Pit Stop Indy
Tune Up Your Team

Functional Gauge Designs
PMPA Technical Conference

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- 44 Years Exp.
  - Automotive
  - Aerospace
  - Education
    - Engineering
    - Manufacturing
    - Quality

- Technical Book Author
  - Quality
  - Engineering
  - Shop Technical
Functional Gauges

Ref: Functional Gauge Designs - Griffith Training
Functional Gauges

- Precision Worst Case Mating Part Replicate
- Receiver Gauge
- Boundary Gauge
- Functional Gauge

Ref: Functional Gauge Designs - Griffith Training
Alpha & Beta Risk

- Alpha Risk
  - Rejection of Good Product

- Beta Risk
  - Acceptance of Bad product

- Functional Gauges should be designed and built for minimal Alpha Risk

Follow the \(<10\%\) Rule

Ref: Functional Gauge Designs - Griffith Training
Premise for Functional Gauging

- It must be a **geometric tolerance** applied at **MMC**
  - RFS cannot be successfully gauged
  - LMC cannot be successfully gauged
- MMC applications on the part create a fixed virtual condition for fixed gauging

Ref: Functional Gauge Designs - Griffith Training
Advantages - Disadvantages

**ADVANTAGES**
- Fast functional inspection
- Represents the actual interface
- Gauges the virtual boundary
- Easy to Use
- Will not accept bad product

**DISADVANTAGES**
- Rejects borderline good product
- Must be reworked if part drawing changes
- Cost prohibitive
- Cannot get quantifiable results

Ref: Functional Gauge Designs - Griffith Training
Inspection of One Part Callout

- Surface Plate Setup
  - 2.5 hours
- Coordinate Measuring Machine
  - 18 Minutes
- Functional Gauge
  - 20 seconds

Ref: Functional Gauge Designs - Griffith Training
Gauging Costs

- Design
- Administrative (authorizations, purchasing, etc.)
- Manufacturing the Gauge
- Gauge Inspection
- Changes due to part design changes
- Certification
- Maintenance
- Storage

Ref: Functional Gauge Designs - Griffith Training
Functional Gauge Materials

Gauge Material Selection Criteria:

- The part material
- Intended use of the Gauge
- Frequency of use of the Gauge
- The environment where the Gauge will be used
- Specific Gauge features that will be used the most
- Moving versus non-moving Gauge features
- Gauge features that will, or will not, make contact with the part

Ref: Functional Gauge Designs - Griffith Training
Typical Gauge Materials
(Wear Members)

Grade A Tool Steel
- Cold Worked
- Air Hardened
- Medium Alloy
- RC 57-62

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<th>Material</th>
<th>Composition</th>
<th>Properties</th>
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<tbody>
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<td>A2</td>
<td>C 1.00, Cr 5.00, Mo 1.00</td>
<td>High Wear Resistance, Medium Toughness, Medium Machinability</td>
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Grade D Tool Steel
- Cold Worked
- High Carbon
- High Chromium
- RC 54-61

<table>
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<tr>
<th>Material</th>
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<tbody>
<tr>
<td>D2</td>
<td>C 1.50, Cr 12.00, Mo 1.00, V 1.00</td>
<td>Very High Wear Resistance, Low Toughness, Low Machinability</td>
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Popular Gauge Materials
(Gage Bodies)

17-4PH Stainless Steel
- Precipitation Hardened

- High Strength
- Corrosion Resistant
- Medium Machinability

Ref: Functional Gauge Designs - Griffith Training
“Plow” Steel (1045-1055):

- High Carbon
- Fine Grain
- RC ~ 16 - 22
- Oil or Water Quench

- High Wear Resistance
- High Toughness
- Medium Machinability
Gauge Maker’s Tolerance and Wear Allowance

- Functional Gauges are supposed to reject borderline good product
- If too much of the part tolerance is consumed, they will reject too many good products
- 10% or less stackup is the standard rule (e.g. old Mil-Std-120)
- The complexity and cost of the Gauge depends largely on part tolerance and machinability rating.
- Fixed Gauges are always plus against the part
- Functional Gauges cannot be designed to accept bad product

Ref: Functional Gauge Designs - Griffith Training
Gauge Materials and Wear Areas

Gauge bodies can often be made from mild tool steel, but wear features should be better. 

Gauge Body: Plow Steel

Gauge Pins: Grade D2

Gauge Datum Sleeve: Grade D2

Ref: Functional Gauge Designs - Griffith Training
Gauge Tolerances Stackup

SLIP FIT GAUGE PIN AT .4999 - .5000 DIAMETER

PRESS-FIT BUSHING .0002" COAXIAL

Ref: Functional Gauge Designs - Griffith Training
Gauges Must Establish Applicable Part Datums

Ref: Functional Gauge Designs - Griffith Training
Fixed Versus Slip-fit Pins

- **Slip-Fit Pins**
  - Often used when datums must be mounted first
  - Offer the flexibility of identifying specific features that are out-of-tolerance

- **Fixed pin designs**
  - Less expensive, but
  - Problems in locating certain datums
  - Problems in locating specific features

Ref: Functional Gauge Designs - Griffith Training
Position of a Hole to Three Datums

Ref: Functional Gauge Designs - Griffith Training
Two-Hole Pattern Position

Ref: Functional Gauge Designs - Griffith Training
Gauge for Two-Hole Pattern Position

Gauge

Part Being Gauged

Ref: Functional Gauge Designs - Griffith Training
Four-Hole Pattern Size Feature Datum

Ref: Functional Gauge Designs - Griffith Training
Three-Hole Pattern Size Feature Datums

Ref: Functional Gauge Designs - Griffith Training
Gauge Design & Part Being Gauged

3X Ø PRESS FIT WITH DETAIL 2

Ø .6500

Ø .2500 + .0000 - .0002

Ø .0730 + .0002 - .0000

2.576 ± .005

GAGE DETAIL 1 - BODY

3X DETAIL 2
GAGE PINS

Ref: Functional Gauge Designs - Griffith Training
4-Hole Position at MMC

Ref: Functional Gauge Designs - Griffith Training
4-Hole Position Gauge

Part being gauged

4 GAGE PINS AT .4900

GAGE SURFACE FOR MOUNTING PART DATUM A

Ref: Functional Gauge Designs - Griffith Training
4-Hole Pattern
MMC Size Datum

Ref: Functional Gauge Designs - Griffith Training
Gauge Design & Gauge

Ref: Functional Gauge Designs - Griffith Training
4-Hole Pattern
“Virtual” Size Datum

Ref: Functional Gauge Designs - Griffith Training
Gauge Design & Gauge

Ref: Functional Gauge Designs - Griffith Training
Position – Hole Pattern Boundary Datums

Ref: Functional Gauge Designs - Griffith Training