5-4 Selection of Power Tools

(1) Selection process

① Power (air, electric, hydraulic)

② Shape (holding by hand, fixed, head shape, reaction force support)

③ Capacity (tightening torque value, tightening accuracy)

④ Tightening time (rotation)

Table 5-6 Selection of power torque tools

		Air			Electric		
		Manual		Fixed	Power		Fixed
		Hand type	With reaction		Hand type	With reaction	
Structure		Auto stop by toggle mechanism	With reaction arm to get reaction on tightening auto stop by toggle mechanism	Built-in automatic equipment auto stop by toggle mechanism tightening completion signal by LS	Auto stop by toggle mechanism Drive by electric motor	With arm to get reaction on tightening	Built-in automatic equipment auto stop by or control by multiple tightening driver
Main purpose		General tightening	Tightening of middle, large screw each bolt in factories	Auto tightening or multiple units each bolt in factories	General tightening for small screw	Tightening of middle, screw inside and outside	Auto tightening or units for huge tightening in factories
Model comparison	Small screw	◎	×	○	◎	×	△
	Middle screw	△	○	◎	△	○	◎
	Large screw	×	◎	◎	×	◎	△
	General multi purpose tightening	○	○	×	○	○	×
	Same screw huge quantity tightening	△	△	◎	△	△	◎
	Rotation(auto shift)	◎	○	◎(○)	○	△	◎(○)
	Weight	◎	○	○	○	△	○
	Noise	○	△	○(△)	◎	○	○(△)
	Accuracy	○	○	○(◎)	○	○	○(◎)
	Operation	○	○	◎	○	○	◎
	Price	◎	○	△	○	○	△
Model		U,AUR,AS	AP	MG,MF,ME, MC,AME	HAT	DAP	DCME

(2) Tightening time of tool

Table 5-7 Tightening time of tool [sec/piece]

Screw joint			Manual		Power	Power+Manual		
Screw, tightening torque	Turns of ridge	Simultaneous tightening [Pieces]	Direct reading	Click	Full automatic direct control	Impact wrench +click	Semi automatic (Air motor +click in a body)	
			(DB50N)	(QL50N)	(ASH40N)	(QL50N)	(AC50N)	(AC100N)
M8 (P1.25) T=22 [N・m] (e=10)	10	1	9.6	8.0	3.2	5.4	4.0	3.5
	10	4	7.2	6.5	1.9	3.0	2.3	2.3
	16	1	14.6	12.6	4.6	7.3	6.7	5.6
	16	4	12.5	10.6	2.5	4.0	4.0	3.6

Prepare the test conditions by inserting the screw in the tapped hole and placing the tool on table. Measure the time interval from the start of tightening until the tool has been returned to the table and tightening completed. For manual tools, you may tighten the screw with your hand.

6-1 Torque Tools are Measurement Equipment

(1) All measurement equipment

Torque tools are categorized into measurement equipment same as calipers and dial gauges.

Beam type torque wrench

Dial type torque wrench

Caliper

Dial gauge

(2) ISO standard

ISO9001:2000 Extract

6.2.2 **Competence, awareness and training**

a) determine the necessary competence for personnel performing work affecting product quality,

b) provide training or take other actions to satisfy these needs,

c) evalute the effectiveness of the actions taken,

7.6 **Control of monitoring and mesuring devices**

Where necessary to ensure valid results, measuring equipment shall

a) be calibrated or verified at specified intervals, or prior to use, against meaure-ment standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded;

b) be adjusted or re-adjusted as necessary;

c) be identified to enable the calibration status to be determined;

d) be safeguarded from adjustments that would invalidate the measurement result;

e) be protected from damage and deterioration during handling, maintenance and storage.

6. Torque Tools are Measurement Equipment

(3) Accuracy of torque tools

A type (Measurement value: Value to show tester)

Example : calibration of torque wrench or torque driver to use measurement point

Example of calibration of models:DB·FTD

$$\text{Relative Error} = \frac{\text{Indicated by tools} - \text{Measured value}}{\text{Measured value}} \times 100$$

B type

Example : calibrate accuracy of torque tools to use weight

Example of calibration of models:TG·TM

$$\text{Relative Error} = \frac{\text{Indicated by tools} - \text{Base torque}}{\text{Base torque}} \times 100$$

(4) Durable accuracy of torque tools

Manual torque tools ··· 100,000 cycles (at maximum torque value) or one year. If you will measure and adjust each 100,000 cycles, it is possible to use up to around 1,000,000 cycles.

