7.3.3 Scale shift error S (maximum permissible error SMPE)

I. Scale shift error is the error of indication when using measuring faces other than the measuring faces for external measurement e.g: internal measurement and depth measurement provided that a full contact of measuring surfaces.

II. Place the specified length of Calliper Checker between the measuring faces for internal measurements.

III. Measure at any position on the jaws under same condition of measurements.

7.3.4 Line contact error L (maximum permissible error LMPE)

I. Error of indication when a measuring face line contact is employed, to be applied for external measurement.

II. Tolerance should be 0.05 mm or under.

III. Shall be tested by measuring a cylindrical measurement standard (approximately 10 mm pin gauge) at different positions along the jaws. Perpendicular to the plane of jaws.

7.4 Measurement Uncertainty

7.4.1 General Model of Measurement

I. The determination of the measurement uncertainty is generally carried out according to the following:

Model function			$y = f(x_1, x_2, \dots, x_N)$
Standard uncertainty	$u(x_i)$	Standard uncertainty attributed to the input/influence quantity	
	c_i	Sensitivity coefficient	$c_i = \frac{\delta f}{\delta x_i}$
	$u_i(y)$	Contribution to the standard uncertainty attributed to the output quantity due to the standard uncertainty $u(x_i)$ of the input quantity x_i	$u_i(y) = c_i \cdot u(x_i)$
	$u(y)$	Standard uncertainty attributed to the output quantity	$u^2(y) = \sum_{i=1}^{N} u_i^2(y)$ $u(y) = \sqrt{\sum_{i=1}^{N} u_i^2(y)}$
Expanded uncertainty	$U(y)$	Expanded uncertainty	$U(y) = k \cdot u(y)$
	k	Coverage factor	$k = 2$ *for a measurand of largely normal distribution and a coverage probability of approximately 95%*

7.4.2 General mathematical model for length

$$L_{20} = E + L_S - L_S(d\alpha \cdot \beta s + \alpha s \cdot d\beta) + G + L$$

where:

L_{20} = Length Test at 20°C

L_S = Length Reference

E = Error

dα = Difference in thermal expansion between Test and Reference

βs = Temperature of Reference

αs = Thermal expansion of Reference

dβ = Difference in temperature between Test and Referance

G = Geometric error

L = Line contact error

7.4.3 General equation deviation from reference temperature.

$$\Delta L = L\Delta\alpha(20 - T)$$

where:
$L =$ the nominal length
$T =$ the temperature
$\Delta\alpha =$ the difference in CTE between the gage blocks and the micrometer.

7.4.4 Uncertainty components of the measurement calibration to be considered but not limited to:

I. Reference Gauge Blocks/Calliper Checker, u_{ref}

II. Repeatability, u_{rep}

III. Readability, u_{res}

IV. Reference Drift, u_{dri}

V. Nominal Coefficient of Thermal Expansion (Ref & UUT), $u_{nomCTEuut}$ /$u_{nomCTEref}$

VI. Nominal Coefficient of Thermal Expansion Difference, $u_{nomCTEdiff}$

VII. Different of Temperature During Handling of Reference and UUT, $u_{tempdiff}$

VIII. Geometrical Error, u_{geo}

IX. Line Contact Error, u_{line}

X. Nominal Coefficient of Thermal Expansion (Pin Gauge), $u_{nomCTEpigauge}$

XI. Pin Gauge Uncertainty, $u_{pingauge}$

XII. Data logger, $u_{dlogger}$

XIII. Resolution of data logger, $u_{dlogres}$

7.5 Sources of Uncertainty

7.5.1 Uncertainty due to Reference Equipment

I. Uncertainty of standard equipment is mentioned on the calibration certificate along with the k value.

$$u_{ref} = \frac{U}{k}$$

II. The degree of freedom *v*, *v = 50*

7.5.2 Uncertainty due to Repeatability

I. Repeatability is the measurement precision under a set of repeatability conditions of measurement.

II. Calculating repeatability uncertainty involve taking 'n' number of measurement, calculating the mean and standard deviation.

III. The standard uncertainty is given by:

$$u_{rep} = \frac{s}{\sqrt{n}}$$

IV. The degree of freedom *v*, *v = n-1*

7.5.3 Uncertainty due to Readability

I. Uncertainty due to Readability, u_{res} can be measured by finding the least significant digit at measurement system or equipment and observe the smallest incremental change.

II. For digital indicating device, after determining whether the instrument counts or rounds the last digit; divide the resolution by 2.

III. Uncertainty due to readability for analogue caliper, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ UUT/2}{\sqrt{3}}$$

IV. Uncertainty due to readability for digital caliper, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ UUT}{\sqrt{12}}$$

V. The degree of freedom *v*, *v = 12.5*

7.5.4 Uncertainty due to due to Reference Drift

I. The reference drift can be taken by referring to reference equipment past calibration certificates and observe the values change based on reference equipment history.

$$u_{drift} = \frac{Reference\ drift}{\sqrt{3}}$$

II. The degree of freedom *v*, *v = 12.5*

7.5.5 Nominal Coefficient of Thermal Expansion (Reference Equipment & UUT)

I. The next contribution is from the uncertainty in the Nominal Coefficient of Thermal Expansion Reference equipment & UUT.

II. The standard uncertainty for Nominal CTE of Reference:

$$u_{nomCTEref} = \frac{(L)(20 - T)(CTEref)}{\sqrt{3}}$$

III. The standard uncertainty for Nominal CTE of UUT:

$$u_{nomCTEuut} = \frac{(L)(20 - T)(CTEuut)}{\sqrt{3}}$$

IV. The degree of freedom *v*, *v = 12.5*

7.5.6 Nominal Coefficient of Thermal Expansion Difference

I. The next contribution is from the Nominal Coefficient of Thermal Expansion Difference between the reference and UUT.

II. The standard uncertainty is:

$$u_{nomCTEdiff} = \frac{(L)(20 - T)(|CTEref - CTEuut|)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

7.5.7 Different of Temperature During Handling of Reference and UUT

I. The next contribution is from the Different of Temperature During Handling of Reference and UUT could be as much as 0.5 °C.

