## Cylinder Production

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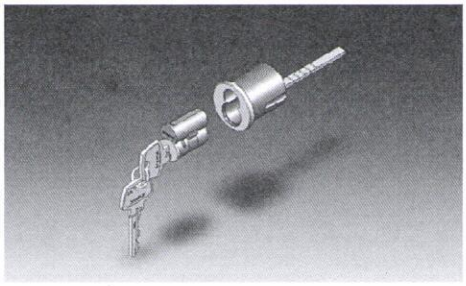

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## Manufacturing Process

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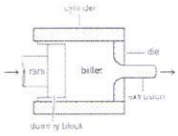
- Brass is smelted and extruded to form long, round or shaped bars

- Requires knowledge of metallurgy and geometry to create a metal with the attributes you want:
  - hardness
  - machinability
  - formability
  - Corrosion resistance

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## Manufacturing Process

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Bars are machined into the parts using computer controlled lathes or machining centers

Swiss Screw Machine Video

- Requires knowledge of metallurgy, machining and geometry to:
  - interpret the design
  - write the programs for the cutting of the metal
  - calculating the speed and feed rate of the tools

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## Manufacturing Process

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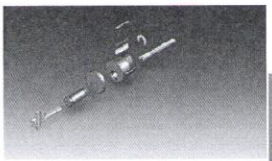
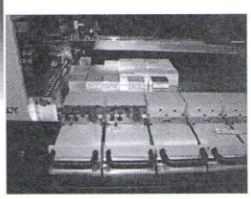
Components are assembled and pins inserted





## Manufacturing Process

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Consideration when developing the process

- Cycle time vs "Takt" time
  - The difference between the actual time it takes to make a part vs how many you need to make in a certain timeframe to meet your customers demand
- Waste production in the process
  - Is it recyclable (brass chips are 100% recyclable)
  - Cutting fluid – is it a hazardous waste when it's reached the end of it's useful life
- Equipment maintenance and tooling costs
- New equipment requirements
- Skill required to Operate and Maintain equipment
- Capability of machine vs design requirements

## Manufacturing Process

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Material Selection

- Brass makes up 99% by weight of the cylinder and key
  - Very easy to machine vs other metals like steel
    - Keeps tooling cost low and saves wear and tear of the machines
  - Very corrosion resistant
    - Does not rust
    - No protective surface that can wear off (like stainless steel)
  - Long wear resistance when mating parts are also brass

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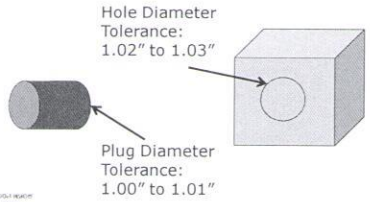
## Geometrical Dimensioning and Tolerancing

- Everything must have a dimension and tolerance
  - Tolerance defines the allowable variation of individual features.

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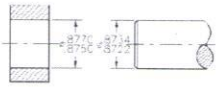
**Class RC6 Clearance Fit**

| Nominal Size Range Inches | | Classes | | Hole Basis RC7 |
|---|---|---|---|---|
| | | Standard Tolerance Limits | | |
| Over | To | Hole H9 | Shaft d9 | |
| 0.40 | 0.71 | +1.8 0 | -4.3 -5.2 | |
| 0.71 | 1.19 | +2.0 0 | -4.6 -5.8 | |

Partial Table

**Example 5**




A nominal hole size of .8750 Diameter and a RC6 Class Fit has been selected.