Power tool·················· 500,000～1,000,000 cycles (at maximum torque) or one year.

6-2 Daily Inspection

Every torque tool will make errors. To prevent this, a daily check and regular calibration are required

Daily check : To prevent occurrence of a large quantity of defects.

Regular calibration : To control the accuracy of torque tools (For traceability)

(1) Control method

Table 6-1 Individual control and Centralized control

		Individual control	Centralized control
Accuracy		Daily inspection by the worker.	Regular inspection in the tool room.
Degradation of torque		Earlier detection.	Can be detected only during a regular inspection.
Adaptable torque wrench		Click-type torque wrench, Power-type torque wrench.	All types.
Tester		Torque wrench checker	Torque wrench tester
Adaptable tester		Checker (LC)	Tester (DOT, DOTE, TTC, TF)
Control of torque wrench	Worker	Precision check, and replaces only defective torque wrenches.	Replacement of defective torque wrenches.
	Tool room	Checking tester at the field and readjusts or arranging the repair of defective torque wrenches.	Checking all normal and defective torque wrenches,of repairs read-justment of defective torque wrenches, and arrangement of repairs.

(2) Selection of testers

Checker (daily check)

- Dry weight correction is necessary because dry weight of torque wrench will be added on vertical direction. (LC etc.)
- It is not stable all the time because not loaded by loading equipment and loaded by the hand. (Speed, position, direction etc.)

Tester (for calibration)

- It is not affected by gravitational acceleration (g) because the torque wrench is loaded by horizontal direction.
- Speed, loaded position, direction can be constant because it is loaded by loading equipment.

Table 6-2 Selection of tester

Checker/ tester model	Checker		Tester			
	For wrench	For rotation	Torque range 1:30 (Digital)	Torque range 1:10 (Mechanical)	Torque range 1:10 (Digital)	Torque range wide (Digital)
Spec.	LC	ST	TDT	DOT	DOTE	TF, TTC
Measurement Instrument	Torque wrench	Power tool torque wrench	Torque driver	Torque wrench	Torque wrench	Torque wrench
Accuracy	±1%+1digit	F.S.±1%	±1%+1digit	±2%	±1%+1digit	±1%+1digit
Capacity	small, middle	small, middle, large	small	small, middle	small, middle, large	small, middle, large
Analog display	×	×	×	○	×	×
Digital display	○	○	○	×	○	○
Manual (handle)	○	○	○	○	○(DOTE)	×
Power (motor drive)	×	×	×	○ (DOT-MD)	○ (DOTE-MD)	○
Measurement	right	right	right/left	right	right/left	right/left
Price	◎	◎	○	◎	○	△

(3) Tester of torque tools

Table 6-3 Torque tools and tester and checker

Torque tools	Tester
Uni screw driver	TCF+TP+CD42
Semi-automatic airtork	DOT, DOTE, TTC, LC, TF Torque wrench tester
Fully-automatic airtork	TCF+TP+CD4,ST
Multiple unit	TCF+TP+CD4,ST
Torque driver	TDT
Manual type torque wrench	DOT, DOTE, TTC, LC, TF Torque wrench tester
Torque meter	Calibration kits (Weight + calibration lever)

(4) Standards of Tohnichi、ISO、JIS

Table 6-5 Permissible deviation of torque value

A.Dial indication type	1, Tohnichi standard	±3%	
	2, ISO standard	±4%～±6%	Dial indication type
	3, JIS standard	±3%	
B.Adjustable type	1, Tohnichi standard	±3%	
	2, ISO standard	±4%～±6%	Wrench type
		±6%	Driver type
	3, JIS standard	±3%	
C.Preset type	1, Tohnichi standard	±3%	
	2, ISO standard	±4%～±6%	Wrench type
		±6%	Driver type
	3, JIS standard	±3%	

