Business Administration

Lecture No. 14: Quality and Its Control (2)

1. Concept of Quality Control
2. Inspection and "Building Quality Into Product"
3. Design of Inspection Process
4. Concept and Practice of TQC

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Recognized Quality and Profitability (PIMS data)

Hypothesis:

high quality →

high share + high price →

low relative cost →

high profitability

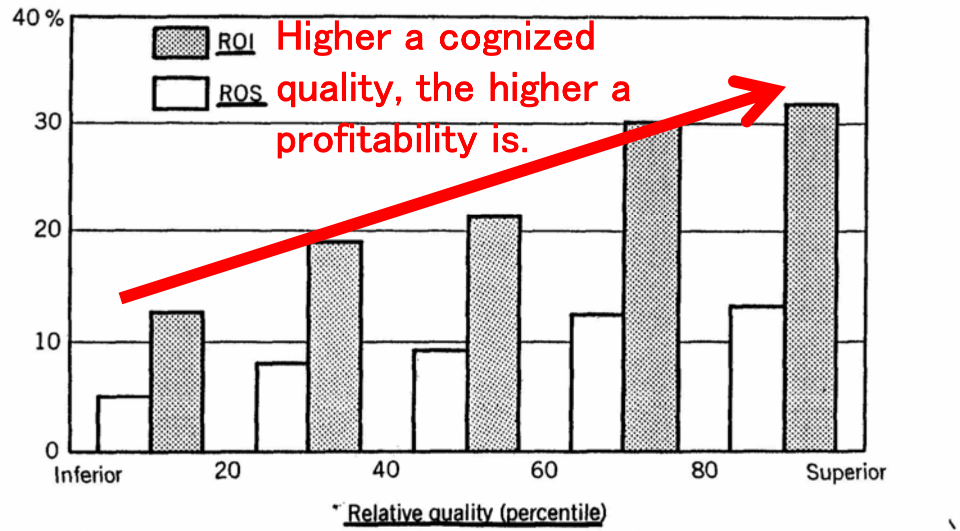


Figure 1.1. Effect of relative quality on return on investment and return on sale

THE PIMS RESULTS 7

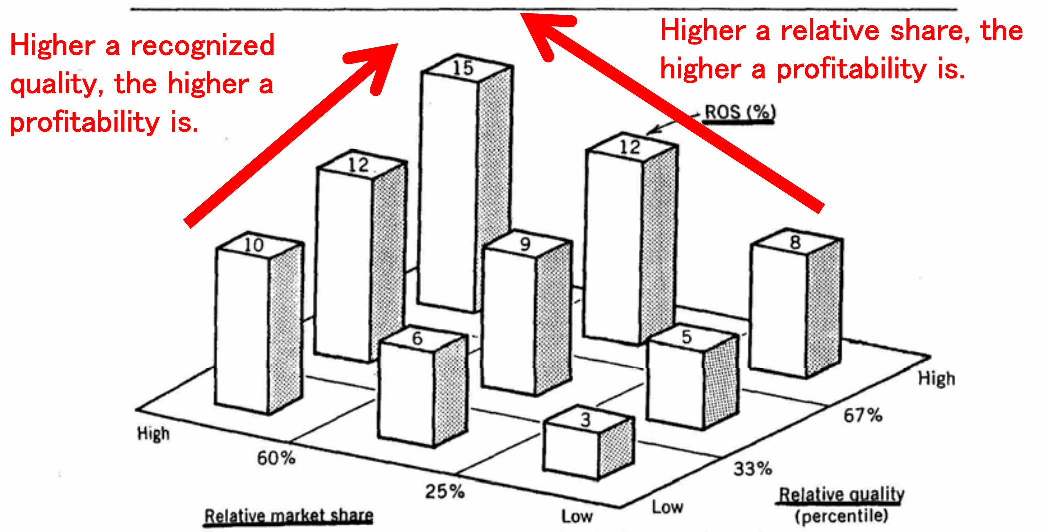


Figure 1.2. Effect of relative quality and relative market share on return on sales.

Reference：PIMS Principle

1. Concept of Quality Control

History of quality control

Statistical Quality Control (SQC)
--- established along with a mass production structure in USA in 20th century

1924: Control chart by Schewhart with Bell Research Center

1940 – 1950: Development of SQC in USA

Post War: quality control seminars (CCS) by GHQ
(Japan visits and coaching by Deming and Juran)

1960s: TQC in Japan, technique's ramification and refinement in US companies

Quality Control is :

- Total quality control ・・・ "TQ・C"
- Design quality control ・・・ product development per se
- Conformance quality control

  ・・・ being "quality control" normally at job site

  conformance quality control at total-company level being called TQC (T・QC)

  or, "CWQC" (Company-Wide Quality Control)

Control ･･･ PDCA Cycle (Plan-Do-Check-Action)

2. Inspection and "Building Quality Into Product"

Step by step, trace back to the source point of "design information flow" to prevent defects.

(1) no inspection

(2) shipping inspection

(3) receiving inspection/in-process inspection

(4) feedback of defect information, and improvement

(5) one-by-one production

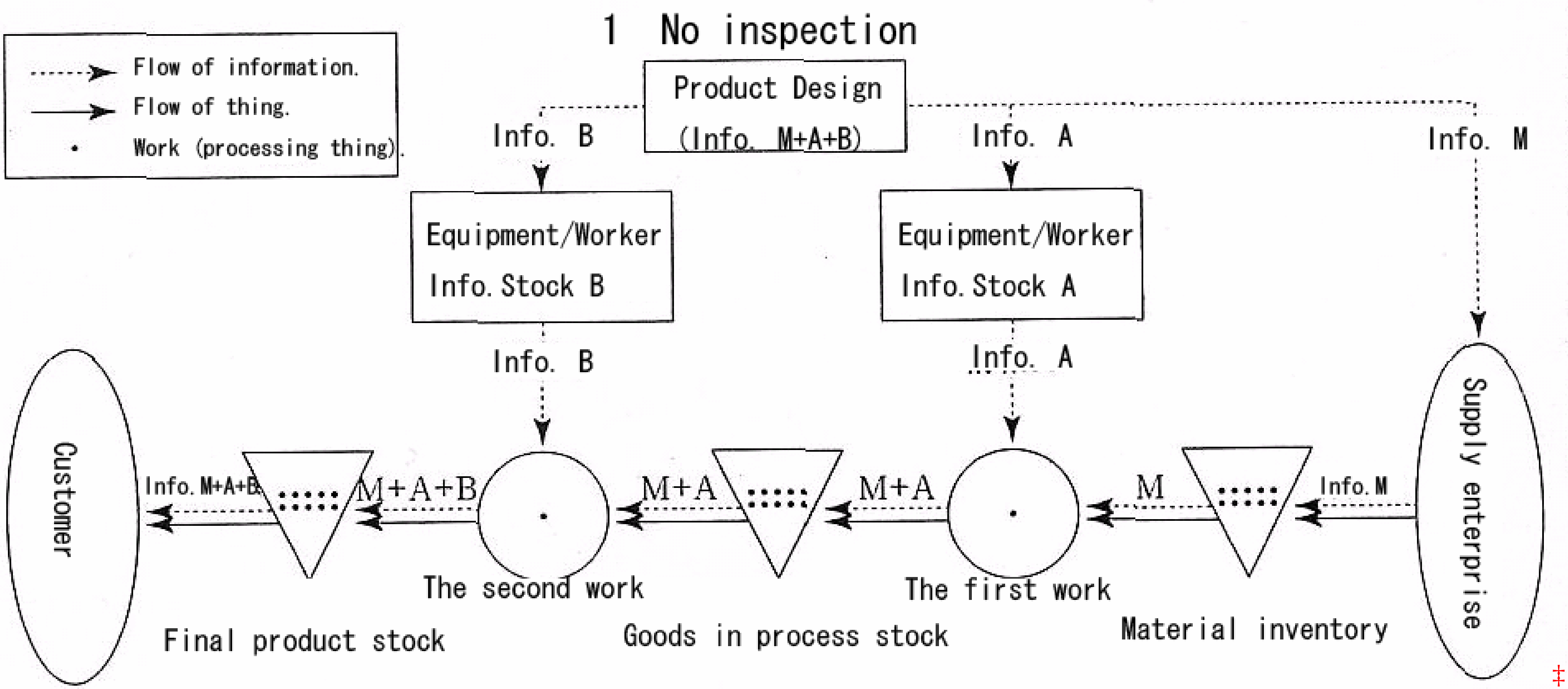
(6) self inspection

(7) prevention of defect

(8) product design resistant to noises

Inspection and Quality Building
1　No Inspection

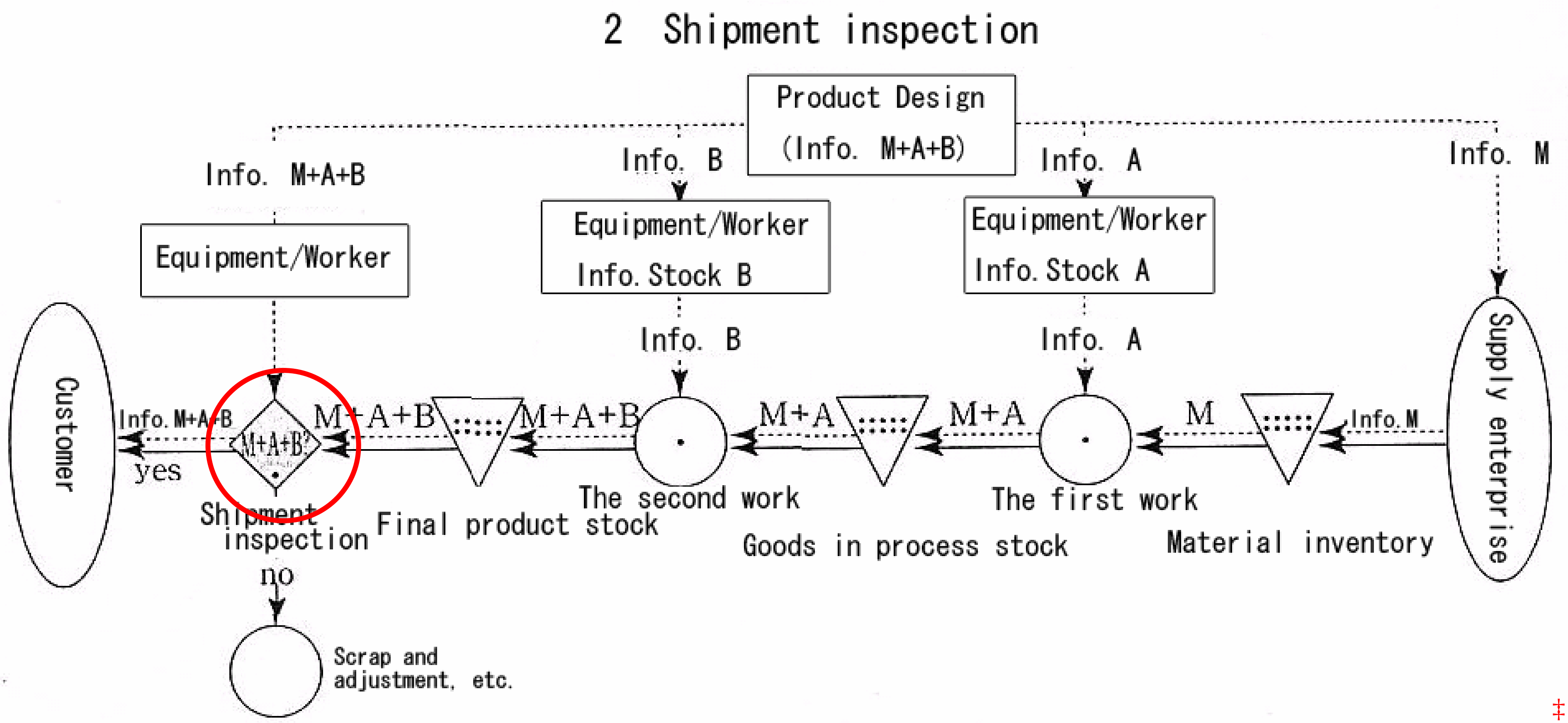
- - - - - -→ information flow
———→ product (Mono) flow
▪ work (processed product)



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p267 figure.7.9)

Inspection and Quality Building
2　Shipping Inspection

- - - - - - → information flow
——→ product (Mono) flow
▪ work (processed product)