II. Uncertainty due to Different of Temperature During Handling of Reference and UUT:

$$u_{tempdiff} = \frac{(L)(0.5)(CTErefxCTEuut/2)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

7.5.8 Geometrical Error (Parallelism)

I. The next contribution for uncertainty is from the geometrical error or from parallelism error.

II. The standard uncertainty is then given by:

$$u_{geo} = \frac{a}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

7.5.9 Line Contact Error

I. The next contribution for uncertainty is from the Error of indication when a measuring face line contact is employed, to be applied for external measurement.

II. The standard uncertainty is then given by:

$$u_{line} = \frac{L}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

7.5.10 Nominal Coefficient of Thermal Expansion (Pin Gauge)

I. The next contribution is from the uncertainty in the Nominal Coefficient of Thermal Expansion of the pin gauge.

II. The standard uncertainty for Nominal CTE of Reference:

$$u_{nomCTEpigauge} = \frac{(L)(20 - T)(CTEpin\ gauge)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

7.5.11 Pin Gauge Uncertainty

I. The next contribution for uncertainty is from the pin gauge calibration.

II. The standard uncertainty is given by:

$$u_{pingauge} = \frac{U}{k}$$

III. The degree of freedom *v*, *v* = 12.5

7.5.12 Data logger

I. The next contribution for uncertainty is from the data logger calibration.

II. The standard uncertainty is given by:

$$u_{dlogger} = \frac{U}{k}(CTE_{ref} - CTE_{uut})$$

III. The degree of freedom *v*, *v* = 12.5

7.5.13 Resolution of data logger

I. The next contribution for uncertainty is from the resolution of the data logger.

II. The standard uncertainty is given by:

$$u_{dlogres} = \frac{resolution}{\sqrt{12}}(CTE_{ref} - CTE_{uut})$$

III. The degree of freedom *v*, *v* = 12.5

7.6 Proposed Distribution and Corresponding Standard Uncertainty

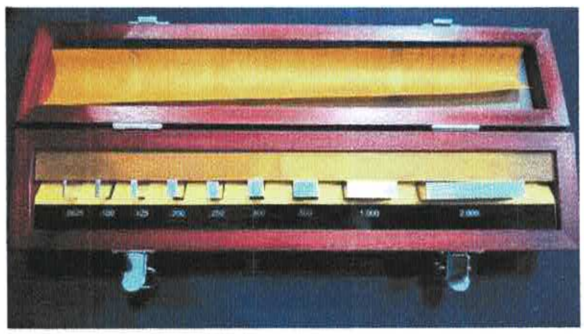
Quantity	Evaluation of standard uncertainty	Distribution function	Standard uncertainty, u in %
Reference Equipment	Type B	Normal	$u_{ref} = \frac{U}{k}$
Repeatability	Type A	Normal	$u_{rep} = \frac{s}{\sqrt{n}}$
Resolution of the Caliper or Micrometer	Type B	Rectangular (analogue)	$u_{res} = \frac{r \times 0.5}{\sqrt{3}}$ (analogue)
		Step (digital)	$u_{res} = \frac{r}{\sqrt{12}}$ (digital)
Reference Drift	Type B	Rectangular	$u_{dri} = \frac{a}{\sqrt{3}}$
Uncertainty in nominal Coefficient of Thermal Expansion	Type B	Rectangular	$u_{nomCTE} = \frac{(L)(CTE\ U_{ref} + CTE\ U_{uut})^{1/2}(20 - T)}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion (reference)	Type B	Rectangular	$u_{nomCTEref} = \frac{(L)(20 - T)(CTEref)}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion (uut)	Type B	Rectangular	$u_{nomCTEuut} = \frac{(L)(20 - T)(CTEuut)}{\sqrt{3}}$

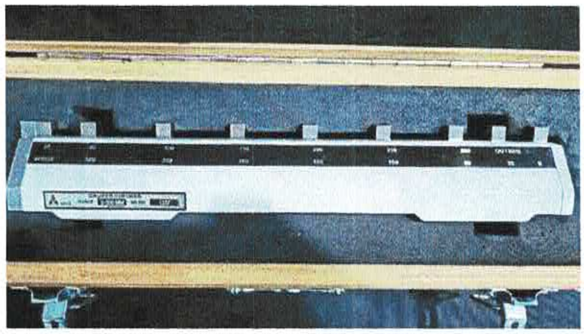
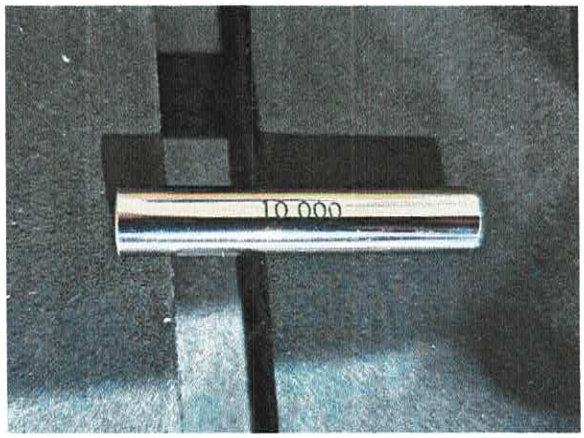
Nominal Coefficient of Thermal Expansion Difference	Type B	Rectangular	$u_{nomCTEdiff} = \frac{(L)(20-T)(\|\Delta ref - \Delta uut\|)}{\sqrt{3}}$
Different of Temperature During Handling of Reference and UUT	Type B	Rectangular	$u_{tempdiff} = \frac{(L)(0.5)(\Delta ref x \Delta uut/2)}{\sqrt{3}}$
Geometrical Error (Parallelism)	Type B	Rectangular	$u_{geo} = \frac{a}{\sqrt{3}}$
Line Contact Error	Type B	Rectangular	$u_{line} = \frac{L}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion (Pin Gauge)	Type B	Rectangular	$u_{nomCTEref} = \frac{(L)(20-T)(CTEpin\ gauge)}{\sqrt{3}}$
Pin Gauge Uncertainty	Type B	Rectangular	$u_{pingauge} = \frac{U}{k}$
Data Logger	Type B	Rectangular	$u_{dlogger} = \frac{U}{k}(CTE_{ref} - CTE_{uut})$
Data Logger Resolution	Type B	Step	$u_{dlogres} = \frac{resolution}{\sqrt{12}}(CTE_{ref} - CTE_{uut})$
Combined standard uncertainty	$u_c = \sqrt{u_{ref}^2 + u_{rep}^2 \ldots\ldots + u_{geo}}$		
Expanded uncertainty	$U = k \cdot u_c, k = 2$		

