[ME 472]

Engineering Metrology & Quality Control

[CHAPTER 6]

Design of Limit Gauges

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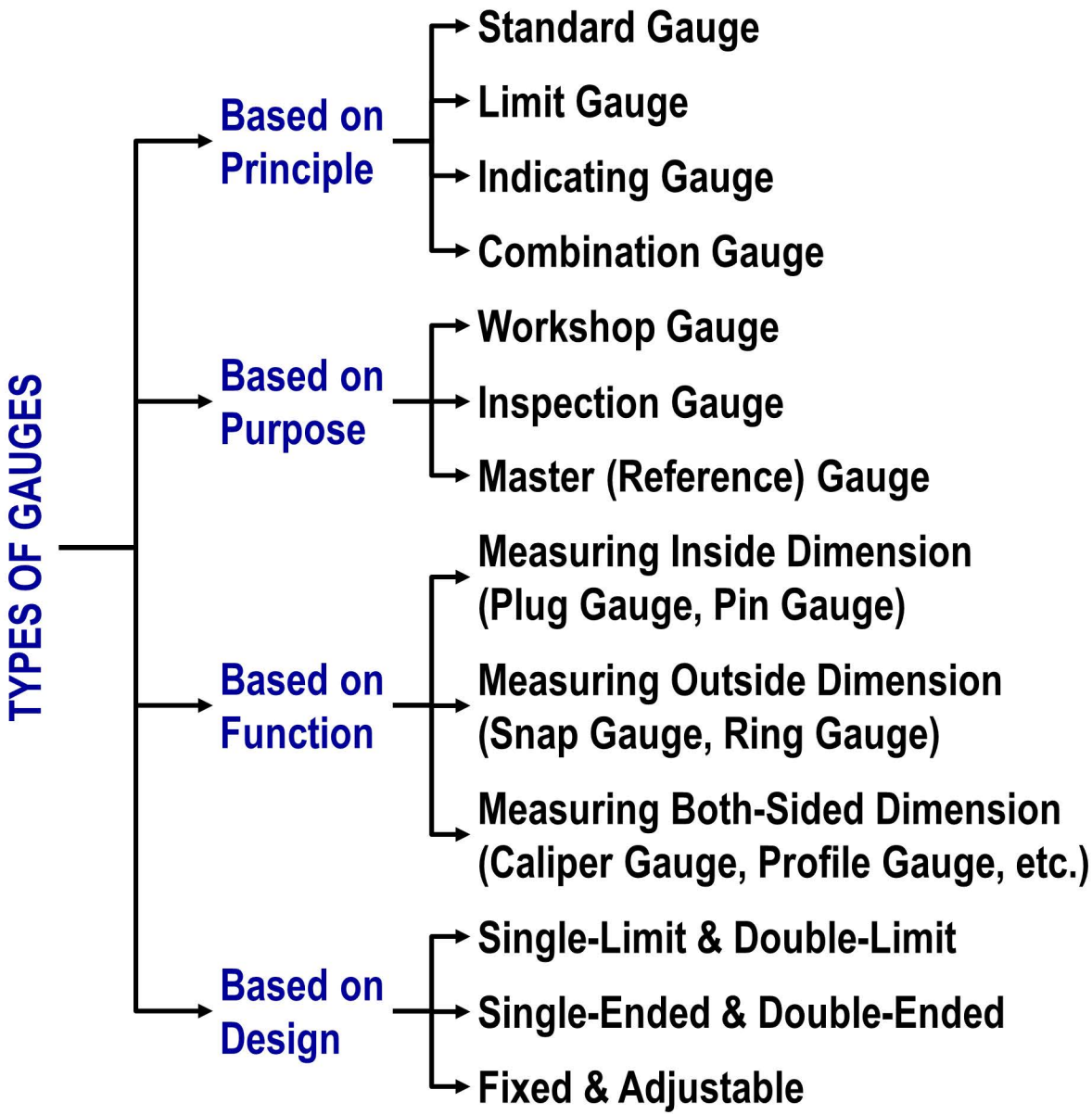
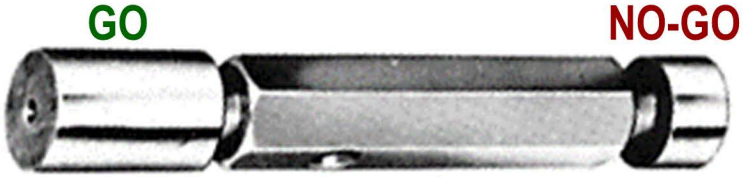
Gauges in Metrology

- Used to **inspect tolerance limits** of parts.
- Instead of measuring actual dimensions, the conformance of part can be checked by **GO (green)** & **NO-GO (red)** gauges.
- **Advantages of gauges are:**
  - free from errors
  - portable & no need for power supply
  - no auxiliary equipments and set-up
  - checking various dimensions
  - inexpensive inspection
  - providing uniform standards
- **Disadvantages of gauges are:**
  - Some parts within tolerance limits may be rejected by workshop gauges.
  - Some parts out of tolerance limits may be accepted by inspection gauges.
  - Gauges must be made separately as their tolerance zones are different.



