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BASIC PRINCIPLES OF FUNCTIONAL GAGING

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Introduction

The representative gages discussed in this paper "receive" the part being gaged like a mating part. Called functional gages, they simulate the most critical conformation of a mating part. They can be mathematically determined if part drawings are toleranced per Mil-Std-8C and include the Maximum Material Condition modifier*.

Functional gages usually have a fixed configuration, like the mating parts they simulate, and allow each part gaged a different tolerance since no two finished parts are identical. Many complex, moveable-element gages are unfortunately used in industry today, but indicate questionable practices as functional gages should simulate mating parts.

There are two kinds of functional gages. The first is called a feature relation gage and the second a feature location and relation gage.

1. Feature Relation Gage: A gage that contacts only the primary (interface) datum surface on the part and checks the relationship of a pattern of part features. See Figure 1.

FEATURE RELATION GAGE
FIG 1

*Maximum Material Condition is the most critical specified interchangeability size. The largest male and/or smallest female feature.

2. Feature Location and Relation Gage: A gage that contacts two or more part datum surfaces and checks the location and relationship of part features from these part datum features. See Figure 2.

FEATURE LOCATION &
RELATION GAGE
FIG 2

Functional Gage Design Principles

Principle 1

Functional gages contain fixed gaging elements (pins, bushings, etc.) located at basic part feature locations.

Principle 2

Part tolerances are true variables since all finished parts vary in size. The maximum material condition concept in Mil-Std-8C recognizes this truth.

Principle 3

When physically possible, a functional gage should simulate the mating part at the gage-part interface.

Principle 4

A gage is truly functional when it physically simulates the "worst" mating part possible.

Principle 5

The gage designer should not arbitrarily decide gage element size or location as the drawing dictates these criteria. The drawing is not complete if such decisions are required.

Principle 6

Parts that can be functionally gaged can also be functionally tooled since gages and tools should be basically identical. Although tools have clamping devices and are designed to withstand cutting forces, their form at the tool-part interface should, if possible, be similar to the gage used to accept the finished part.

Principle 7

All functional gage elements should receive the part simultaneously since most assembly features (bolts, pins, etc.) must all go simultaneously.

Principle 8

If several "identical" functional gages are within their specification limits, any part accepted by any one of these gages is acceptable.

Principle 9

One "datum" (usually encompassing several mutually perpendicular part datum features) per part will enable one gage to be used. Any increase in the number of "datums" will increase the number of gages and increase cost.

Principle 10

Gaging policy should be centered on the principle of acceptance--not rejection--of all possible in-tolerance parts. Since tolerances and wear allowances can make the gage worse than the "worst" mating part, a careful engineering analysis of each gage drawing can greatly increase acceptance rates.

Some Basic Interchangeability Gage Forms

The following gage forms will guarantee functional interchangeability for the two cases discussed.

Case I Clearance Holes in Both Mating Parts

Rule: The gage for each part consists of a pattern of pins located at the part basic hole locations. The gage pins will be the MMC size of the fastener (bolt or screw).

Explanation: Figures 3A, 3B, and 3C illustrate Case I. Since the part drawing (Figure 3B) does not specify a tolerance, a separate Go gage is not

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required since it is built into the functional gage shown in Figure 3C. A separate Not-Go gage, of .530 diameter, is required.

THIS ASSEMBLY
FIG 3A

MEANS THIS DRAWING
(FOR BOTH PARTS)
FIG 3B

FIG 3c

Case II Clearance Holes in Part 1 Tapped Holes in Part 2

Rule for Part 1: The gage for Part 1 consists of a pattern of pins located at the part basic hole locations. The gage pins will be the MMC size of the clearance hole.

Rule for Part 2: The gage for Part 2 consists of a pattern of bushings located at the part basic tapped hole locations and a set of Go thread gages for each tapped hole. The difference in size between the bushing ID (Figure 4E) and the shank diameter of the Go thread gage (where it goes through the bushing) will be the positional tolerance diameter specified at MMC to the tapped thread. The gage bushing will be a minimum of .500 high, the maximum thickness of Part 1.

Explanation: Figures 4A through 4E illustrate Case II. Note how the gages for Parts 1 and 2 simulate the worst mating part. The p .500 specification (Figure 4C) states that the mating part (Figure 4B) is .500 maximum thickness.

THIS ASSEMBLY
FIG 4A

MEANS THIS DRAWING
FOR PART 1
FIG 4B

MEANS THIS DRAWING
FOR PART 2
FIG 4C

MEANS THIS GAGE
FOR PART 1
FIG 4D

MEANS THIS GAGE
FOR PART 2
FIG 4E

References:

1. Functional Gaging of Positionally Toleranced Parts, ASTM E Manufacturing Data Series Book. Price \$2.75 to ASTM E Members.
2. Phantom Gage Dimensioning, SC-TM-64-669, Office of Technical Service, Department of Commerce, Washington 25, D. C. Price 50¢.