7.7 Calibration System Standards

7.7.1. Gauge Block, Calliper Checker and Pin Gauge.

Components	Range	
Gauge Block	0.5000 mm to 100.0000 mm	

Components	Range	
	25.000 mm to 200.000 mm	
Gauge Block	0.0625 inch to 2.000 inch	
	1.000 inch to 8.000 inch	

Components	Range	
Caliper Checker	0 mm – 300 mm	
Pin Gauge	10 mm	

7.8 Forms

I. GAM/CL-F17: Calibration Records
II. GAM/CL-F19: Delivery Order
III. GAM/CL-F34: Calliper Calibration Form

GalaxyAerospace

CALIBRATION FORM
CALLIPER

Work Order No.	

UNIT UNDER CALIBRATION

EQUIPMENT/TOOL ID:	
ITEM DESCRIPTION:	
MODEL NO:	
MANUFACTURER BY:	
SERIAL NO:	
SIZE/RANGE/CAPACITY:	
READABILITY:	
RESOLUTION:	
THERMAL EXPANSION:	

STANDARD(S) EQUIPMENT USED

ITEM DESCRIPTION:	
PART NO:	
SERIAL NO:	
UNCERTAINTY:	
DRIFT:	
THERMAL EXPANSION:	

CALIBRATION SUMMARY

CALIBRATION DATE:			CERTIFICATE NO:		
CALIBRATION VALID UNTIL:			CONDITION OF THE TOOL:	BEFORE	AFTER
TEMPERATURE	Min °C	Max °C			
HUMIDITY:	Min % rh	Max % rh			

FEATURE EXAMINED

1/ Partial Surface Contact Error (Parallelism Test)

External Measurement, Unit in mm/inch						
Nominal Value	Reading			Max	Min	Parallelism
	Root	Middle	Tip			Max-Min

2/ Partial Surface Contact Error & Repeatability (Tips Only)

External Measurement, Unit in mm/inch							
Nominal Value	Reference Value	Correction			Average (R1,R2,R3)	Error	Repeatability
		Reading 1	Reading 2	Reading 3			Std Dev, S

3/ Scale Shift Error (Internal Measurement)

Internal Measurement, Unit in mm/inch							
Nominal Value	Reference Value	Correction			Average (R1,R2,R3)	Error	Repeatability
		Reading 1	Reading 2	Reading 3			Std Dev, S

Galaxy Aerospace

CALIBRATION FORM
CALLIPER

4/ Line Contact Error

Nominal Value	External		Error, L
Pin Gauge	Root	Tip	[Root-Tip]

Remarks/Comments:

	Name & Signature	Date	Company Stamp Holder
Calibrated By:			
Certified By			

Page 2 of 2 GAM/CL-F34 REV.1 (08/24)

8 MICROMETRES

8.1 Calibration device standards

Components	Range	Part Number
Gauge Block	0.5000 mm – 100.0000 mm	516-950-10
	25.000 mm – 200.000 mm	516-1115-10
	0.0625 inch – 2.000 inch	516-934-16
	1.000 inch – 8.000 inch	516-126-16
Optical Flat	45 mm (0.2 µm)	158-117
Optical Parallel	25.00, 25.12, 25.25, 13.37mm,	MTY157-904

8.2 Pre-Calibration

8.2.1 Ensure that micrometre function as normal before calibration.

8.2.2 Check the measuring anvil and spindle surface are all in satisfactory condition before proceeding with calibration.

8.2.3 Clean the surfaces on the micrometre using alcohol and stabilize the IUT inside the calibration environment for at least 2 hours.

8.2.4 Closing the anvil and spindle tightly and holding the micrometre to a light source. If you do not see light breaking through at any point along the jaw boundary proceed for calibration.

8.2.5 Zero the measuring surface gauge adjust as necessary.

8.3 Calibration Method

8.3.1 Repeatability

i. This measurement is the closeness of agreement between the results of successive measurements of same measurand.

ii. Place the specified length of Gauge Block between the anvil and spindle for measurements.

iii. Measure at any position between the anvil and spindle under same condition of measurement

8.3.2 Flatness of measuring surface

I. Flatness can be estimated using an optical flat held against the anvil face.

II. Count the number of fringes seen on the anvil measuring face.

III. Each fringe represents a half wavelength difference in height.

IV. Flatness error is as the following:

$$Flatness\ error = \frac{\lambda}{2}.n$$

where

λ : Wavelength of light used
n : Maximum number of fringes

8.3.3 Parallelism

8.3.3.1 Method 1

I. Bring a combination of gauge block and optical parallel, or optical parallel into close contact with the measuring face of the anvil (to the degree that a single colour or closed curve of interference fringe is observed).

II. Count the number of fringes produced on the measuring face of a spindle using a measuring-force limiting device of the micrometre' and take it as a parallelism.

III. Parallelism error is as the following:

$$Parallelism\ error = \frac{\lambda}{2}.n$$

where

λ : Wavelength of light used
n : Maximum number of fringes

8.3.3.2 Method 2

I. Place a precision sphere or a gauge block in the centre of both measuring faces and read the indication using a measuring-force limiting device of the micrometre.

II. Place separately the gauge blocks in four corners of the measuring face, read each indication, and obtain the maximum difference. Figure1.

III. Alternatively, bring the gauge block (equal to the minimum measurable dimension) into close contact with the centre of anvil measuring face. Place separately another gauge blocks between the gauge block and the spindle measuring face, in centre and four corners of the measuring face. Figure 2.