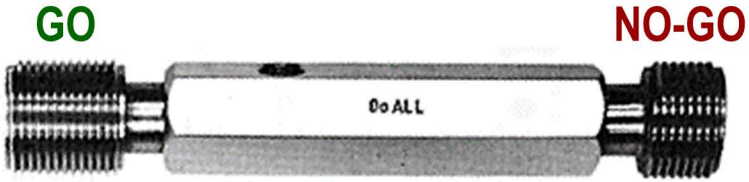
Gauges for Inspection of Holes & Shafts

Plain Pin Gauge



Plain Plug Gauge

Progressive Plug Gauge

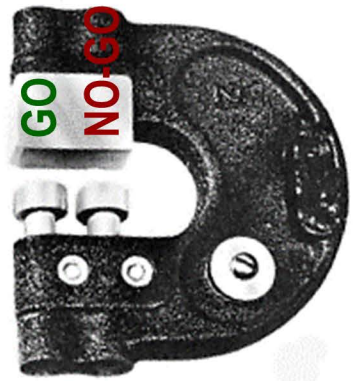


Thread Plug Gauge

Plain Ring Gauge

Adjustable Ring Gauge

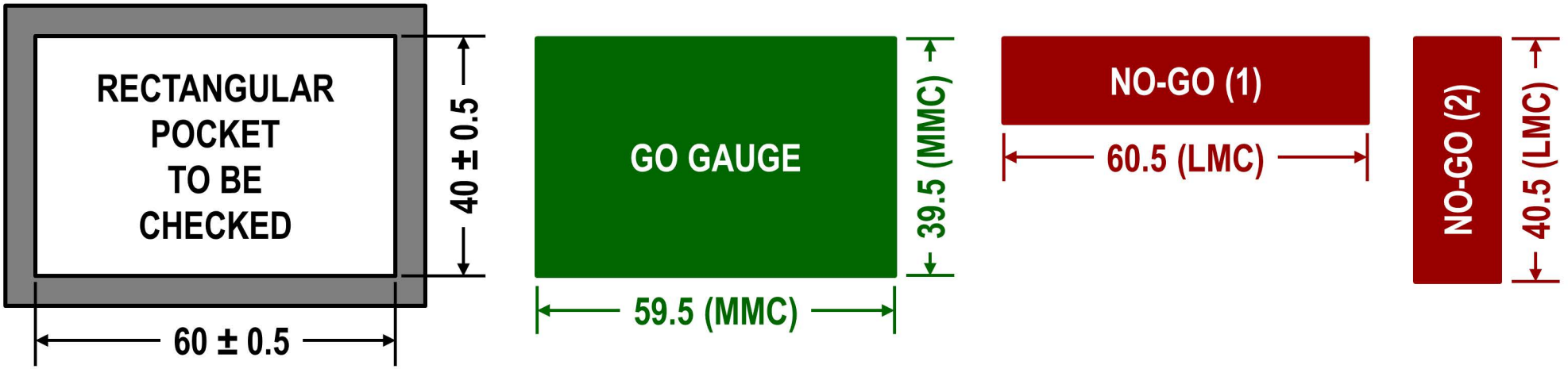
Plain Snap Gauge



Adjustable Snap Gauge

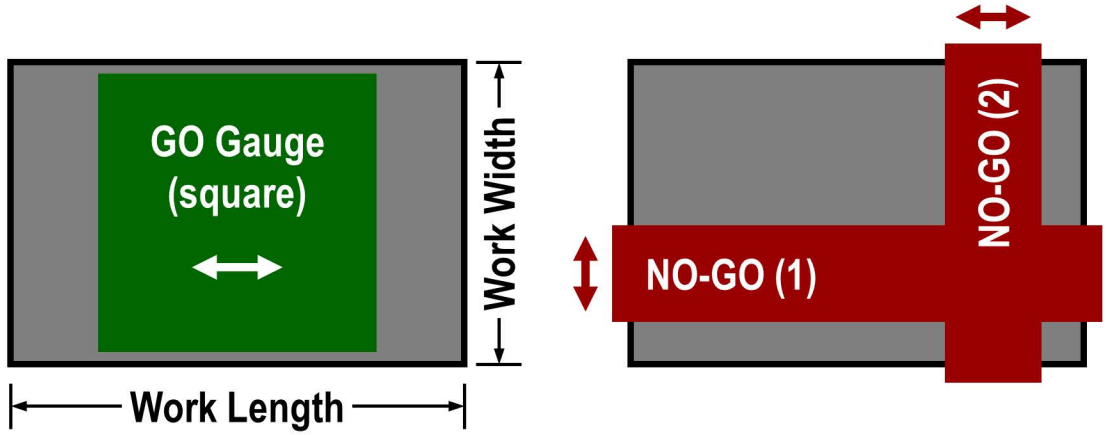
Taylor's Principle of Gauge Design

- It is used for **determination of shape & dimensions of the gauge**.
- The gauges are designed based on the following statements:
  - **GO Gauge** checks **Maximum Material Condition (MMC)**, it should check as many dimensions as possible.
  - **NO-GO Gauge** checks **Least Material Condition (LMC)**, it should check a single dimension at once.
- **GO gauge fits into work** in certain direction, but **NO-GO gauge must not fit into work** at specific orientations.
- As seen from the example below, only one GO gauge is sufficient (for checking the lowest limit of all dimensions) whereas separate NO-GO gauges are required (for checking the highest limit of each dimension).