Table 6-6 Measurement procedure

A.Dial indication type	1, Tohnichi standard	Additional loading (min.→ max. scale) 1 time
	2, ISO standard	5 times successively at each measuring points
	3, JIS standard	Not described
B.Adjustable type	1, Tohnichi standard	Mean value of 3 times measurements at each measuring points
	2, ISO standard	5 times successively at each measuring points
	3, JIS standard	Mean value of 3 times or more measurements
C.Preset type	1, Tohnichi standard	Mean value of 3 times measurements
	2, ISO standard	5 times successively at measuring point
	3, JIS standard	Mean value of 3 times or more measurements

Table 6-7 Measurement point

A.Dial indication type	1, Tohnichi standard	Min., around center, max. of scale
	2, ISO standard	20, 60, 100%
	3, JIS standard	Min., close 2 points of equally divided 3, max. of scale
B.Adjustable type	1, Tohnichi standard	Min., center, max. of scale
	2, ISO standard	20, 60, 100%
	3, JIS standard	Min., close 2 points of equally divided 3, max. of scale
C.Preset type	1, Tohnichi standard	Setting torque
	2, ISO standard	Any of torque
	3, JIS standard	Setting torque

(ISO 6789), (JIS B 4650)

6-3 Traceability

Torque is the result of multiplying the length by the force. As the units of length and force are approved by the official organization respectively, the traceability is obtained through these units.

(1) Traceability system

Use the Tohnichi tools for ISO 9000 torque control systems.

Tohnichi is produces a wide variety of torque tools that are involved in traceability systems (Figure 6-2). Services, such as calibration and repair, are very important and necessary factors in the control process. All of these are necessary for internal company controls for torque tools, such as inspection sheets, calibration certificates, traceability systems are available upon request. Use the application forms for such traceability requests.

Figure 6-1Traceability of Tohnichi products

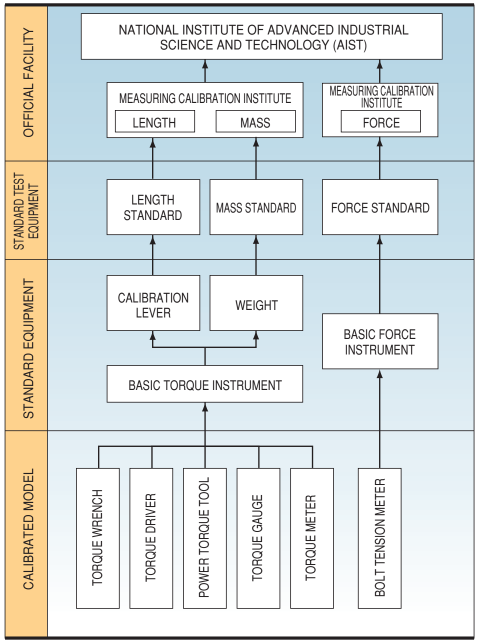
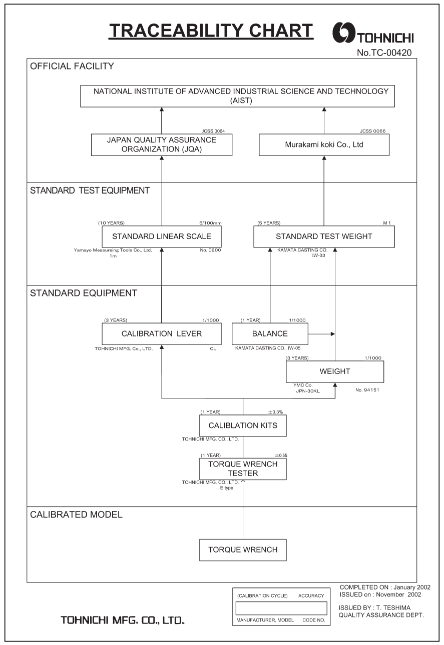


