Key Characteristics

- Goals of this class
  - Introduce Key Characteristics (KCs)
  - Show what the issues are for top-down tolerance design
Key Characteristics (KCs)

- Key characteristics are product requirements that demand attention because
  - they are critical for performance, safety, or regulations
  - AND
  - they are at risk of not being achieved due to process variations

- Two basic issues for KCs are
  - priorities
  - flowdown

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“Chain of Delivery” of Quality

No single part “delivers” the KC.

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KC Priorities

- Everything is important to someone
- KCs should be confined to things that are not only important but are at some risk of not being achieved
- Usually, manufacturing or assembly variation are considered to be the main threat
- So there is a direct link between KCs and assembly tolerances
- If priorities are not assigned, and if there is no systematic process for identifying KCs, then they tend to proliferate

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When Can Key Characteristics Be Used?

• During concept design, to capture customer req’mts

• During system engineering, to flow down req’mts to lower levels of the design process

• During detail design, to deliver req’mts via tolerances and process planning

• During supplier selection and preparation of specs, to define deliverables

• During program management, to track and assure achievement of requirements
Optical Disk Drive KCs

Where the laser points

Where the data track is

Source: Scientific American
September, 1998 © Slim Films
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KC: Size, weight, $/megabyte
Stapler Parts

- BASE
- CARRIER
- ANVIL
- STAPLES
- PUSHER
- RIVET
- PIN
- AXIS "A"
- AXIS "B"
- "X" DIRECTION
- "Y" DIRECTION
- "Z" DIRECTION
- TOP VIEW
- SIDE VIEW
- CRIMP AREA
- HANDLE
- HAMMER
- © Daniel E Whitney
Key Characteristics

Liaison Diagram

KCs

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Liaisons that Matter in KC Delivery
Delivery Path for Each KC
KC Flowdown

• Product KCs can be defined for customer requirements and then decomposed into lower level Assembly and Manufacturing KCs

• Achievement of the PKCs requires achievement of the AKCs and MKCs

• Full implementation requires that each AKC and MKC meet a specific tolerance or Cpk

• Suppliers’ capability may limit AKCs and MKCs, requiring flow-up and negotiation

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CUSTOMER REQUIREMENTS:

- PRODUCT KCS
  - Car Door KC Flowdown
  - DOOR KCS
  - SUBSYSTEM KCS
  - ASSEMBLY PROCESS KCS
  - PARTS FAB AND ASSEMBLY KCS

CUSTOMER PERCEPTION OF DOOR

- UNIFORMITY OF DOOR-BODY GAPS
- FLUSHNESS OF DOOR-BODY SURFACES
- DOOR CLOSING FORCE
- WATER LEAKAGE AND WIND NOISE

DOOR BODY SUBSYSTEM KCS

- DOOR-BODY ALIGNMENT UP/DOWN AND FORE/AFT
- DOOR-BODY ALIGNMENT IN/OUT
- DOOR MOUNTING METHOD AND EQUIPMENT
- DOOR ATTACHMENT TO BODY
- HINGE ATTACHMENT TO DOOR

- SEAL TIGHTNESS
- SEAL ATTACHMENT TO BODY

DOOR FRAME PERIMETER SHAPE ACCURACY

- BODY ASSEMBLY METHOD AND EQUIPMENT
- BODY PARTS ASSEMBLY
- BODY PARTS FABRICATION

- DOOR PERIMETER SHAPE ACCURACY
- DOOR THICKNESS ACCURACY

- DOOR ASSEMBLY METHOD AND EQUIPMENT
- DOOR PARTS ASSEMBLY
- DOOR PARTS FABRICATION

BODY PARTS ASSEMBLY

© Daniel E Whitney
These gaps are seen and measured between door outer panels

These gaps are seen and measured between door outer panels and the body
Door Assembly

- Door Outer Panel
- Door Inner Panel
- Locators for Mounting Door
- Locators for Mounting Hinges

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How Doors are Built

Mate inner to outer

“Hem” the outer over the inner

Attach hinges and latch bar
Door Hem

© Daniel E Whitney
Car “Aperture”
Car Door Design KCs

- Appearance KC depends on placement of the outer panel
- Weather seal KC depends on placement of the inner panel
- Door tolerances and fit

Appearance KC = uniformity of this gap

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Two Door Methods

Assembly Step 1a

Assembly Step 1b

Assembly Step 2a

Assembly Step 2b

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KC Conflict in Door Assembly

Align door inner to seal, then attach inner to frame.

Align door outer to frame gaps, then attach outer to inner.

Attach door outer to door inner, aligning parts.

Mount door (inner+outer) to frame and align seals, possibly misaligning gaps.

Mount door (inner+outer) to frame and align gaps, possibly misaligning seals.

Impossible to assemble this way!

Difficult to achieve both KCs this way!

Not enough independent DOF available!
How It Is Done

Subassembly of inner, outer, hinges, and latch bar

Final assembly involves using hinges to adjust door position fore-aft and, possibly, up-down

Hinge mounting seeks to place door in the correct in-out and up-down positions
Ford Hinge Mounting
Ford Door Mounting to Car

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An Interesting Wrinkle

• Doors are usually installed on a car before painting and removed for trim installation
  – you can grab a door rigidly (accurately) when there is no paint to scratch
  – it is easier to install stuff on/in the door and in the car if the doors are separate

• The challenge is to get them back on in the right place without the benefit of assembly tooling

• It is done cleverly with the hinges
  – install door+hinges to car, remove door from hinges
  – remove a temporary hinge pin, reinstall a final one
  – check which bolts have paint to see how it was done

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Conclusions

• Tolerancing an assembly builds on tolerancing of the individual parts
• More important than tolerancing is the locating scheme
• There are many possible choices for locating schemes
• Different schemes imply different assembly sequences
• The shape and location of assembly features play a large role in implementing the scheme