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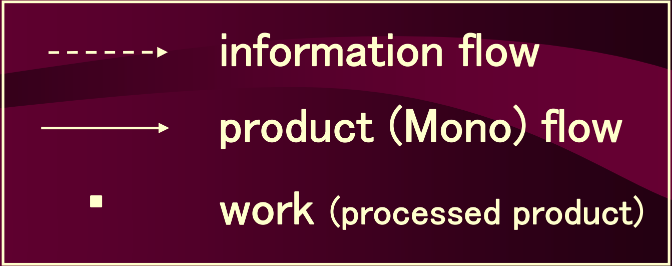
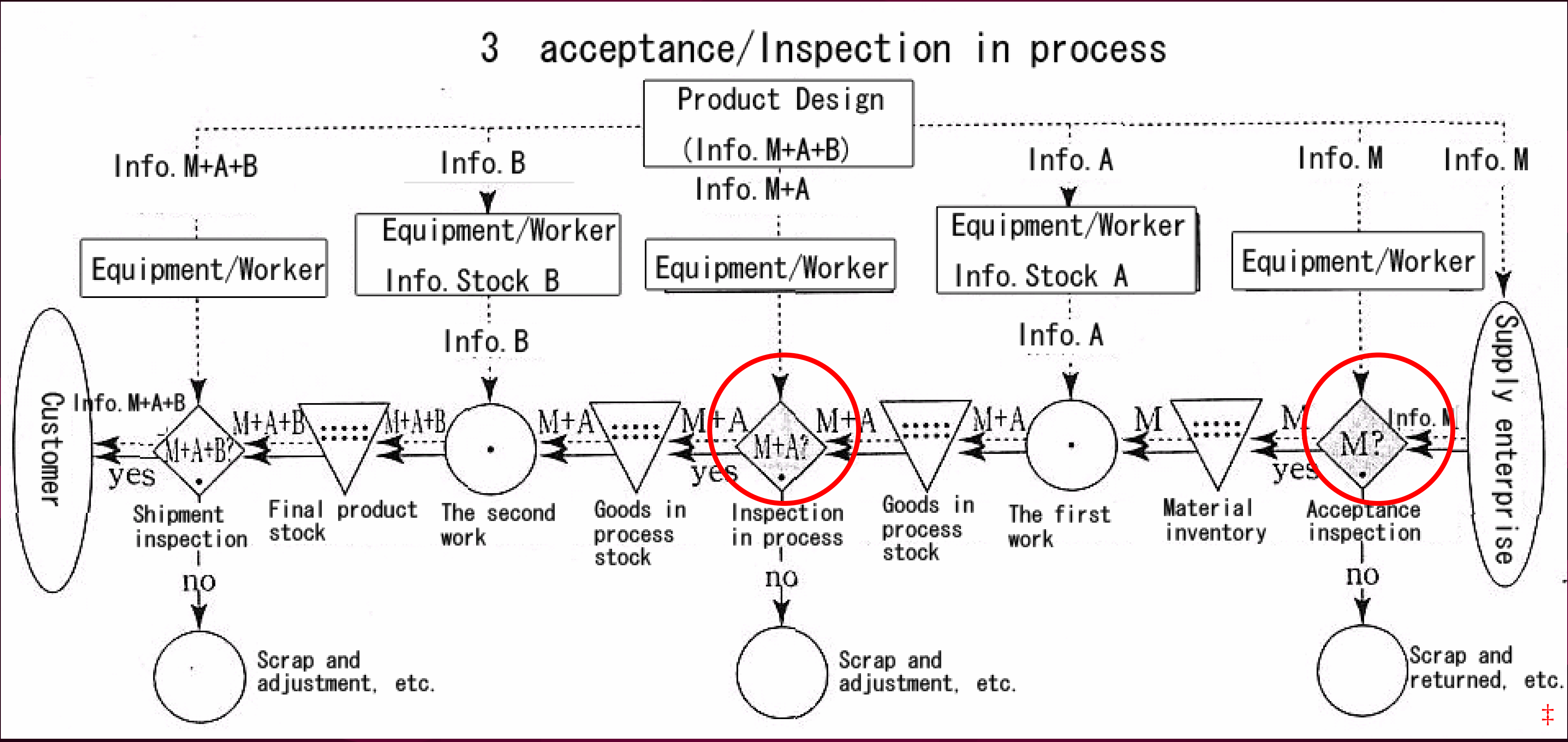
Inspection and Quality Building
3 Receiving Inspection/In-Process Inspection





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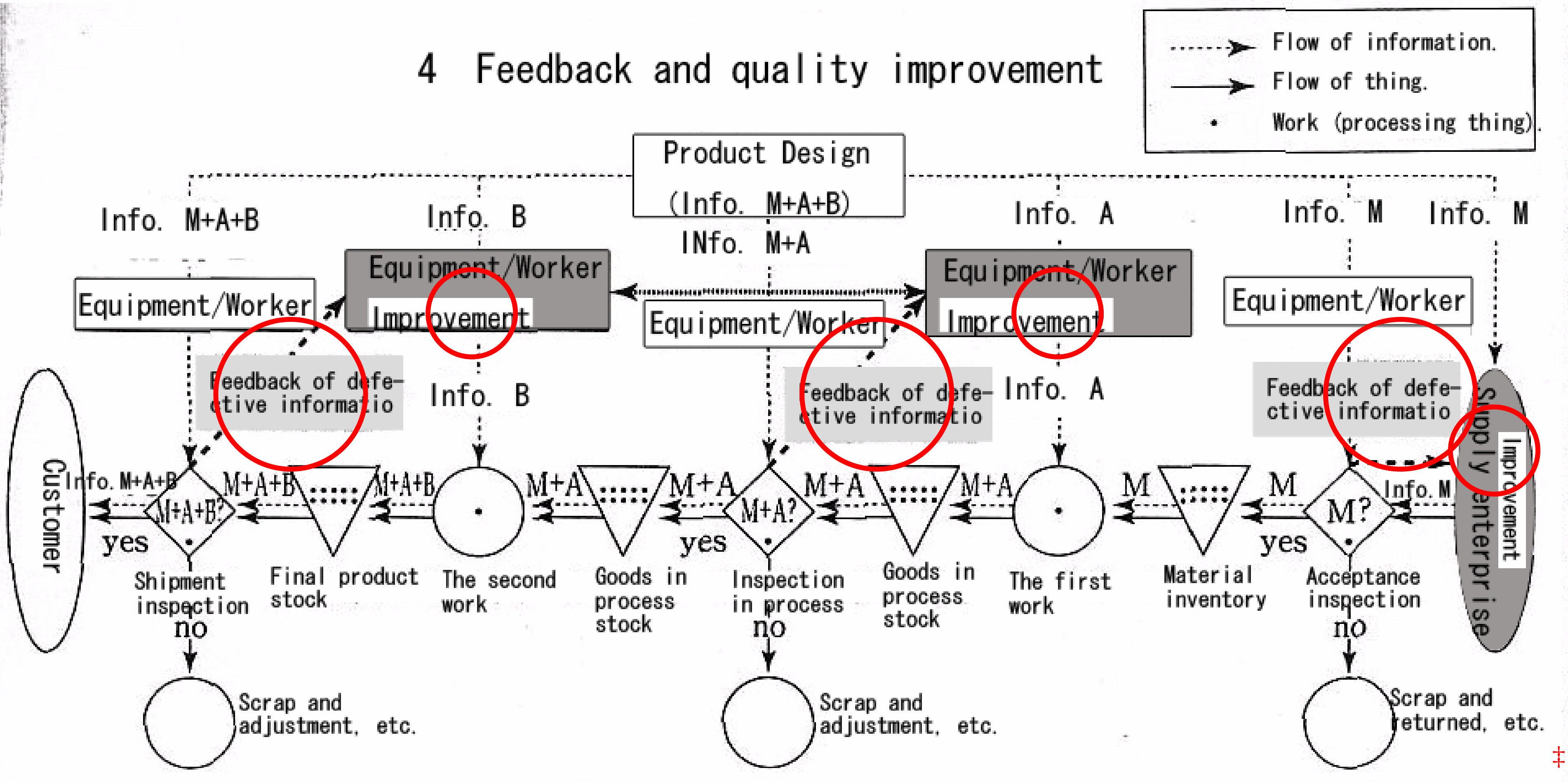
Inspection and Quality Building
4　Feedback and Quality Improvement

- - - - - -→ information flow
———→ product (Mono) flow
▪ work (processed product)



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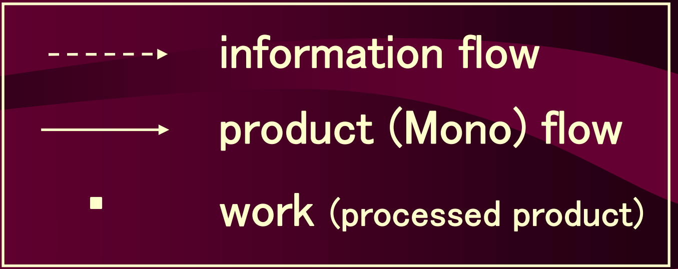
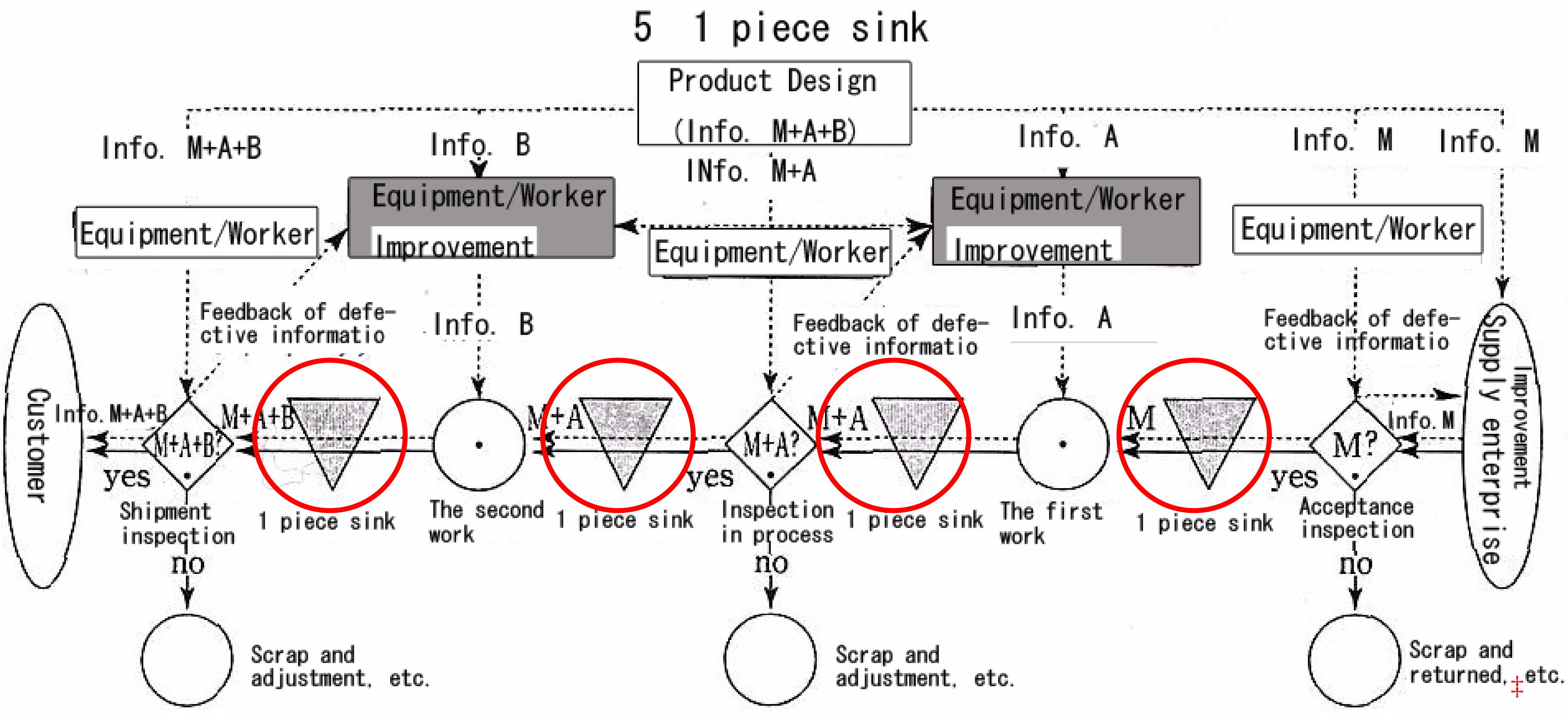
Inspection and Quality Building
5　One-By-One Production