Figure 6-2 Traceability chart



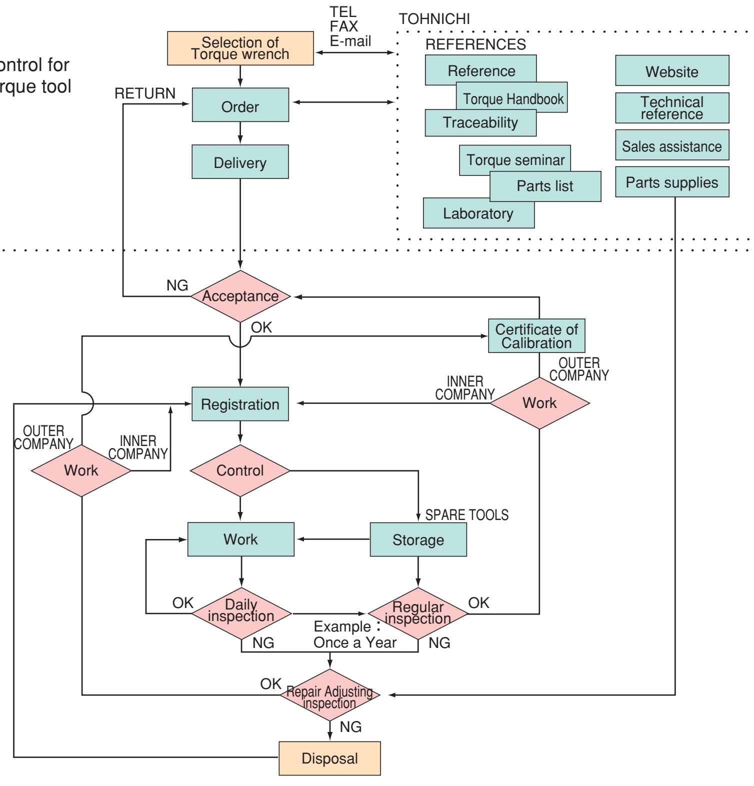
(2) Examination and calibration

Because torque is expressed as Torque = Force × Length, it is required that the standard instrumentation should be calibrated using weights for the force and a scale or caliper for the length. Instruments being used as the standard for testing other torque tools should be 3 times more accurate than the item being tested. Therefore to calibrate a torque wrench with a 1% accuracy rating a more than ±0.3% rated torque standard must be used. The standard must then be periodically calibrated and examined to maintain its accuracy and traceability.

(3) Management of torque tools

The process for controlling torque tools (Figure 6-3) involves ascertaining the accuracy by adequately checking the measurement of the tools upon reception in the facility and or on a daily basis. Decide how to setup a process for control by referencing JIS standards, (JIS B 4650) and nominal accuracy as defined by the manufacturer and by assessing the following factors: importance, usage frequency, and usage torque capacity of the measuring instruments. The periodic check cycle depends on these factors, but normally this falls between 3 months and a year and, if possible, readjusts the cycle as the tool ages.

Figure 6-3 Control for torque tool



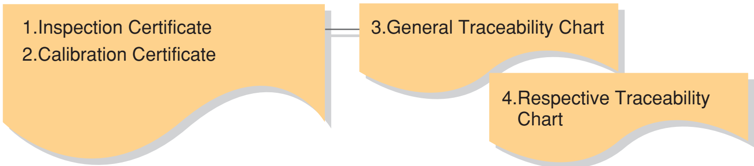
(4) Trends to provide the new traceability control and the national torque standards

As industrial globalization has accelerated, so has the use of torque tools. Their importance in the field of quality control has led to increased requirements for traceablility through national torque standards and international agreements. Currently, preparations are being made for a system to provide torque standards and the calibration methods for torque tools. These preparations are proceeding and the provisions for a national torque standard has already started.

(5) ISO related documents

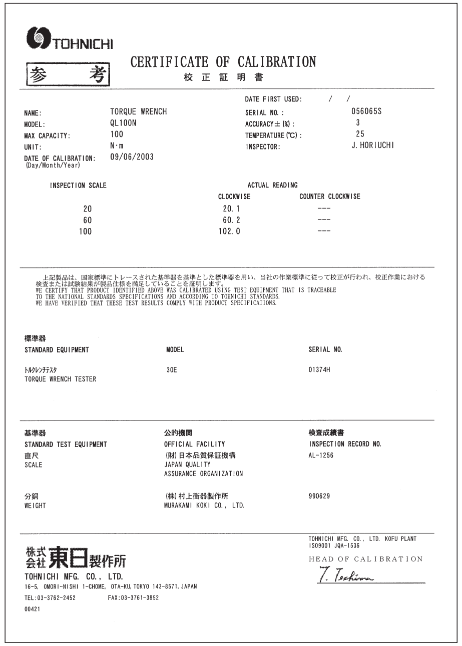
Tohnichi provides the customers who are approved / being approved by ISO 9000 with the requires documents. The documents available are as follows (Figure 6-4);

Figure 6-4 ISO related documents issued by Tohnichi



Tohnichi will provide the document service related to ISO 9000 accreditation. In general, the required documents for accreditation are the inspection certificate and calibration certificate. Upon the customer's request, we also issue a traceability chart. Tohnichi keeps the histories of issued documents for the required period for the customers who maintain ISO 9000.