IV. Read each indication and obtain the maximum difference.

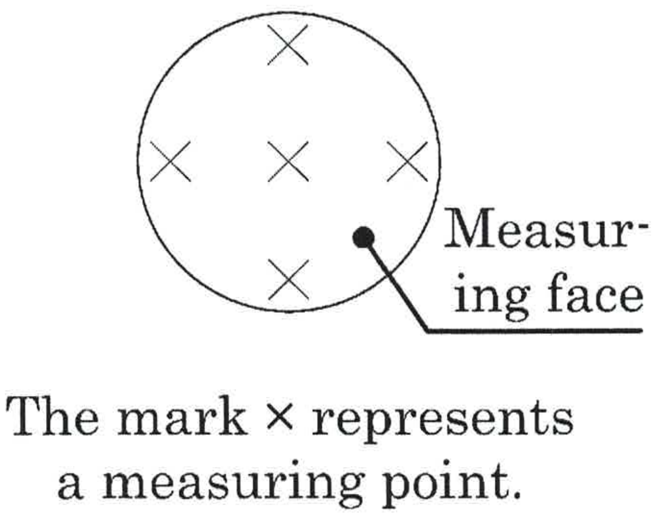


Figure 1.

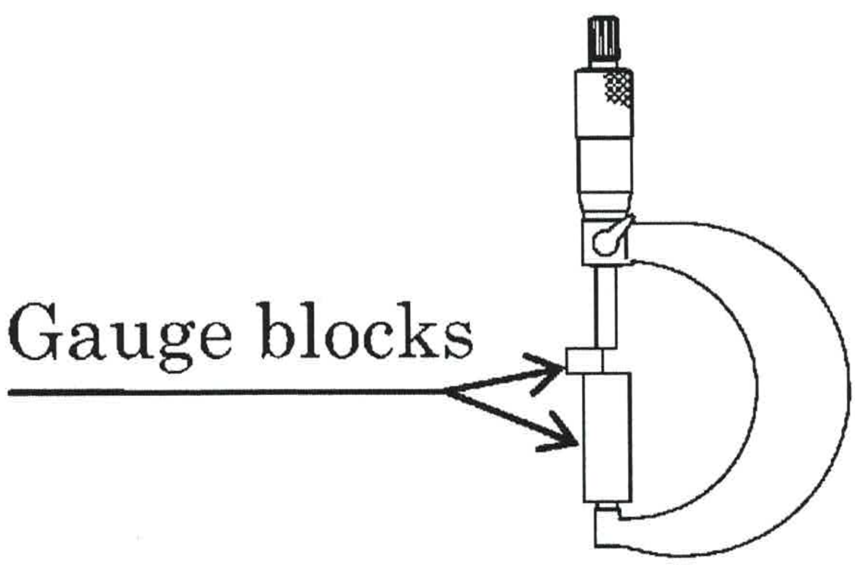


Figure 2.

8.4 MEASUREMENT UNCERTAINTY

8.4.1 General Model of Measurement

I. The determination of the measurement uncertainty is generally carried out according to the following:

Model function			$y = f(x_1, x_2, \dots, x_N)$
Standard uncertainty	$u(x_i)$	Standard uncertainty attributed to the input/influence quantity	
	c_i	Sensitivity coefficient	$c_i = \frac{\delta f}{\delta x_i}$
	$u_i(y)$	Contribution to the standard uncertainty attributed to the output quantity due to the standard uncertainty $u(x_i)$ of the input quantity x_i	$u_i(y) = c_i \cdot u(x_i)$
	$u(y)$	Standard uncertainty attributed to the output quantity	$u^2(y) = \sum_{i=1}^{N} u_i^2(y)$ $u(y) = \sqrt{\sum_{i=1}^{N} u_i^2(y)}$
Expanded uncertainty	$U(y)$	Expanded uncertainty	$U(y) = k \cdot u(y)$
	k	Coverage factor	$k = 2$ *for a measurand of largely normal distribution and a coverage probability of approximately 95%*

8.4.2 General mathematical model for length

$$L_{20} = E + L_S - L_S(d\alpha \cdot \beta s + \alpha s \cdot d\beta) + P + F$$

where:

L_{20} = Length Test at 20°C

L_S = Length Reference

E = Error

$d\alpha$ = Difference in thermal expansion between Test and Reference

βs = Temperature of Reference

αs = Thermal expansion of Reference

$d\beta$ = Difference in temperature between Test and Referance

P = Parallelism

F = Flatness

8.4.3 General equation deviation from reference temperature.

$$\Delta L = L\Delta\alpha(20 - T)$$

where:
$L =$ the nominal length
$T =$ the temperature
$\Delta\alpha =$ the difference in CTE between the gage blocks and the micrometer.

8.4.4 Uncertainty components of the measurement calibration to be considered but not limited to:

I. Reference Gauge Blocks, u_{ref}

II. Repeatability, u_{rep}

III. Readability, u_{res}

IV. Reference Drift, u_{dri}

V. Uncertainty in nominal Coefficient of Thermal Expansion, u_{nomCTE}

VI. Nominal Coefficient of Thermal Expansion (Ref & UUT), $u_{nomCTEuut}$ / $u_{nomCTEref}$

VII. Nominal Coefficient of Thermal Expansion Difference, $u_{nomCTEdiff}$

VIII. Different of Temperature During Handling of Reference and UUT, $u_{tempdiff}$

IX. Geometrical Error (flatness), u_{flat}

X. Geometrical Error (parallelism), u_{par}

XI. Data logger, $u_{dlogger}$

XII. Resolution of data logger, $u_{dlogres}$

XIII. Wringing, u_{wrin}

8.5 Sources of Uncertainty

8.5.1 Uncertainty due to Reference Equipment

I. Uncertainty of standard equipment is mentioned on the calibration certificate along with the k value.

$$u_{ref} = \frac{U}{k}$$

II. The degree of freedom *v*, *v = 50*

8.5.2 Uncertainty due to Repeatability

I. Repeatability is the measurement precision under a set of repeatability conditions of measurement.

II. Calculating repeatability uncertainty involve taking 'n' number of measurement, calculating the mean and standard deviation.

III. The standard uncertainty is given by:

$$u_{rep} = \frac{s}{\sqrt{n}}$$

IV. The degree of freedom *v*, *v = n-1*

8.5.3 Uncertainty due to Readability

I. Uncertainty due to Readability, u_{res} can be measured by finding the least significant digit at measurement system or equipment and observe the smallest incremental change.