Hole nominal size range = .71 – 1.19

Minimum clearance = .0016

Maximum clearance = .0048

Tolerance of hole = + .0020, - .0000

Tolerance of shaft = - .0016, - .0028

Calculations:

| | | | | |
|---|---|---|---|---|
| Hole: | Basic size | .8750 | | .8750 |
| | Tolerance | + .0020 | | - .0000 |
| | Maximum hole | .8770 | Minimum hole | .8750 |
| Shaft: | Basic size | .8750 | | .8750 |
| | Tolerance | - .0016 | | - .0028 |
| | Maximum shaft | .8734 | Minimum shaft | .8722 |

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| FACTS TO REMEMBER | SYMBOLS, RULES, AND GUIDELINES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | TYPE | SYMBOL | AS SHOWN ON DRAWING | TOLERANCE ZONE | MMC CAN BE USED | DATUM USED | FUNC GAGE USED | TOLER ZONE TYPE |
| Ⓜ - MMC - MAXIMUM MATERIAL CONDITION THAT CONDITION WHEN A FEATURE OF SIZE CONTAINS THE MAXIMUM AMOUNT OF MATERIAL WITHIN THE STATED LIMITS OF SIZE. EXAMPLE: MINIMUM HOLE SIZE AND MINIMUM SHAFT SIZE | GEOMETRIC CHARACTERISTICS | | | | | | | |
| Ⓛ - LMC - LEAST MATERIAL CONDITION THAT CONDITION WHEN A FEATURE OF SIZE CONTAINS THE LEAST AMOUNT OF MATERIAL WITHIN THE STATED LIMITS OF SIZE. EXAMPLE: MAXIMUM HOLE SIZE AND MINIMUM SHAFT SIZE | | | | | | | | |
| RFS - REGARDLESS OF FEATURE SIZE THIS IS THE DEFAULT CONDITION FOR ALL GEOMETRIC CHARACTERISTICS. NO BONUS TOLERANCE IS ALLOWED. FUNCTIONAL GAGES MAY NOT BE USED | | | | | | | | |
| Ⓟ - PROJECTED TOLERANCE ZONE - WHEN THE DRAWING SHOWS THAT A FEATURE'S TOLERANCE ZONE IS EXTENDED BEYOND THE SURFACE OF THE PART, NOT WITHIN THE PART | | | | | | | | |
| STATISTICAL TOLERANCE - A TOLERANCE FOR A PART OR AN ASSEMBLY BASED ON THE RESULTS FROM A STATISTICAL CALCULATION. THE REQUIRED DEVICE / FEATURE CAPABILITY IS REQUIRED | | | | | | | | |
| Ⓣ - TAE STAT - THIS SYMBOL INDICATES THE PART'S MUST PASS SETTING / FEED DURING INSPECTION | | | | | | | | |

## STATISTICAL ANALYSIS

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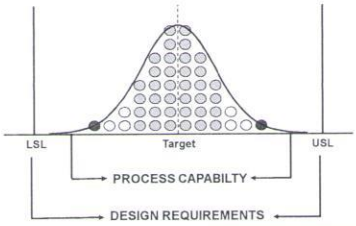


## STATISTICAL ANALYSIS

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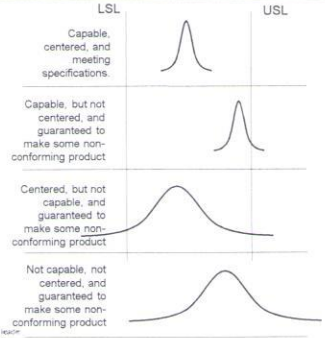


## STATISTICAL ANALYSIS

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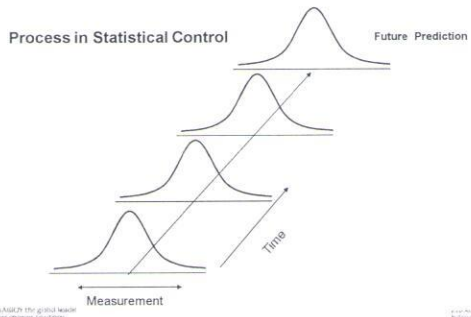

## STATISTICAL ANALYSIS

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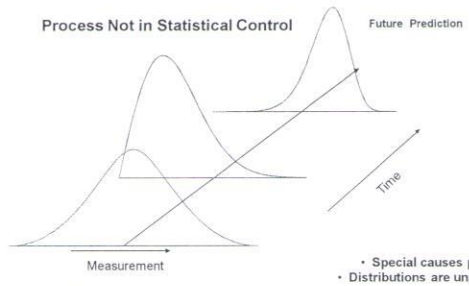