Figure 6-5 The certificate of calibration supplied with torque wrenches



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参　考

CERTIFICATE OF CALIBRATION
校 正 証 明 書

DATE FIRST USED: / /

NAME: TORQUE WRENCH
MODEL: QL100N
MAX CAPACITY: 100
UNIT: N·m
DATE OF CALIBRATION: (Day/Month/Year) 09/06/2003

SERIAL NO.: 056065S
ACCURACY± (%): 3
TEMPERATURE (℃): 25
INSPECTOR: J. HORIUCHI

INSPECTION SCALE	ACTUAL READING CLOCKWISE	ACTUAL READING COUNTER CLOCKWISE
20	20. 1	---
60	60. 2	---
100	102. 0	---

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WE CERTIFY THAT PRODUCT IDENTIFIED ABOVE WAS CALIBRATED USING TEST EQUIPMENT THAT IS TRACEABLE TO THE NATIONAL STANDARDS SPECIFICATIONS AND ACCORDING TO TOHNICHI STANDARDS.
WE HAVE VERIFIED THAT THESE TEST RESULTS COMPLY WITH PRODUCT SPECIFICATIONS.

標準器 STANDARD EQUIPMENT	MODEL	SERIAL NO.
トルクレンチテスタ TORQUE WRENCH TESTER	30E	01374H

基準器 STANDARD TEST EQUIPMENT	公的機関 OFFICIAL FACILITY	検査成績書 INSPECTION RECORD NO.
直尺 SCALE	(財)日本品質保証機構 JAPAN QUALITY ASSURANCE ORGANIZATION	AL-1256
分銅 WEIGHT	(株)村上衡器製作所 MURAKAMI KOKI CO., LTD.	990629

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ISO9001 JQA-1536
HEAD OF CALIBRATION
T. Toshima

6-4 Accuracy and Uncertainty

(1) Accuracy

Accuracy=Deviation + Dispersion

Deviation : Graduated torque measuring devices: The difference between the scale and the measured values.
Torque measuring device without graduation (single-purpose type): The difference between the set value and the measured value.

Dispersion: The standard is 2σ or 3σ

Figure 6-6 Accuracy

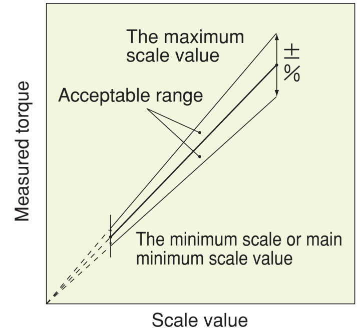


Table 6-8 Torque dispersion

Item	Model name	Accuracy
Digital torque wrench tester	TF, TTC, DOTE	±1%+1digit
Digital torque meter	TME	
Digital torque driver tester	TDT	
Digital torque wrench checker	LC	
Digital torque driver	STC	
Digital torque wrench	CEM, CTA, CTA-P, CTB	
Analog torque meter	TG, TM	±2%
Analog torque wrench tester	DOT	
Manual torque driver	FTD-S, FTD, MTD, RTD, LTD, NTD, RNTD, AMLD	±3% ※±5%(repaired)
Manual torque wrench	F, DB, CDB, QL, CL, YCL, QSP, SP	
Semi-automatic torque wrench	A, AC	
Power torque tool	U, AUR, AS, AP, M, DAP, HAT	±5%

(2) Uncertainty

Without assuming the conventional conception of true value (in general unknown), it is obtained from the data dispersion (already known) in the data range, using the measured results.
The methods to evaluate uncertainty are classified under the following two methods:

①Evaluation method by statistical analysis from a series of measured values. (**Uncertainty type-A**)
②Evaluation method by other means for statistical analysis from a series of measured values. (**Uncertainty type-B**)

Further, for both type-A and B, evalute the standard uncertainties as the standard deviations (or similar values) from normal distribution, rectangular distribution and trapezoid distribution. And finally, compound them by the propagation rule of errors. (The combined standard uncertainty) under the procedures like these, the comprehensive uncertainty is indicated as the Extended Uncertainty.