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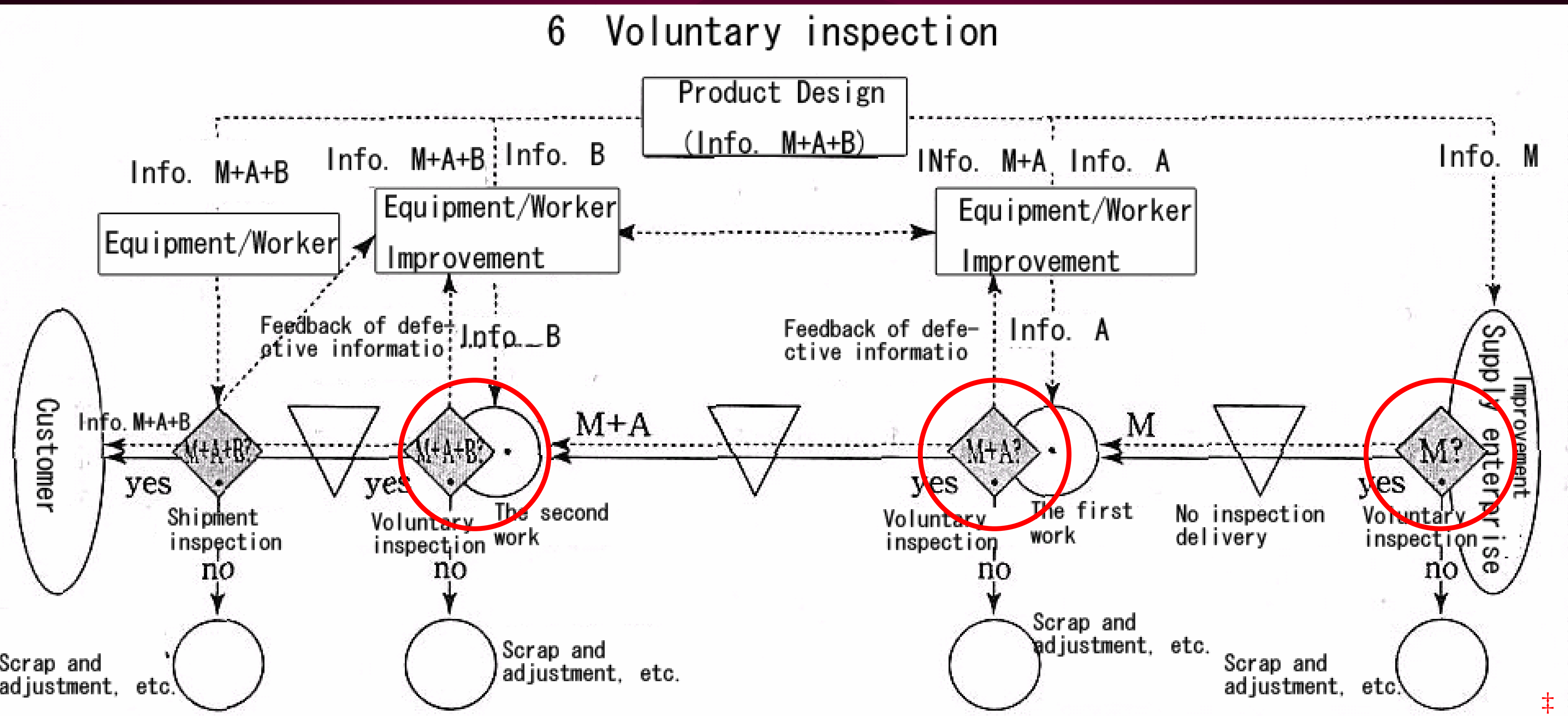
Inspection and Quality Building
6　Self Inspection

information flow
product (Mono) flow
work (processed product)



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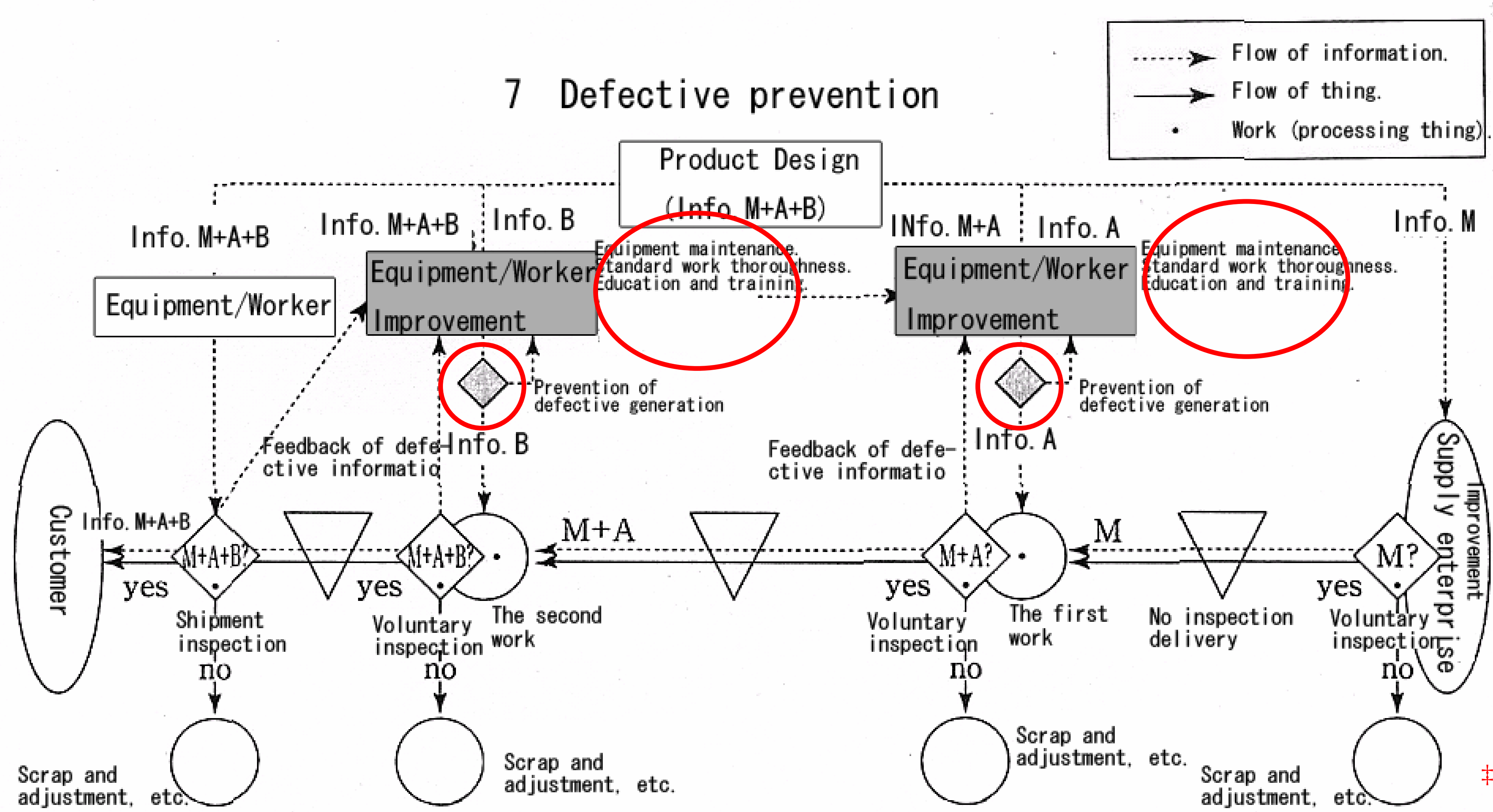
Inspection and Quality Building
7　Defect Prevention

- - - - - - → information flow
———→ product (Mono) flow
▪ work (processed product)



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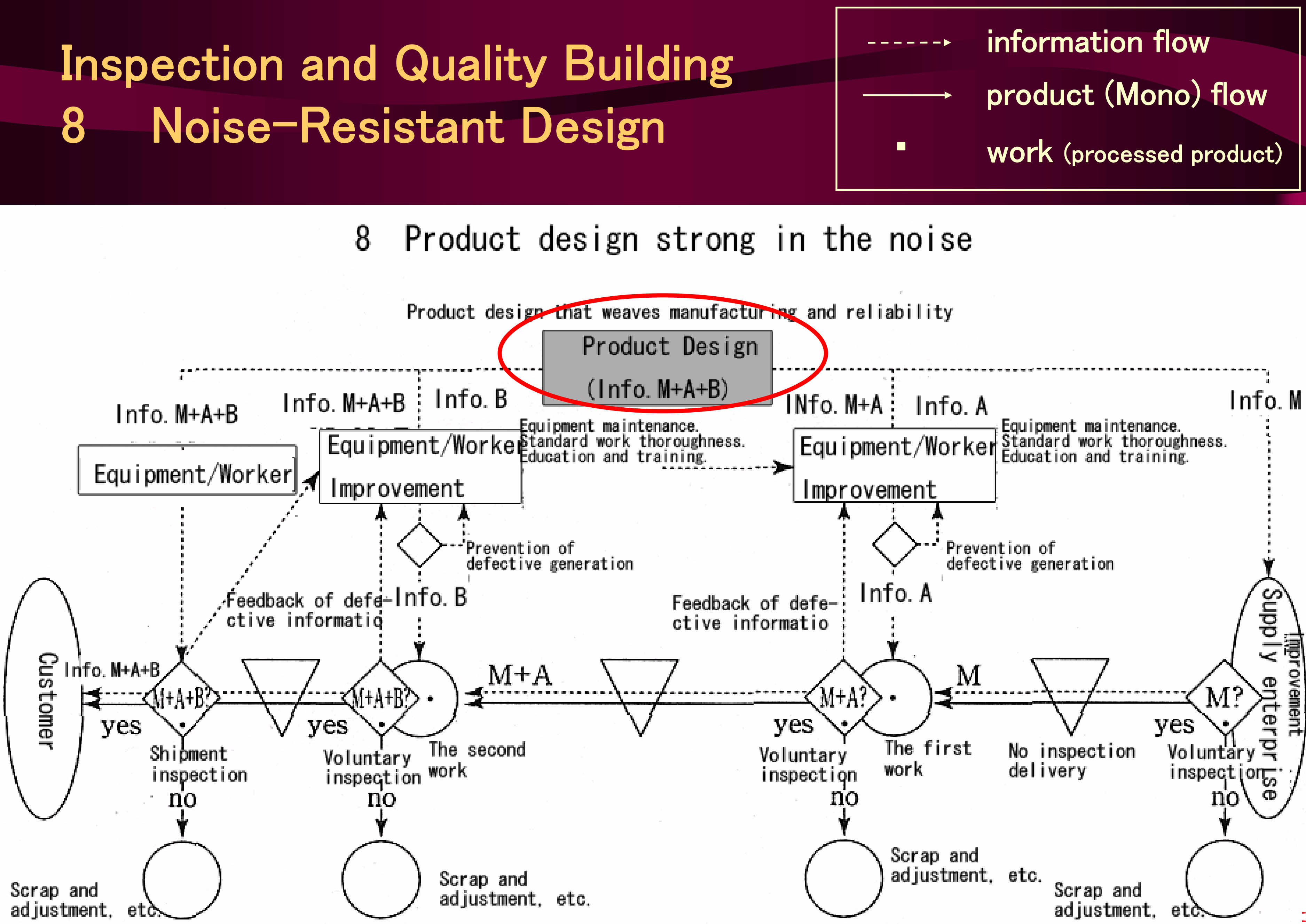
Inspection and Quality Building
8 Noise-Resistant Design



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3. Design of Inspection Process

Inspection = to judge each item by good or failure, by comparing results of testing in some way, against a quality judgment criteria

or, to judge each lot by qualified or disqualified comparing against a lot judgment criteria

Classification by Inspection Target

(1) Receiving inspection --- purchased material, parts

(2) In-process inspection --- in-process products

(3) Shipping inspection --- finished product

(a) Individual-unit inspection

(b) Lot-unit inspection (inspection of samples only)