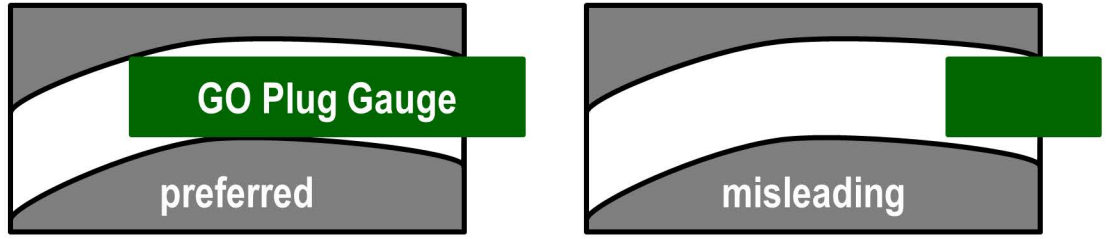
Need for Separate NO-GO Gauges

- As seen in figure, **a square-shape GO gauge** can be used to **check both length & width** of work by moving the gauge along the length.
- **NO-GO (2)** can be used to **check the width**, but not the length. Using **NO-GO (1)** to **check the width would be meaningless** as its size is very much oversized for that purpose.



Significance of Gauge Length

- **GO gauges** have **longer length** (about 3 to 4 diameters of hole/shaft to be checked) so that **possible geometric errors can be checked** (e.g. straightness of a hole as seen in figure).
- **NO-GO gauges** are **always shorter** (usually equal to hole/shaft diameter).

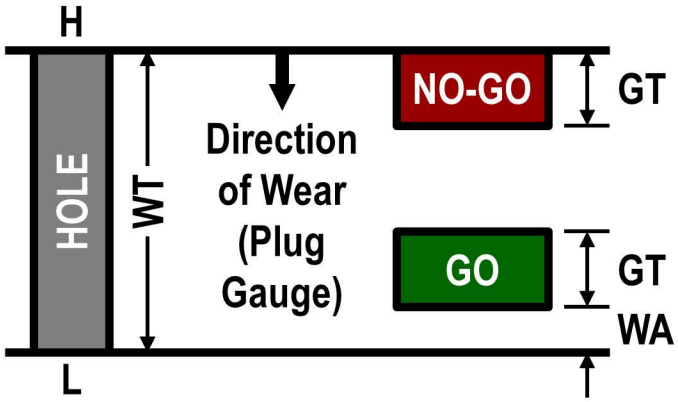


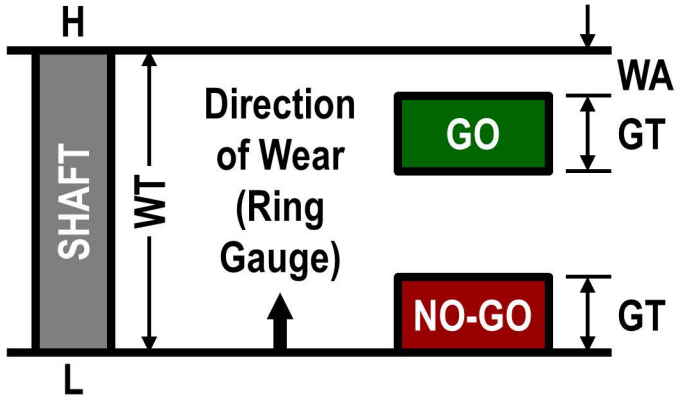
Wear of Gauges

- Gauges eventually lose their nominal size due to rubbing against work surface. **Wear Allowance** is considered in design of **GO gauges**. This is not applied to **NO-GO gauges** as they are not subjected to much wear.