II. For digital indicating device, after determining whether the instrument counts or rounds the last digit; divide the resolution by 2.

III. For analogue indicating device, resolution of the indicating device is obtained from the ratio of the pointer width to the centre distance of two adjacent graduation lines (scale interval).

IV. Uncertainty due to readability for analogue micrometer, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ UUT/2}{\sqrt{3}}$$

V. Uncertainty due to readability for digital micrometer, u_{res} can be expressed as follows:

$$u_{res} = \frac{Resolution\ of\ UUT/2}{\sqrt{12}}$$

VI. The degree of freedom *v*, *v = 12.5*

8.5.4 Uncertainty due to due to Reference Drift

I. The reference drift can be taken by referring to reference equipment past calibration certificates and observe the values change based on reference equipment history.

$$u_{drift} = \frac{Reference\ drift}{\sqrt{3}}$$

II. The degree of freedom *v*, *v = 12.5*

8.5.5 Uncertainty in nominal Coefficient of Thermal Expansion

I. In this contribution of uncertainty are from both uncertainty of the Coefficient of Thermal Expansion UUT & Ref equipment itself.

II. The standard uncertainty for uncertainty in nominal CTE:

$$u_{nomCTE} = \frac{(L)(CTE\ U_{ref} + CTE\ U_{uut})^{1/2}(20 - T)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v* = 12.2

8.5.6 Nominal Coefficient of Thermal Expansion (Reference Equipment & UUT)

I. The next contribution is from the uncertainty in the Nominal Coefficient of Thermal Expansion Reference equipment & UUT.

II. The standard uncertainty for Nominal CTE of Reference:

$$u_{nomCTEref} = \frac{(L)(20 - T)(CTEref)}{\sqrt{3}}$$

III. The standard uncertainty for Nominal CTE of UUT:

$$u_{nomCTEuut} = \frac{(L)(20 - T)(CTEuut)}{\sqrt{3}}$$

IV. The degree of freedom *v*, *v = 12.5*

8.5.7 Nominal Coefficient of Thermal Expansion Difference

I. The next contribution is from the Nominal Coefficient of Thermal Expansion Difference between the reference and UUT.

II. The standard uncertainty is:

$$u_{nomCTEdiff} = \frac{(L)(20 - T)(|CTEref - CTEuut|)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

8.5.8 Different of Temperature During Handling of Reference and UUT

I. The next contribution is from the Different of Temperature During Handling of Reference and UUT could be as much as 0.5 °C.

II. Uncertainty due to Different of Temperature During Handling of Reference and UUT:

$$u_{tempdiff} = \frac{(L)(0.5)(CTErefxCTEuut/2)}{\sqrt{3}}$$

III. The degree of freedom *v*, *v = 12.5*

8.5.9 Geometrical Error (Flatness)

I. The next contribution for uncertainty is from geometrical error from flatness.

II. Flatness error is as the following:

$$Flatness\ error = \frac{\lambda}{2}.n$$

III. The standard uncertainty is then given by:

$$u_{flat} = \frac{flatness\ error}{\sqrt{3}}$$

IV. The degree of freedom *v*, *v = 12.5*

8.5.10 Geometrical Error (Parallelism)

I. The next contribution for uncertainty is from geometrical error from parallelism.

II. Parallelism error is as the following (method 1):

$$Parallelism\ error = \frac{\lambda}{2}.n$$

III. The standard uncertainty is then given by (method 1):

$$u_{par} = \frac{paralellism\ error}{\sqrt{3}}$$

IV. Parallelism error is as the following (method 2):

Parallelism error = max-min
(from 5 point of measurement
on anvil)

V. The standard uncertainty is then given by (method 2):

$$u_{par} = \frac{paralellism\ error}{\sqrt{3}}$$

VI. The degree of freedom *v*, *v = 12.5*

8.5.11 Data logger

I. The next contribution for uncertainty is from the data logger calibration.

II. The standard uncertainty is given by:

a. $u_{dlogger} = \frac{U}{k}(CTE_{ref} - CTE_{uut})$

III. The degree of freedom *v*, *v* = 12.5

8.5.12 Resolution of data logger

I. The next contribution for uncertainty is from the resolution of the data logger.

II. The standard uncertainty is given by:

a. $u_{dlogres} = \frac{resolution}{\sqrt{12}}(CTE_{ref} - CTE_{uut})$

III. The degree of freedom v, $v = 12.5$

8.5.13 Wringing

I. The next contribution for uncertainty is from the wringing of the gauge block.

II. As per ASME B89.1.13 – 2013 para D-7.6 the value 0.1µm will be used for the uncertainty.

III. The standard uncertainty is given by:

$$u_{wrin} = \frac{0.1}{\sqrt{3}}$$

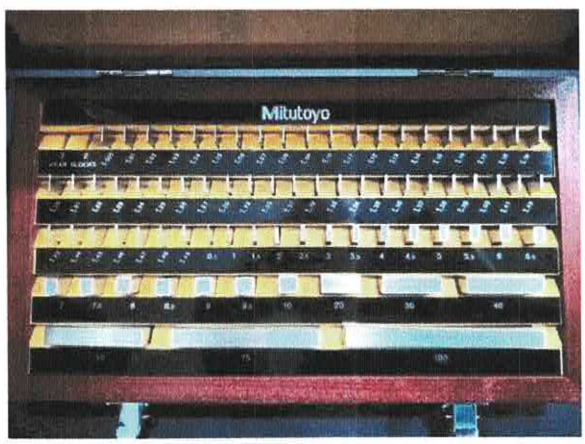
IV. The degree of freedom v, $v = 12$.