Classification by Measured Data for Inspection

(1) Counting inspection

---- discretely judge product by good or bad

(2) Metric inspection

---- measure product attribute as continuous quantity

measure defect rate by its distribution and tolerance

Classification by way of handling defects

scrap, recycle, re-work (amend), other

Classification by Frequency/Density of Inspection

(1) Total inspection

(2) Inspection of first and last samples of a lot

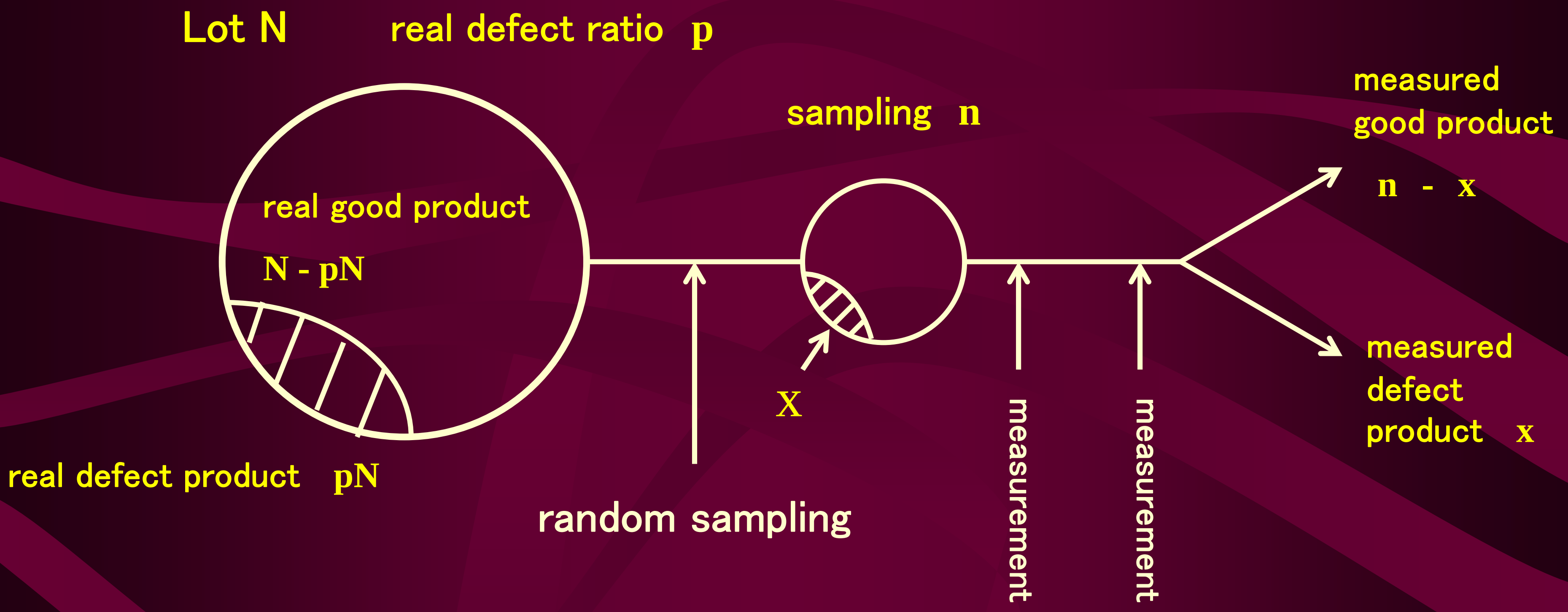
(3) Random inspection (counting model)

Extract **n** units from lot (N).
When the number of defects exceeds a qualification judgment criteria, that entire lot is judged disqualified, and when the same number is below the same criteria, the whole lot is judged qualified.

(4) Inspection by control chart (metric extraction inspection)

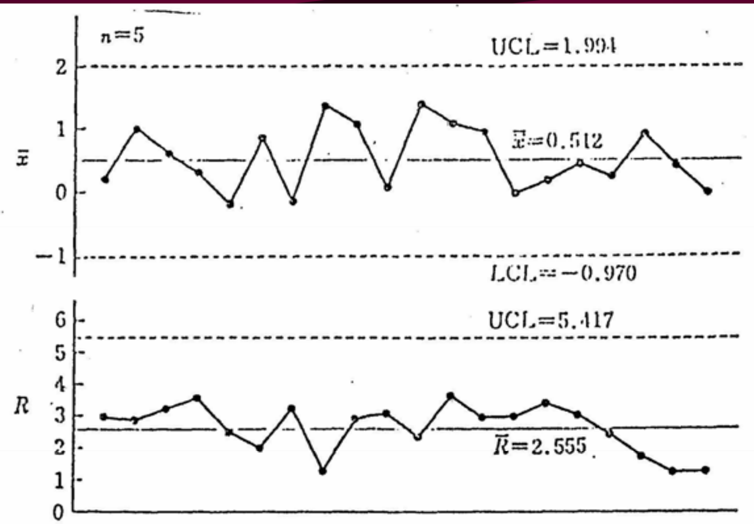
Control chart = to differentiate a trouble cause from an accidental cause
Focus on improving the former

Method of Counting Extraction Inspection



Yozo Mukawa 'Quality Control for Cotowaricou Student and Engineer' JUSE Press, Ltd. 1977 (p.86) ‡

Example of x-R Control Chart（filling quantity of powder: in unit of gram）



注：基本的なデータと管理限界の計算根拠は以下の通り。

観測１回当たりのサンプル数（n）＝5

観測回数２０回

サンプルの平均 $\bar{x}$ の平均（$\bar{\bar{x}}$）=0.512

範囲（R）の平均（$\bar{R}$）=2.555

以上から推定される母集団の標準偏差＝2.555÷2.326＝1.10

これに対応する $\bar{x}$ の上方管理限界＝0.512 + 2.555 x 0.577 = 1.994

これに対応する $\bar{x}$ の下方管理限界＝0.512 - 2.555 x 0.577 = -0.970

範囲（R）の上方管理限界＝2.555 x 2.115＝5.417

係数（2.326, 0.577, 2.115）は、管理図用係数表の「n＝5」の欄から引用した。‡

Author making (reference: Yozo Mukawa 'Quality Control for Cotowaricou Student and Engineer')

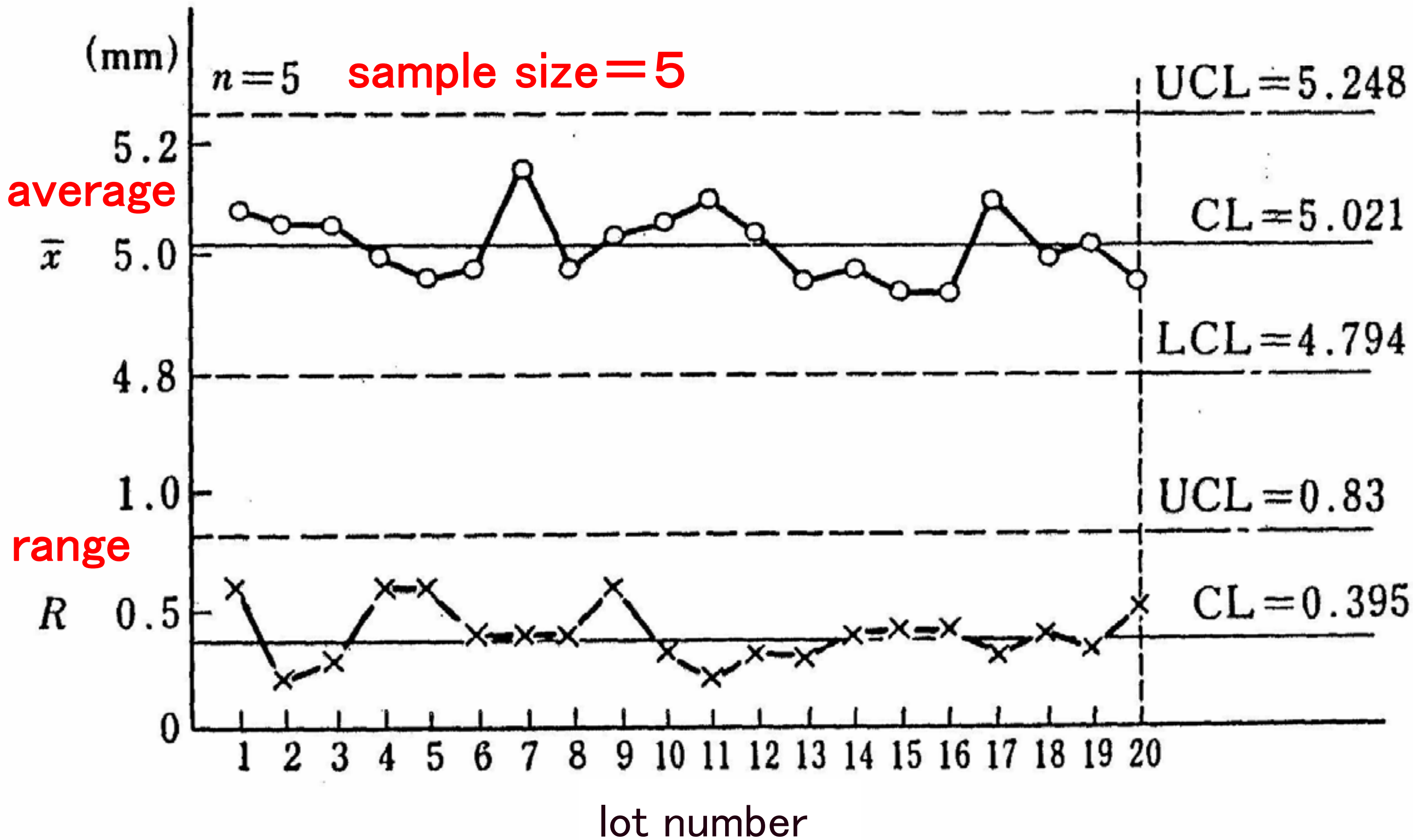
Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p275)

Example of x-R Control Chart

x-R control chart

PC second machine

rubber plate #500



x-R Control Chart --- Data Sheet

表5.5　$\bar{x}$-R 管理図　データ・シート

$\bar{x}$-R 管理図データ・シート

品名　　　　　：ゴム板＃500　　　サンプリング日時：9/1～9/12

品質特性　　　：厚さ　　　　　　測定者　　　　　：KK

サンプリング場所：PC　2号機

sampling of 5 units　　average　　range

群番号	日　付	x_1	x_2	x_3	x_4	x_5	$\bar{x}$	R
1	9/1	4.6	5.2	5.2	5.2	5.2	5.08	0.6
2		5.0	5.1	5.2	5.0	5.0	5.06	0.2
3	2	5.2	5.0	5.1	4.9	5.1	5.06	0.3
4		4.9	4.9	4.7	5.3	5.2	5.00	0.6
5	4	4.7	5.3	4.9	5.0	4.9	4.96	0.6
6		5.2	5.0	5.0	4.9	4.8	4.98	0.4
7	5	4.9	5.2	5.3	5.2	5.2	5.16	0.4
8		5.2	4.8	5.2	4.9	4.8	4.98	0.4
9	6	5.2	4.9	4.9	5.4	4.8	5.04	0.6
10		4.9	5.2	5.2	4.9	5.1	5.06	0.3
11	7	5.0	5.0	5.2	5.1	5.2	5.10	0.2
12		5.2	5.1	5.0	5.0	4.9	5.04	0.3
13	8	4.8	5.0	5.1	5.1	4.8	4.96	0.3
14		5.2	4.8	4.8	5.1	5.0	4.98	0.4
15	9	4.8	4.8	4.8	5.2	5.1	4.94	0.4
16		5.1	5.0	5.1	4.8	4.7	4.94	0.4
17	11	5.2	5.0	5.2	5.2	4.9	5.10	0.3
18		5.2	5.2	4.9	4.9	4.8	5.00	0.4
19	12	4.9	5.1	5.2	5.0	4.9	5.02	0.3
20		4.6	5.1	5.0	5.1	5.0	4.96	0.5
合計							100.42	7.9
平均							$\bar{\bar{x}}=5.021$	$\bar{R}=0.395$

Inspection Design and Quality Cost

No inspection --- zero inspection cost. cost corresponding to defects, only.

Extraction inspection --- extraction inspection cost +

cost of defects accrued from a lot qualified in inspection +

cost of total inspection of a lot disqualified by inspection

Total inspection --- cost of total inspection, only.
zero cost corresponding to defects.