Figure 6-7 Factors about uncertainty in general measurements

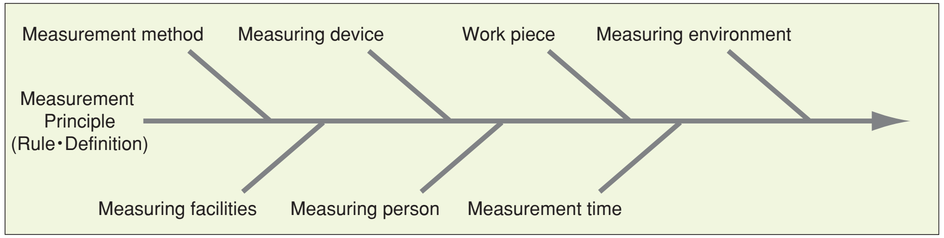


Figure 6-8 Scope of the measured values

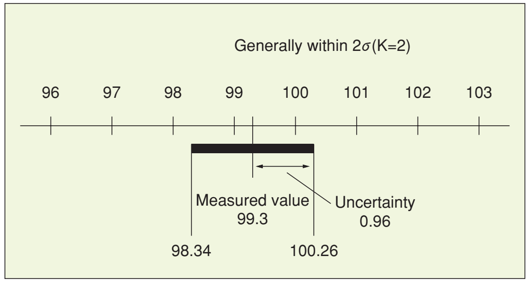
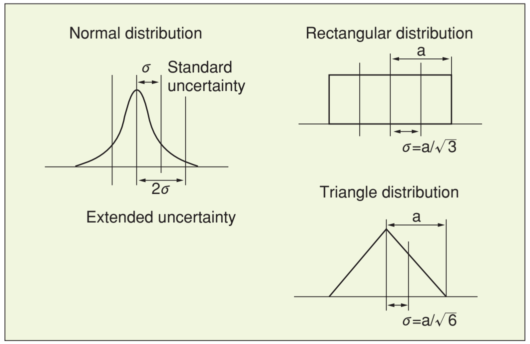
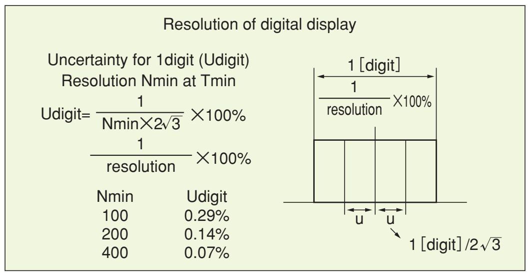


Figure 6-9 How to estimate the uncertainty



At normal distribution, σ (standard uncertainty) equals standard uncertainty and generally, 2σ equals extended uncertainty. At rectangular distribution, divide a (half width of distribution) by $\sqrt{3}$ equals extended uncertainty($a/\sqrt{3}$). At triangle distribution, divide a (half width of distribution) by $\sqrt{6}$ equals extended uncertainty ($a/\sqrt{6}$).

Figure 6-10 Estimate the uncertainty from rectangular distribution



To get the resolution of digital display for uncertainty of 1[digit], divide 0.5[digit] (half width of 1[digit]) by $\sqrt{3}$ equals standard uncertainty (1[digit]/$2\sqrt{3}$). For example, if the resolution (Nmin) of the minimum torque capacity (Tmin) is 100, 1[digit] equals 1% and the uncertainty of its resolution (Udigit) equals 0.29.

(3) Analysis procedure about uncertainty in measurements

① Set a method of measurement and calibration. (Describe the procedure concisely.) Describe the principles and measuring methods, measuring devices and instruments, concisely.

② Construction of mathematics model (Write formulas or put principal factors.)

a) Describe the formula if it can lead to uncertainty.

b) If the uncertainty cannot be expressed by numerical formulas, point out the factors of uncertainties and compound them by adding.

c) Execute the test of significance through experiments based upon the design of experiments and factorial experiments. Then estimate the uncertainties factor by factor.

③ Corrections of values (Describe the correction items and the methods, if any.) If corrections are made, the estimations of uncertainties are executed after data corrections. Then get the discretion estimation Y.