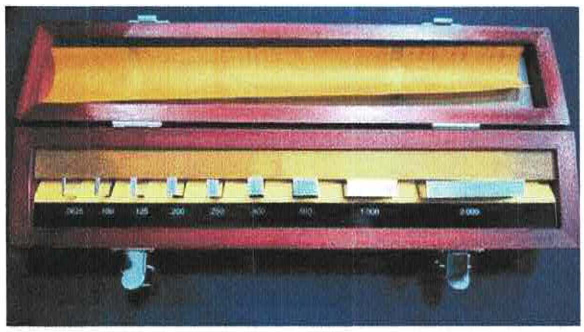
8.6 Proposed Distribution and Corresponding Standard Uncertainty

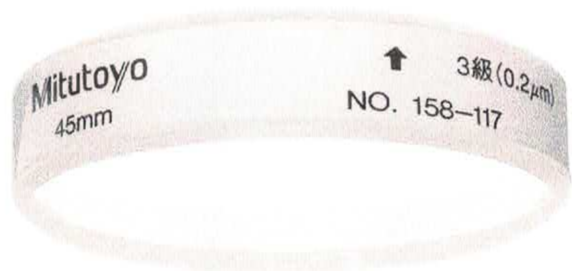
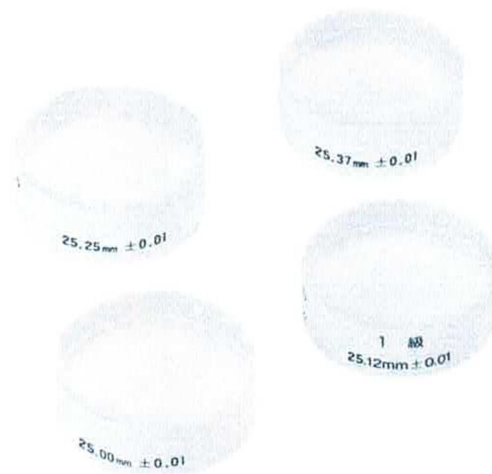
Quantity	Evaluation of standard uncertainty	Distribution function	Standard uncertainty, u in mm/inch
Reference Equipment	Type B	Normal	$u_{ref} = \frac{U}{k}$
Repeatability	Type A	Normal	$u_{rep} = \frac{s}{\sqrt{n}}$
Resolution of the Caliper or Micrometer	Type B	Rectangular (analogue)	$u_{res} = \frac{r \times 0.5}{\sqrt{3}}$ (analogue)
		Step (digital)	$u_{res} = \frac{r}{\sqrt{12}}$ (digital)
Reference Drift	Type B	Rectangular	$u_{dri} = \frac{a}{\sqrt{3}}$
Uncertainty in nominal Coefficient of Thermal Expansion	Type B	Rectangular	$u_{nomCTE} = \frac{(L)(CTE\ U_{ref} + CTE\ U_{uut})^{1/2}(20 - T)}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion (reference)	Type B	Rectangular	$u_{nomCTEref} = \frac{(L)(20 - T)(CTEref)}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion (uut)	Type B	Rectangular	$u_{nomCTEuut} = \frac{(L)(20 - T)(CTEuut)}{\sqrt{3}}$
Nominal Coefficient of Thermal Expansion Difference	Type B	Rectangular	$u_{nomCTEdiff} = \frac{(L)(20 - T)(\lvert \Delta ref - \Delta uut \rvert)}{\sqrt{3}}$

Different of Temperature During Handling of Reference and UUT	Type B	Rectangular	$u_{tempdiff} = \frac{(L)(0.5)(\Delta ref x \Delta uut/2)}{\sqrt{3}}$
Geometrical Error (Flatness)	Type B	Rectangular	$u_{flat} = \frac{flatness\ error}{\sqrt{3}}$
Geometrical Error (Parallelism)	Type B	Rectangular	$u_{par} = \frac{parallelism\ error}{\sqrt{3}}$
Data Logger	Type B	Rectangular	$u_{dlogger} = \frac{U}{k}(CTE_{ref} - CTE_{uut})$
Data Logger Resolution	Type B	Step	$u_{dlogres} = \frac{resolution}{\sqrt{12}}(CTE_{ref} - CTE_{uut})$
Wringing	Type B	Rectangular	$u_{wrin} = \frac{0.1}{\sqrt{3}}$
Combined standard uncertainty	$u_c = \sqrt{u_{ref}^2 + u_{rep}^2 \ldots.. + u_{geo}}$		
Expanded uncertainty	$U = k \cdot u_c, k = 2$		

8.7 Calibration System Standard

Components	Range	
Gauge Block	0.5000 mm to 100.0000 mm	

Components	Range	
Gauge Block	25.000 mm to 200.000 mm	
	0.0625 inch to 2.000 inch	
	1.000 inch to 8.000 inch	

Components	Range	
Optical Flat	Diameter: 45 mm Flatness: 0.0002 mm	
Optical Parallel	Diameter: 30mm Flatness: 0.0001mm Parallel: 0.0002mm	

8.8 Forms

I. GAM/CL-F17: Calibration Records

II. GAM/CL-F19: Delivery Order

III. GAM/CL-F33: Micrometer Calibration Form

Galaxy Aerospace

CALIBRATION FORM
MICROMETER

Work Order No.	

UNIT UNDER CALIBRATION

EQUIPMENT/TOOL ID:	
ITEM DESCRIPTION:	
MODEL NO:	
MANUFACTURER BY:	
SERIAL NO:	
SIZE/RANGE/CAPACITY:	
READABILITY:	
RESOLUTION:	
THERMAL EXPANSION	

STANDARD(S) EQUIPMENT USED

ITEM DESCRIPTION:	
PART NO:	
SERIAL NO:	
UNCERTAINTY:	
DRIFT:	
THERMAL EXPANSION:	

CALIBRATION SUMMARY

CALIBRATION DATE:			CERTIFICATE NO:		
CALIBRATION VALID UNTIL:			CONDITION OF THE TOOL:	BEFORE	AFTER
TEMPERATURE:	Min °C	Max °C			
HUMIDITY:	Min % rh	Max % rh			

FEATURE EXAMINED

FLATNESS

	NO OF FRINGES	FLATNESS
Flatness of Anvil		
Flatness of Spindle		

PARALELISM

CENTRE	FRONT	BACK	LEFT	RIGHT	MAX. DRIFF.