"defect rate = unit inspection cost / unit defect cost"
at break even

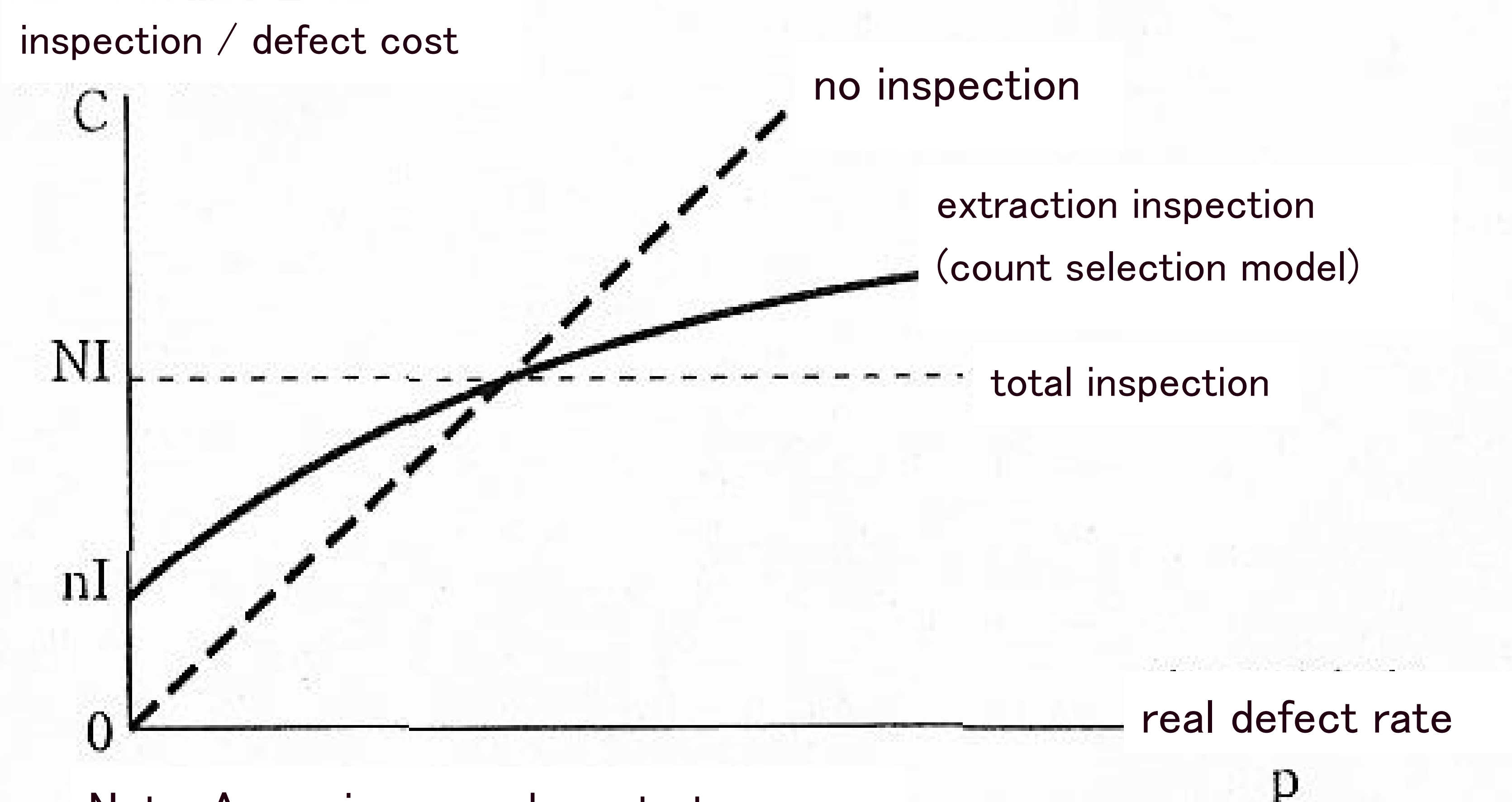
① no inspection $C = N p F$

② extraction inspection $C = n I + g (N - n) p F + (1 - g) (N - n) I$

③ total inspection $C = N \cdot I$

break even point for ② and ③: $p = I / F$

Inspection Method and Quality Cost



Note: Assuming rework cost at zero

Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (I p277 figure.7.11)

Design of Extraction Inspection ---

To review on a diagram the relationship between a real defect rate (p) and a lot's pass rate.

(1) AQL (Acceptable Quality Level) :

Reason on a maker's side insisting, ″The lot is of low defect rate, and shouldn't be mistaken as disqualified.″ (5% as standard)

(2) Producer's risk :

No matter how high a reject rate of AQL-level lot is, it's better not to go beyond this level. (5% as standard)

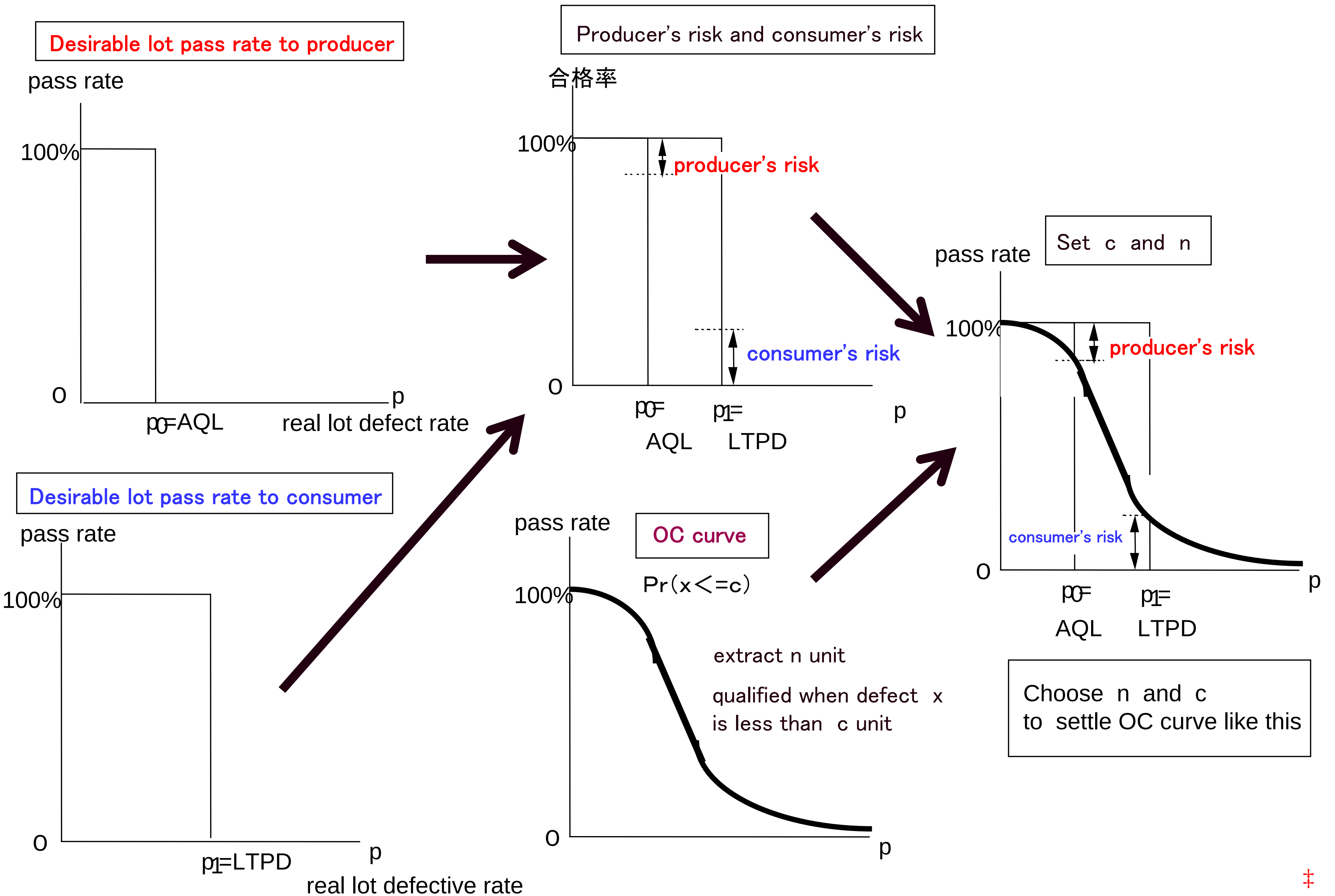
(3) LTPD (Lot Tolerance Percent Defective) :

To pass a lot whose defect rate exceeds this criteria is not acceptable from a consumer stand point.

(4) Consumer risk :

Probability for a LTPD-level lot to be mistakenly qualified should be below this.

Design of Extraction Inspection



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p278 figure.7.12)

Operating Characteristic Curve (OC Curve)

When real defect rate extracts n unit from universe p ,

probability Pr (x) at which x unit of defect is mixed follows binomial distribution.

When a rule is to pass a lot having number of defects below c unit,

pass rate = Pr ($x \leqq c$) can be expressed in cumulative probability of binomial distribution.

This pass rate curve (cumulative probability of binomial distribution) is "OC curve".

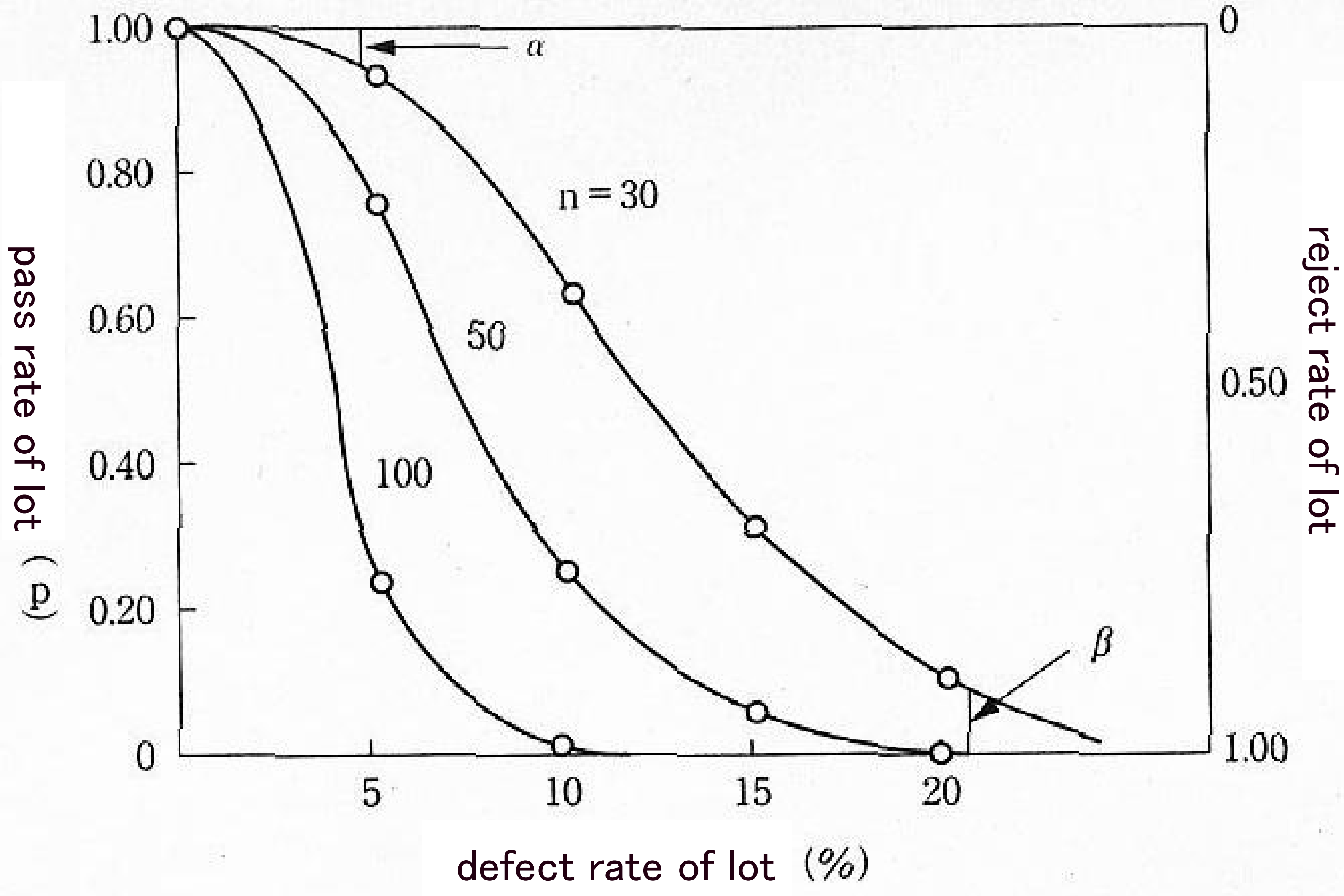
When n and c are set, so is a shape of OC curve.