Tolerances in Gauges

- Based on the related standard **(BS 969:2008)**, the dimensions of gauges can be determined.
- **Work Tolerance (WT)** is found based on **the highest limit (H)** & **the lowest limit (L)** of work.
- Then, the corresponding value of **Gauge Tolerance (GT)** is selected from table.
- **Wear Allowance (WA) added** to the size of **GO plug gauge**, but **subtracted** from the size of **GO ring gauge**.
- If **WT < 0.009 mm**, the work should be measured directly or by means other than gauges described in this standard.





Work Tolerance	Gauge Tolerance	Wear Allowance	Plug Gauge Dimensions (for checking holes)		Ring Gauge Dimensions (for checking shafts)	
WT (mm)	GT (mm)	WA (mm)	GO	NO-GO	GO	NO-GO
≥ 0.009 ≤ 0.018	0.001	0.001	$L^{+0.002}_{+0.001}$	$H^{0}_{-0.001}$	$H^{-0.001}_{-0.002}$	$L^{+0.001}_{0}$
> 0.018 ≤ 0.032	0.002	0.001	$L^{+0.003}_{+0.001}$	$H^{0}_{-0.002}$	$H^{-0.001}_{-0.003}$	$L^{+0.002}_{0}$
> 0.032 ≤ 0.058	0.003	0.002	$L^{+0.005}_{+0.002}$	$H^{0}_{-0.003}$	$H^{-0.002}_{-0.005}$	$L^{+0.003}_{0}$
> 0.058 ≤ 0.100	0.004	0.004	$L^{+0.008}_{+0.004}$	$H^{0}_{-0.004}$	$H^{-0.004}_{-0.008}$	$L^{+0.004}_{0}$
> 0.100 ≤ 0.180	0.006	0.007	$L^{+0.013}_{+0.007}$	$H^{0}_{-0.006}$	$H^{-0.007}_{-0.013}$	$L^{+0.006}_{0}$
> 0.180 ≤ 0.320	0.009	0.012	$L^{+0.021}_{+0.012}$	$H^{0}_{-0.009}$	$H^{-0.012}_{-0.021}$	$L^{+0.009}_{0}$
> 0.320 ≤ 0.580	0.014	0.025	$L^{+0.039}_{+0.025}$	$H^{0}_{-0.014}$	$H^{-0.025}_{-0.039}$	$L^{+0.014}_{0}$
> 0.580 ≤ 1.000	0.025	0.048	$L^{+0.073}_{+0.048}$	$H^{0}_{-0.025}$	$H^{-0.048}_{-0.073}$	$L^{+0.025}_{0}$
> 1.000 ≤ 1.800	0.040	0.080	$L^{+0.120}_{+0.080}$	$H^{0}_{-0.040}$	$H^{-0.080}_{-0.120}$	$L^{+0.040}_{0}$
> 1.800 ≤ 3.200	0.050	0.155	$L^{+0.205}_{+0.155}$	$H^{0}_{-0.050}$	$H^{-0.155}_{-0.205}$	$L^{+0.050}_{0}$

Exercise (1) : Design of a Plug Gauge

Hole Size : $20\ ^{+0.1}_{-0.1}$

Highest Limit (H) : 20.1 mm

Lowest Limit (L) : 19.9 mm

Work Tolerance (WT) : 0.2 mm

Work Tolerance	Gauge Tolerance	Wear Allowance	Plug Gauge Dimensions (for checking holes)	
WT (mm)	GT (mm)	WA (mm)	GO	NO-GO
> 0.180 ≤ 0.320	0.009	0.012	$L^{+0.021}_{+0.012}$	$H^{\ 0}_{-0.009}$

GO	NO-GO
↓	↓
$19.9\ ^{+0.021}_{+0.012}$	$20.1\ ^{0}_{-0.009}$
↓	↓
19.921 mm	20.100 mm
19.912 mm	20.091 mm

Exercise (2) : Design of a Ring Gauge

Shaft Size : $20\ ^{+0.3}_{0}$

Highest Limit (H) : 20.3 mm

Lowest Limit (L) : 20.0 mm

Work Tolerance (WT) : 0.3 mm

Work Tolerance	Gauge Tolerance	Wear Allowance	Ring Gauge Dimensions (for checking shafts)	
WT (mm)	GT (mm)	WA (mm)	GO	NO-GO
> 0.180 ≤ 0.320	0.009	0.012	$H^{-0.012}_{-0.021}$	$L^{+0.009}_{\ 0}$

GO	NO-GO
↓	↓
$20.3\ ^{-0.012}_{-0.021}$	$20.0\ ^{+0.009}_{0}$
↓	↓
20.288 mm	20.009 mm
20.279 mm	20.000 mm