INSTRUMENTENTAL ERROR

Linearity. Unit in mm, inch

Nominal Value	Reference Value	Correction			Average	Error	Standard Deviation
		Reading 1	Reading 2	Reading 3			

Remarks/Comments			
	Name & Signature	Date	Company Stamp Holder
Calibrated By:			
Certified By:			

CALIBRATION TECHNICAL PROCEDURES

FORCE
CL-TP-05

1 PURPOSE

1.1 This verification procedure describes the verification of Crimping/Lugging tools both hand and power operated that used to produce solderless electrical connections.

1.2 This document is to specify requirements with which a laboratory must operate and demonstrate its competency to carry out verification in accordance with ISO 1966-1973 and MS ISO/IEC 17025:2017.

1.3 Implementation of this verification procedure ensures that crimping/lugging tools used is properly identified and verified at appropriate intervals to maintain accuracy within specified limits.

2 SCOPE

2.1 This procedure should be used in the absence of any specific calibration/verification for contact crimping and lugging tools.

2.2 Verification of the crimped joints to assess their suitability for aircraft shows that certain condition for example vibration and electrical properties of the wire have no significant effect on the performance of the joint. It has therefore not been considered necessary to provide for such test.

2.3 Crimping Tool Verification that is within GAM CL capability are as follows:

Component	Description	Part Number	Range
Crimping and Lugging Tools	Crimping Tool	YJQ-W2A	26AWG – 12AWG
	Ratchet Crimp Tool	499-2313	1.5 – 6mm²
	Crimping Tool	M22520/7-01	28AWG – 16AWG
	Crimping Tool	M22520/1-01	26AWG – 12AWG
	Crimping Tool	M22520/31-01	26AWG

3 STANDARDS AND REFERENCES

3.1 GAM/CL/P – Calibration Laboratories Procedure.

3.2 ISO 1966-173 – Crimped Joints for Aircraft.

3.3 MS ISO/IEC 17025:2017

3.4 IPC/WHMA-A-620E

4 DEFINITIONS

4.1 Termination

A permanent connection formed by the end of an electrical cable conductor with a terminal end or a pin socket.

4.2 Terminal end

A connecting device with barrel accommodating an electrical cable conductor with or without additional provision to accommodate and secure the insulation.

4.3 Pin or Socket Contact

A contact used in a plug or socket with barrel at one end to accommodate an electrical cable conductor with or without additional provision to secure the insulation.

4.4 Cable Splice

A connecting device with barrel each accommodating an electrical cable conductor with or without additional provision to accommodate and secure the insulation.

4.5 Cable Splice Connection

A permanent connection formed by the ends of electrical cable conductors attached to cable splice.

4.5 Crimping

A method of firmly attaching a terminal end or cable splice to a conductor by reshaping the barrel around the conductor to establish good electrical and mechanical contact.

4.6 Insulation Grip

That part of a terminal barrel or cable splice barrel into which the insulation of the cable is placed, and which by reforming grips the insulation.

4.7 Pre insulated Joint.

A crimped connection formed with an insulated terminal end or insulated cable splice.

4.8 Post insulated joint.

An uninsulated crimped connection insulated after conductor crimping.

4.9 Crimping Tool

A manually operated or power operated mechanical device for making a crimp or insulation grip.

4.8 Positioner

A locator, turret or other device permanently or removably attached to a crimping tool, serving correctly to locate and control the position of the crimp on the barrel.

5. REQUIREMENTS

5.1 Terminal Ends, pin or socket contacts and cable splices shall comply with the requirements of the appropriate national and international standards.

5.2 The terminal end, pin or socket contact or cable splice shall be such that adequate engagement of the cable conductor in the completed joint can be readily established by inspection.

5.3 The completed crimped joint should take the form of a conductor crimp and insulation grip effect in one operation using the die or dies stipulated by the tool manufacturer. All terminal ends or cable splices for size 12 cable or smaller shall have an insulation grip unless equivalent insulation support is otherwise provided.

5.4 The mechanical strength and electrical performance of the completed joints shall be such that they fulfil the requirement of the appropriate national and international standards.

6 ENVIRONMENTAL CONDITION

6.1 Calibration shall be carried out at a temperature of 20°C ± 5°C. Maximum relative humidity 80 % RH and shall be documented.

7 PROCEDURE

7.1 Crimp combination shall be identified by part number, wire size, type, coating, terminal colour and terminal name. Overall length of test samples shall be 152 ±1.3mm (6 ±0.05) in long.

7.2 The contact crimping and/or lugging tool will hereafter be referred to as the Unit Under Test (UUT).

7.3 Verify that the Unit Under Test (UUT) is clean.

7.4 Visually examine the Unit Under Test (UUT) for any condition that could cause errors during testing.

7.5 Check if UUT operates properly, that the ratchet release operates, and that dies / indenter close properly.

7.6 If any of the requirements cannot be met, refer to the applicable manufacturer manual.

7.7 If a malfunction occurs or a defect is observed while testing is in progress, the test shall be discontinued and necessary corrective action taken; if corrective action affects a measurement function previously tested, the function shall be retested before the remainder of the procedure implemented.

8 TEST AND INSPECTION

8.1 Inspection

I. The following shall be verified:

II. Use of correct cable, tool, die and terminal end, pin and socket contact or cable splice.

III. Correct of dimension.

IV. Correctness of form and location of crimp.

V. Freedom from fracture, rough or sharp edges.

VI. Adequate insertion of conductor strands in the barrel.

VII. Correct die mark.

8.2 Test

I. Unless otherwise specified, all tests shall be performed at a temperature of 20±5 °C and relative humidity not greater than 80%.

II. The test shall be applied to each combination of type, size, material, and finish of crimped conductor barrel, crimped to appropriate sizes of conductor of each type, material, and finish, by each type of tool and each size of die, indenter, or positioner.

III. When a particular crimped conductor barrel is used on more than one item, test need only be carried out on one type of item.

IV. When a particular crimped conductor barrel is designed to accommodate a range of conductor sizes, for a particular type of tool or type and size of die or positioner, test need only be carried out on the smallest and the largest size commonly used of conductors in the range.

V. When a particular tool, die or positioner is designed to accommodate a range of crimping barrels, test need only be carried out on the largest and the smallest size commonly used of crimping barrel.