Conversely, when AQL, LTPD, producer's risk, and consumer's risk are determined,

OC curve to pass 2 points [(AQL, producer's risk) and (LTPD, consumer's risk)],

and corresponding n and c are determined.

Sample Size (n) and Shape of OC Curve



注：母集団（N）は1000、c＝3を仮定している。

‡

Hideo Kuwata 'Production Management Outline' THE NIKKAN KOGYO SHIMBUN,LTD. 1998

4. Concept and Practice of TQC

(1) Traditional SQC ---

To emphasize optimization of inspection design
(assuming certain level of defect rate)

control chart, extraction inspection, test plan, etc.

(2) Production thought like JIT/TQ --- Improvement of process capability

To emphasize "building quality into product", "in-process total inspection"

(1) not to accrue a defect in the first place

(2) no to accrue a defect outside of the station

(3) to grasp defect outside of the station as early as possible

(4) to find and improve a basic cause of the defect swiftly

TQC (Total Company Quality Control)

TQC in Japan is CWQC (Company-Wide Quality Control)

Conceptually started in USA (Feigenbaum and others) → expanded in Japan

Its characteristics ----

- Total company activity (all layers, all departments)
- Continuous improvement (problem solving)
- Small group activity (QC circle)
- Usage of statistical method at job site ("QC 7 tools", etc.)
- emphasis on education/training
- Cross-company popular organization

(Union of Japanese Scientists and Engineers, Japan Management Association, Japanese Standards Association, Japan Productivity Center)

QC Circle

Kind of Small Group Activity

"Small group to voluntarily run a quality control activity in the same work office"

Many groups being composed of approximately 10 persons.

To meet a few times a month by selecting a leader.

To execute continuous improvements, all participation, by using QC method,

Presentation activity, recognition system.

QC Story

Periodical problem-solving steps (routine)

- theme
- reason for taking up a particular theme
- grasping status quo
- factor analysis
- measure
- confirmation of effectiveness
- brake (maintaining performance, relapse prevention)
- issues left to be addressed and way to proceed further (follow-up)

Same for MAIC method of "Six Sigma" (measure-analyze-improve-control)

QC 7 Tools

pareto chart, characteristic diagram (fishbone diagram), histogram,

check sheet, control chart, scatter graph, by layer

Its features --

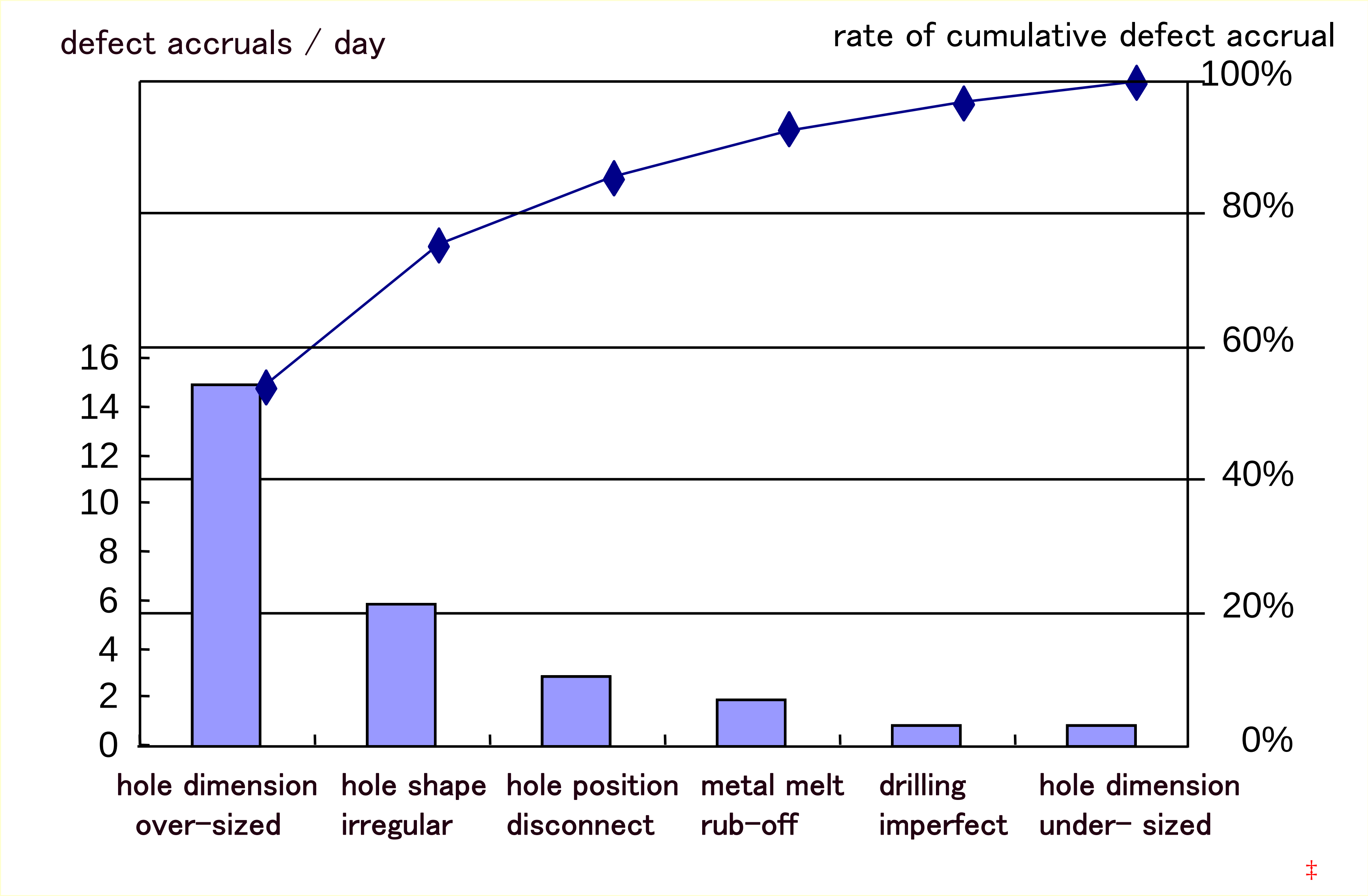
(1) simple and easy to understand

(2) graphic (control by eye sight)

(3) problem solving/improvement oriented

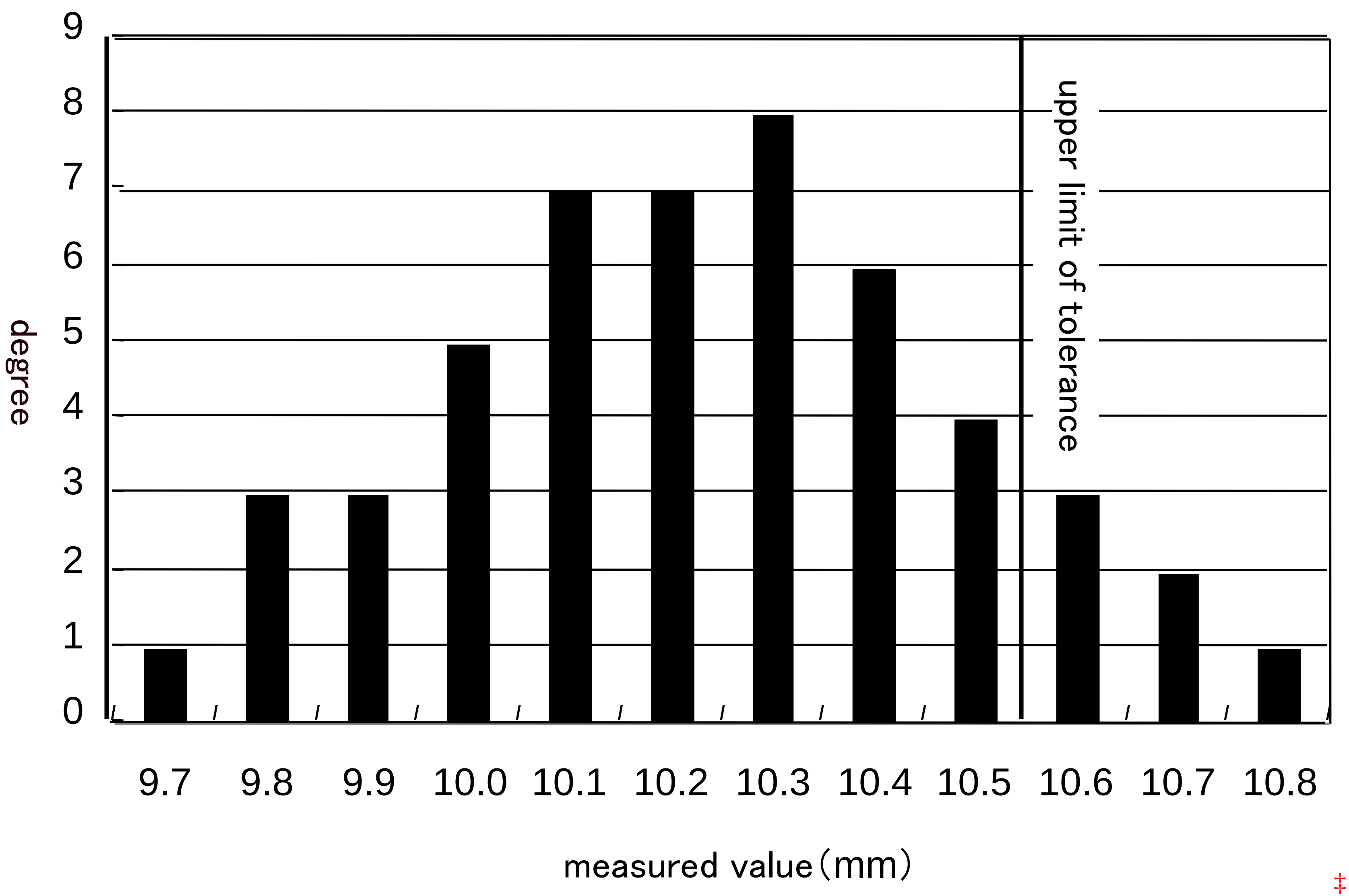
Tools for statistical analysis should not be a monopoly of experts. Use at the job site.

Numerical Example: Defect Accruals and Cumulative Rate (Pareto Chart)
----- Over size in hole dimension is the largest problem.



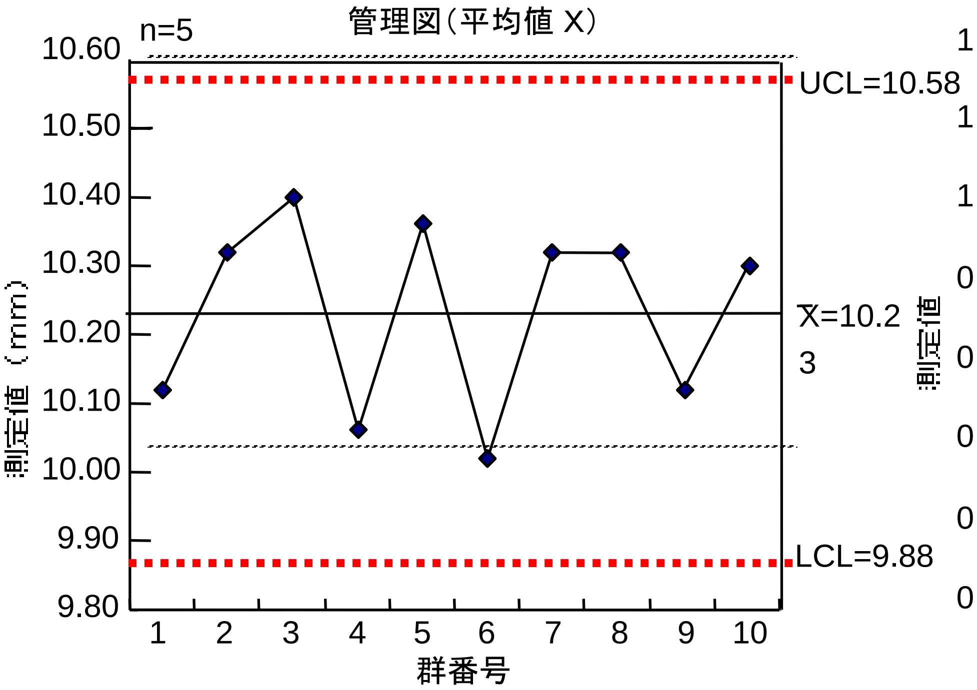
Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p287 table.7.1a figure7.14a)