④ Analysis and estimation about uncertainty elements (Including type-A and type-B classification) the uncertainty elements are pointed out and classified. Estimate the standard deviation (or similar values) per element as follows;

a) Uncertainty which standard has. (Described in standard uncertainty.)

b) Uncertainty, comparing to standard. Uncertainty resulted from calibration equipment, calibration environment, calibration period, work piece, etc. (Described in standard uncertainty).

⑤ Calculation about combined standard uncertainty

$$uc = \left(\sum_{i=1}^{n} ui^2\right)^{1/2} = \sqrt{u1^2+u2^2+\cdots+un^2}$$

(Apparently there is no distinction between type-A and type-B)

⑥ Calculation about extended uncertainty

$$U = k \cdot uc$$

k: Coefficient

(Generally k=2 is taken. If not, describe the reason)

(4) Example for uncertainty

① Theoretical formula

Torque [N.m]

= Mass of dead weight [kg]×Gravitational acceleration [m/s²]×Effective length of calibration lever [mm]

② Hypothetical models

- ·Torque calibration kit DOTCL100N
- ·Torque wrench tester DOTE100N

③ Uncertainty of calibration of torque tester

Extended uncertainty of torque calibration kit: UIA

Extended uncertainty of torque calibration work: UIB

Extended uncertainty of measured torque: UIT($UIT^2=UIA^2+UIB^2$)

Extended uncertainty of torque wrench tester: UC

Extended uncertainty of calibration of torque wrench tester; UT($UT^2=UIT^2+UC^2$)

④ Uncertainty of torque calibration kit

Factors	Standard uncertainty
·Mass (standard dead weight)	0.0004%
·Mass for measurement	0.01%
·Gravitational acceleration	0.005% *(Table 1-1)
·Corrections of specific gravity	0.015%
·Vertical/horizontal conversion	0.014%

Combined standard uncertainty for force;

$$uf=\sqrt{0.0004^2+0.01^2+0.005^2+0.015^2+0.014^2}=0.023\%$$

·Scale (calibration)	0.006%
·Length of lever (processing tolerance)	0.02%
·Diameter of wire	0.02%
·Elongation of lever	0.014%

Combined standard uncertainty of torque length of lever;

$$ul=\sqrt{0.006^2+0.02^2+0.02^2+0.014^2}=0.032\%$$

Combined standard uncertainty of torque calibration kit;

$$ua=\sqrt{uf^2+ul^2}=\sqrt{0.023^2+0.032^2}=0.04\%$$

Extended standard uncertainty of torque calibration kit (k=2);

$$UIA=2\times ua=0.08\%$$

⑤ Uncertainty of torque calibration work

Factors	Standard uncertainty
·Level of wire	0.06%
·Inclination of lever (level)	0.06%
·Length of lever (angle of drive)	0.03%
·Newton conversion	0.03%
·Repeated uncertainty	0.1%

Combined standard uncertainty of torque calibration work;

$$ub=\sqrt{0.06^2+0.06^2+0.03^2+0.03^2+0.1^2}=0.14\%$$

Extended uncertainty of torque calibration work;

$$UIB=2\times ub=0.28\%$$

Extended uncertainty of measured torque;

$$UIT=\sqrt{UIA^2+UIB^2}=0.29\%$$

⑥ Uncertainty of calibration of torque wrench tester

Factors	Standard uncertainty
·Resolution of torque wrench tester (zero point)	0.06%
·Resolution of torque wrench tester (display)	0.06%
·Friction of bearing area	0.005%
·Uncertainty of gauge	0.14%
·Uncertainty of display	0.14%

Combined standard uncertainty of torque wrench tester;

$$uc=\sqrt{0.06^2+0.06^2+0.005^2+0.14^2+0.14^2}=0.22\%$$

Extended uncertainty of torque wrench tester;

$$UC=2\times uc=0.44\%$$

Extended uncertainty of calibration of torque wrench tester;

$$UT=\sqrt{UIT^2+UC^2}=0.52\%$$

⑦ Traceability of torque tools

The expanded uncertainty of torque wrench tester requires below ±1% (k=2).
The expanded uncertainty of torque calibration kit is expected below ±0.3% (k=2).
Therefore, standard uncertainty of calibration kit is expected below 0.15%.
Each standard uncertainty of inferior characteristics, which is below 0.015%, can be ignored.