8.3 Test sample shall consist of:

8.3.1 Terminal ends: length of cable with a terminal end at each end.

8.3.2 Cable splices: lengths of cable joined by an inline connector.

8.3.3 Pin or socket contacts: a length of cable with a pin or socket contact at each end.

8.3.4 The cable shall be 152±1.3 mm (6±0.05 in) long, measured before crimping between the points where the conductor enters the respective conductor crimping barrels.

8.4 Conductor Pull Off Test.

8.4.1 Each sample shall be tested in suitable testing machine in which an axial pull is applied and in which the jaws separate at a steady rate.

8.4.2 Each end of the sample shall be tested to destruction and shall not fail below the relevant load specified in Table 1.

Conductor Size		Machined Contacts				Crimp Splices[1]		Stamped and Formed Contacts and Terminals[1]	
		Silver/Tin Plated Wire		Nickel Plated Wire					
AWG	(mm²)	Pounds	(N)	Pounds	(N)	Pounds	(N)	Pounds	(N)
30	0.050	1.5	6.7	1.5	6.7	1.5	6.7	1.52	6.72
28	0.080	3	13.4	2	8.9	2	8.9	22	8.92
26	0.130	5	22.3	3	13.4	3	13.4	7	31.2
24	0.200	8	35.6	6	26.7	5	22.3	10	44.5
22	0.324	12	53.4	8	35.6	8	35.6	15	66.8
20	0.519	20	89.0	19	84.6	13	57.9	19	84.6
18	0.823	32	142	NE	NE	20	89.0	38	169.1
16	1.310	50	222.3	37	164.6	30	133.5	50	222.5
14	2.080	70	311.5	60	266.9	50	222.5	70	311.5
12	3.310	110	489.5	100	445.0	70	311.5	110	489.5
10	5.261	150	667.5	135	600.5	80	356.0	150	667.5
8	8.367	220	978.6	200	890.0	90	400.5	225	1001.3
6	13.300	300	1235.0	270	1201.0	100	445.0	300	1335.0
4	21.150	400	1780.0	360	1601.4	140	623.0	400	1780.0
3	26.670	NE	NE	NE	NE	160	712.0	NE	NE
2	33.620	550	2447.5	495	2201.9	180	801.0	550	2447.5
1	42.410	650	2892.5	585	2602.2	200	890.0	650	2892.5
1/0	53.490	700	3115.0	630	2757.9	250	1112.5	700	3115.0
2/0	67.430	750	3337.5	675	3002.5	300	1235.0	750	3337.5
3/0	85.010	NE	NE	NE	NE	350	1557.5	825	3671.3
4/0	107.200	875	3893.0	785	3491.9	450	2202.5	875	3893.8
250	127	NE	NE	NE	NE	500	2225.0	NE	NE
300	156	NE	NE	NE	NE	550	2447.5	NE	NE
350	177	NE	NE	NE	NE	600	2670.0	NE	NE
400	203	NE	NE	NE	NE	650	2892.5	NE	NE
500	253	NE	NE	NE	NE	800	3560.0	NE	NE
600	304	NE	NE	NE	NE	900	4005.0	NE	NE
700-2000	355 – 1016	NE	NE	NE	NE	1000	4450.0	NE	NE

Note 1: Plated or unplated copper stranded wire

Note 2: Value per UL 486A specification and established only for Class 1 assemblies

Table 1.

8.5 Continuity Test

8.5.1 Continuity test to be performed on the test sample to verify the quality of the contact between the crimping and the cable.

8.5.2 Using a multimeter check the continuity by placing one side of the multimeter test lead to the crimping end of the cable and placing another side of the multimeter test lead to the conductor of the cable.

8.5.3 Verify the continuity between the crimping end of the cable and the conductor of the cable below 50.0Ω.

8.6 Go No Go Gauge.

8.6.1 Alternatively, when a Go No Go gauge is available it can also be used for verification of the crimping tool. The crimping tool datasheet or manual will be used as reference.

8.6.2 For DMC adjustable crimp tool AF8 (M22520/1-01) a go no go gauge G125 (M22520/3-1) will used on SEL #4.

8.6.3 For DMC intermediate adjustable crimp tool MH860 (M22520/7-01) a go no go gauge G145 (M22520/3-3) will be used ON SEL #8

8.6.4 For DMC circular indent hand crimp tool GS200-1 (M22520/31-01) a go no go gauge G443 (M22520/3-15) will be used.

8.6.5 For crimping tool other than DMC the gaging limit table from the DMC datasheet will be a reference for the size of go no gauge to be used.

9 FORMS

I. GAM/CL-F17: Calibration Records

II. GAM/CL-F19: Delivery Order

III. GAM/CL-F35: Crimp and Lug Tool Verification Form

Galaxy Aerospace

VERIFICATION FORM
CRIMP AND LUG TOOLS

Work Order No.	

UNIT UNDER CALIBRATION

EQUIPMENT/TOOL ID:	
ITEM DESCRIPTION:	
MODEL NO:	
MANUFACTURER BY:	
SERIAL NO:	
SIZE/RANGE/CAPACITY:	
READABILITY:	
RESOLUTION:	
THERMAL EXPANSION	

STANDARD(S) EQUIPMENT USED

ITEM DESCRIPTION:	
PART NO:	
SERIAL NO:	
UNCERTAINTY:	
DRIFT:	

VERIFICATION SUMMARY

CALIBRATION DATE:			CERTIFICATE NO:		
CALIBRATION VALID UNTIL:			CONDITION OF THE TOOL:	BEFORE	AFTER
TEMPERATURE:	Min °C	Max °C			
HUMIDITY:	Min % rh	Max % rh			

EQUIPMENT USED

EQUIPMENT	MODEL	PART NUMBER	CALIBRATION DUE DATE	REMARKS
PULL FORCE TESTER:				
WIRE :				
PIN:				

TYPE OF CONDUCTOR:	

ACTUAL TEST

Size No. (AWG/mm²/in²)	Pull-Off Test	Continuity Test	Pass Or Fail

Remarks/Comments

	Name & Signature	Date	Company Stamp Holder
Calibrated By:			
Certified By:			

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