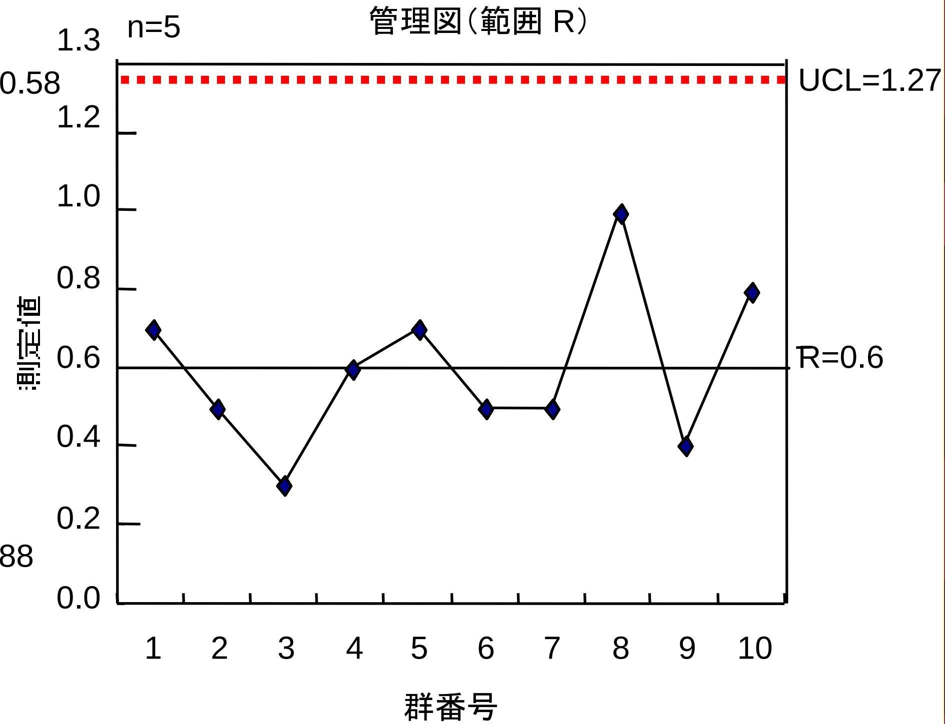
Numerical Example: Distribution of Measured Value (Histogram) ---- Exceeding Tolerance Over



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p288 figure.7.14c)

Numerical Example: x-R Control Chart ---- No Problem



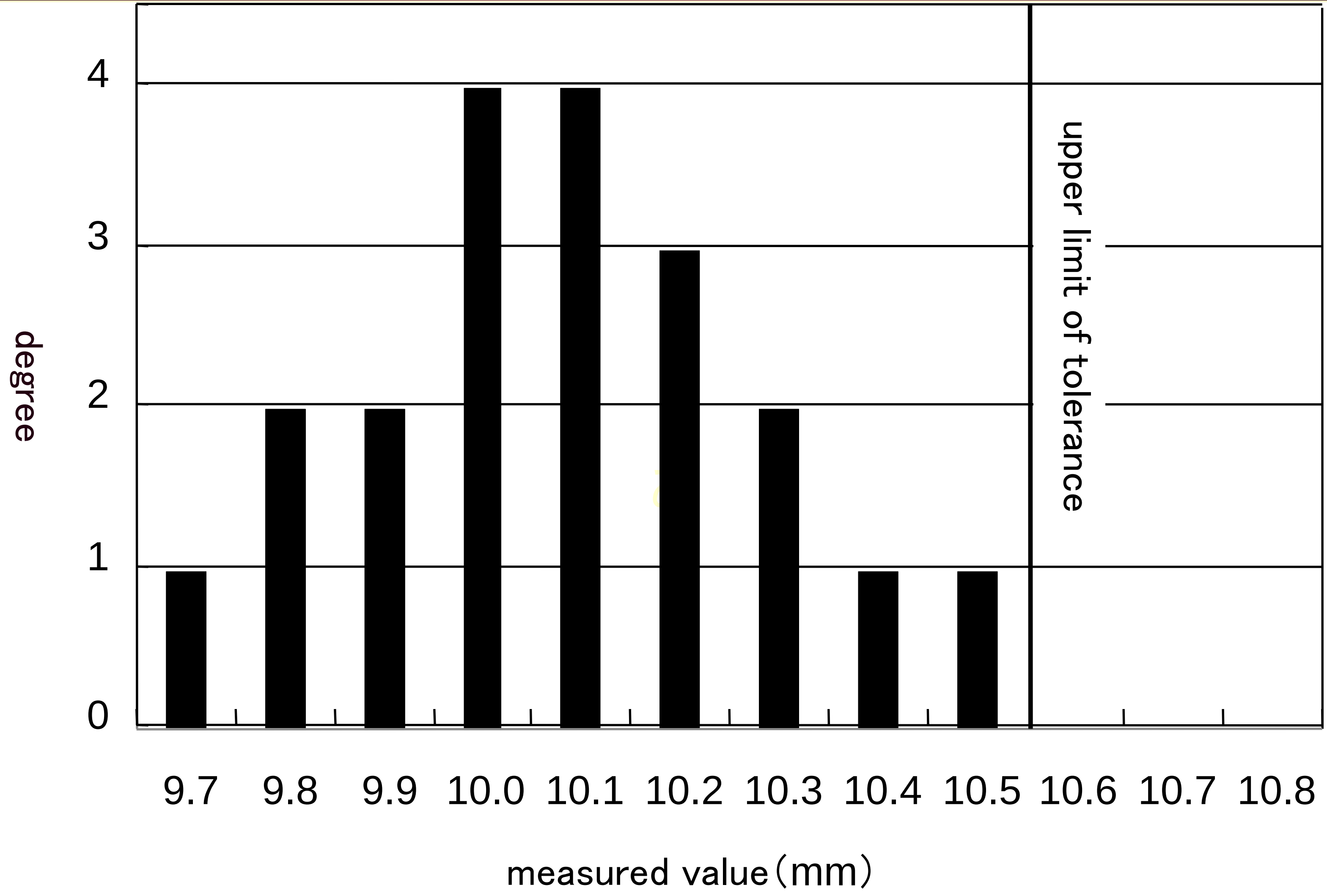


注：基本的なデータと管理限界の計算根拠は以下の通り。

観測1回当たりのサンプル数（n）＝5
観測回数10 回
サンプルの平均 x の平均（x）＝10.23
範囲（R）の平均（R）＝0.6
以上から推定される母集団の標準偏差＝0.6÷2.326＝0.26
これに対応する x の上方管理限界＝10.23 + 0.6 x 0.577 = 10.58
これに対応する x の下方管理限界＝10.23 - 0.6 x 0.577 = 9.88
範囲（R）の上方管理限界＝0.6 x 2.115＝1.27
係数（2.326, 0.577, 2.115）は、管理図用係数表の「n＝5」の欄から引用した。

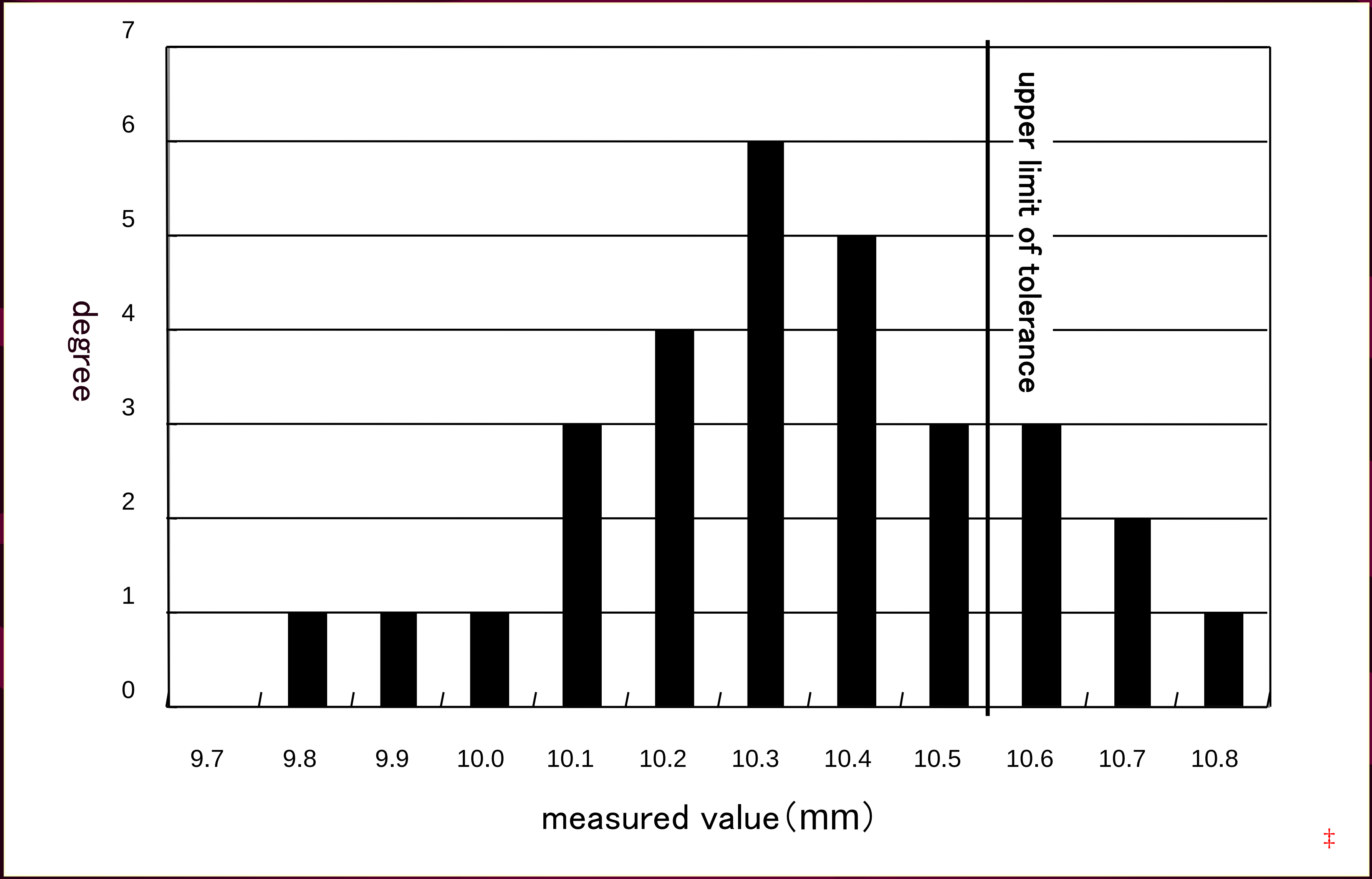
Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p289 figure.7.14d)

Numerical Example (by Layer): Distribution of Measured Value (Y company's steel sheet) --- Y company's product is OK.



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p290 figure.7.14e)

Numerical Example (by Layer): Distribution of Measured Value (Y company's steel sheet) --- X company's product is the problem.



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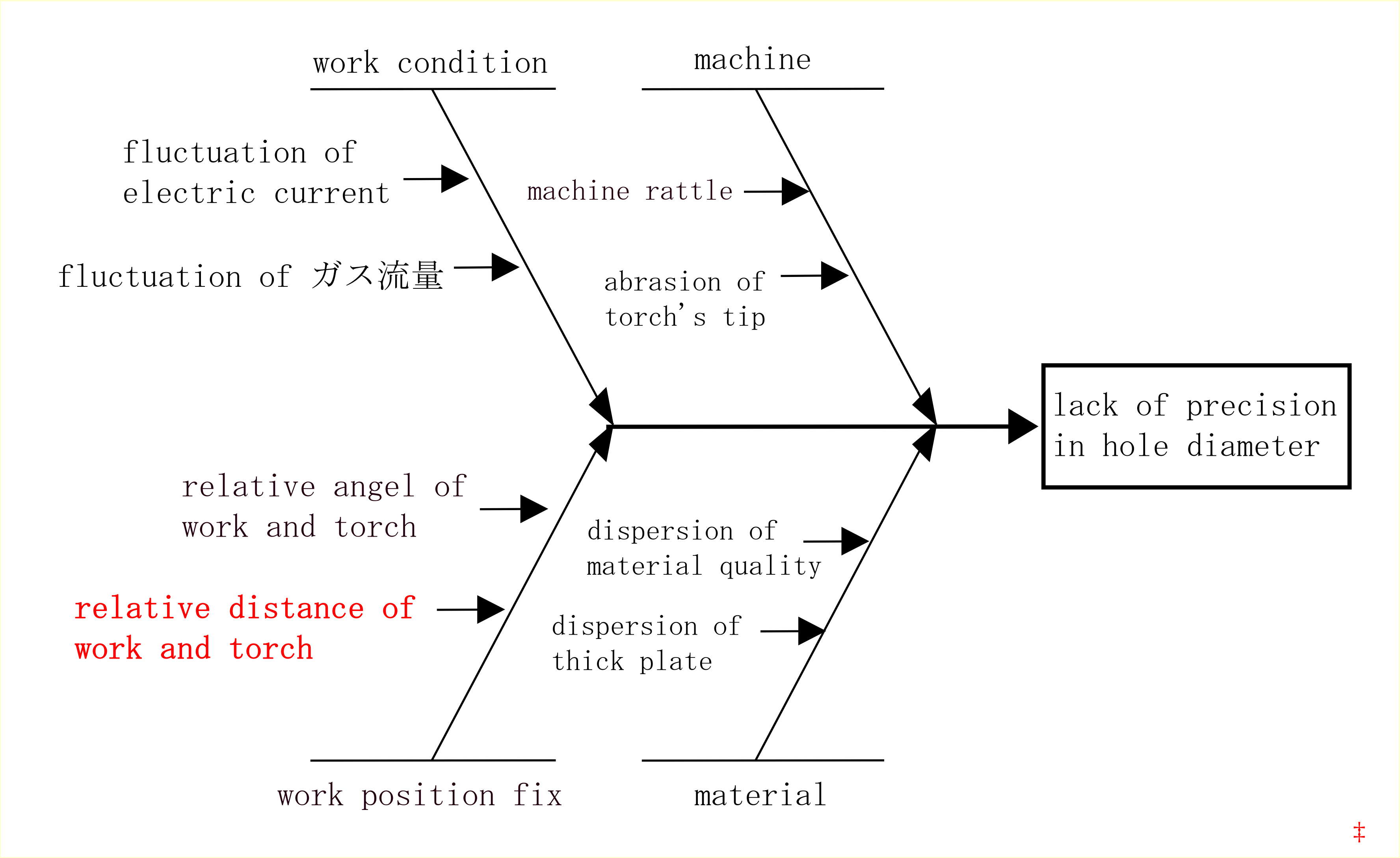
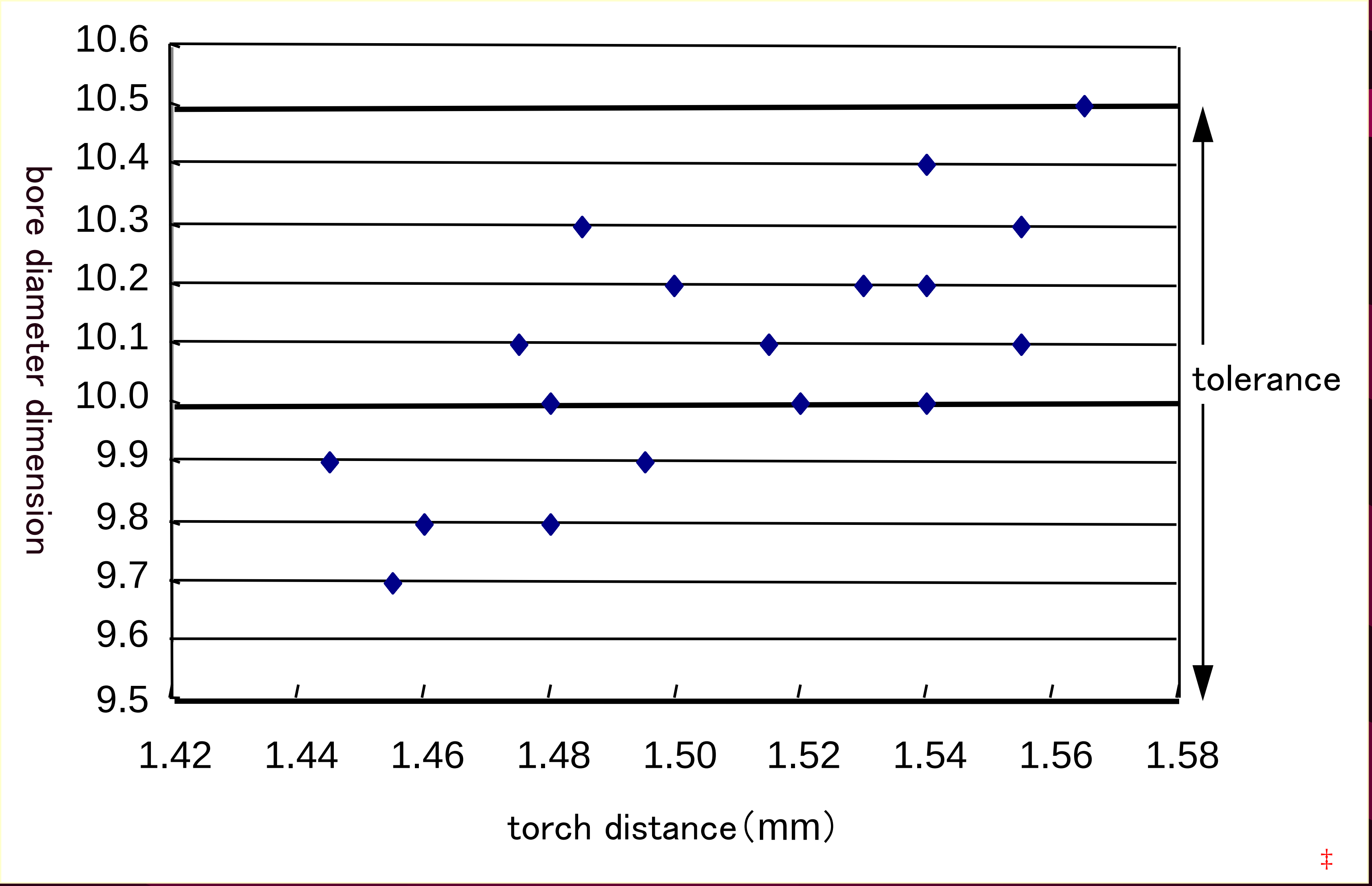
Numerical Example: Factor Analysis on Lack of Precision in Hole Diameter (Characteristic Diagram)



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p291 figure.7.14g)

Numerical Example: Torch Distance and Bore Diameter Dimension (Scatter Graph) --- Certainly related



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p291 figure.7.14h)

Policy Control

Kind of Objective Control

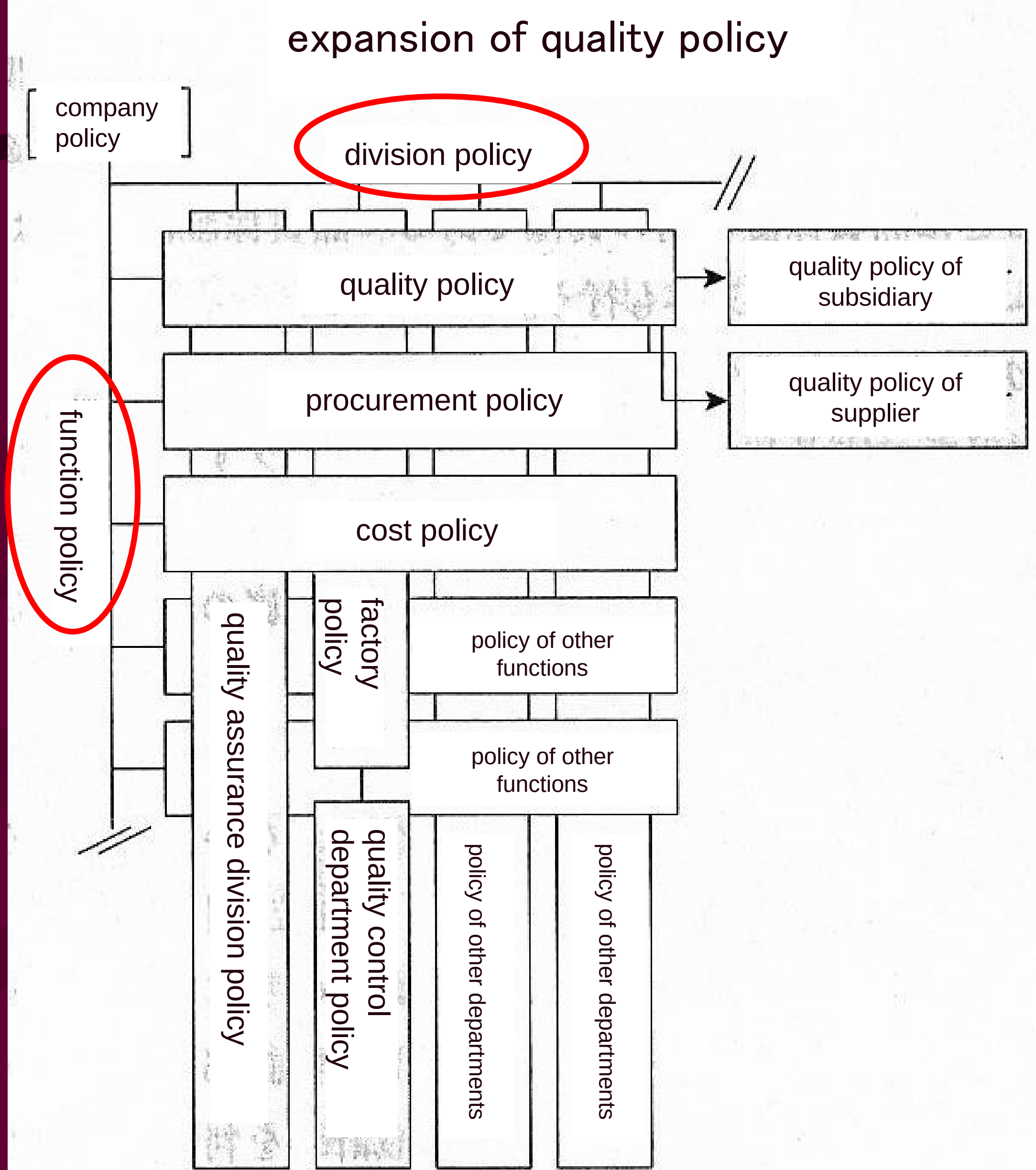
company motto → basic policy → long-term policy → annual policy

total company annual policy by top management
(objective and measure)

→ expansion by top-down onto each division/department/individual
(policy expansion)

→ discussion between superior and subordinate
rotate PDCA cycle (TQC method)

Policy Expansion



Note: Boxes in gray indicate policies related to quality.

Source: X Company

Takahiro Fujimoto
'Introduction to Production Management'
Nihon Keizai Shimbun, Inc. 2001 (Ⅰ p295 figure.7.15)

Role of Quality Assurance Division

① Previously, a quality assurance division executed inspections.

↓

② Now, a quality assurance division emphasizes functions of planning, operation, and organizer relative to total company quality assurance activities.

Problems of TQC

Self-righteous activities to win Deming Prize (totalism, spirit doctrine)

Losing substance

Negative effect of top-down method

From TQC to TQM (1996)

Effect of TQM (Total Quality Management) started in USA

In reference to "Malcom Bordeaux ridge national quality prize"

Emphasis on customer satisfaction/total quality

View of "quality of management"

Directly related to management strategy

Enriching problem-solving methods (Six Sigma' MAIC method)

Broadened problem solving activities

"ISO 9000 Series (9001, 9002, 9003)
= ISO (International Organization for Standardization;
an international standard established by a worldwide federation of each national standard bodies in 1987

Standards regarding to "quality system" which customers demand to supplier of a particular product

"Quality system" : documentation of steps for a series of activities, and recording of these activities' results, for suppliers to assure the quality of own company's products. Third-party screening/registration organizations implement screening/authorization on behalf of customers.

A system strongly reflecting Western thoughts of a contract society.

To Japanese companies of TQC model, this has not provided much effectiveness in enhancing their direct competitiveness.

Some appraise an effectiveness of basic motions' confirmation.

However, it is perhaps unlikely that this system will play a major role in advancing quality.