- Special causes present
- Distributions are unpredictable

## STATISTICAL ANALYSIS

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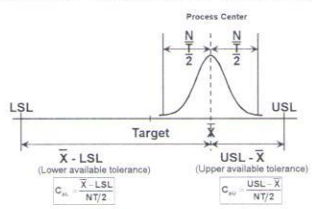
- Compare the difference between the *process center* and each specification limit to one-half the natural tolerance of the process
- $C_{pk}$ is the smaller of the two values ($C_{pL}$, $C_{pU}$), because the smaller value is the worst case.

$$ET = USL - LSL$$
$$NT = 6\sigma$$
$$\hat{\sigma} = s = \frac{\overline{R}}{d_2}$$




$C_{pk}$ = minimum($C_{pL}$, $C_{pU}$)

## STATISTICAL ANALYSIS

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**Process Capability Calculations - Example**

- Specification Limits : $LSL = 8,\ USL = 20$
- Process Information : $\overline{X} = 16,\ \hat{\sigma} = \overline{R}/d_2 = 2$

$$C_p = (USL - LSL)/6\hat{\sigma} = (20-8)/6(2) = 12/12 = 1.00$$ ← *Marginal Potential*

$$C_{pU} = (USL - \overline{X})/3\hat{\sigma} = (20-16)/3(2) = 4/6 = 0.67$$ POOR

$$C_{pL} = (\overline{X} - LSL)/3\hat{\sigma} = (16-8)/3(2) = 8/6 = 1.33$$ GOOD

$$C_{pK} = \min\{C_{pL}, C_{pU}\} = \min\{0.67, 1.33\} = 0.67$$ POOR

A $C_{pk}$ of 1.33 is the minimal target

## PROGRAMMING

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- Review part print for manufacturability
- Determine tools needed
- Based on part material, calculate speed (RPM) used for turning and drilling
- Formula for calculating RPM: 3.82 x SFM/stock Diam
  - SFM is a tabulated standard that is found in Mfg handbooks and dependant on material qualities

| Material | SFM |
|---|---|
| Brass | 600 |
| 303 Stainless Steel | 300 |
| 316 Stainless Steel | 90 |
| 4140 Steel | 120 |

- Example: Brass part made from 1.5" diameter bar with 0.5" drilled hole
- 3.82 x600/1.50 = 1528 RPM for turning
- 3.82x600/.5=4584RPM for drilling

## PROGRAMMING

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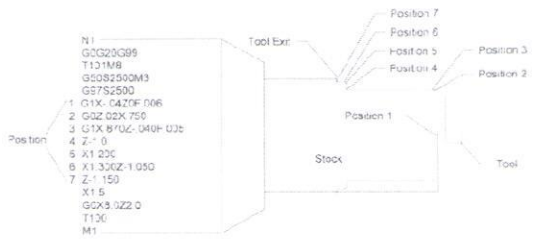


## Staffing

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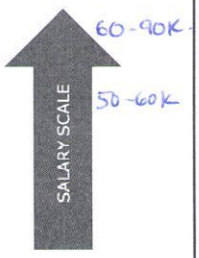
**Types of Positions**

- Top Level (Bachelors or Masters Degree)
  - Manufacturing Engineer
  - Quality Engineer
  - Design Engineer
  - Management Positions
- Mid-Level (Associates Degree or specialized training)
  - CNC Programmers
  - CAD Designers
  - Engineering Technicians
  - Buyer/Planners
  - Customer Technical Support
  - Skilled Trades/Non-Degreed
    - Tool and Die Makers
    - Electricians
    - Automation Technicians
    - CNC Operators and Machinists
- Entry Level (High School Diploma)
  - Machine Operators and Assemblers

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## Staffing

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**Skills we look for in a new hire**

Ability to understand complex systems and information
- PROBLEM SOLVING SKILLS

The level of complexity is dependent on the position:
- Engineers (quality, mfg and design) need to understand a very high level of complexity.
  - How parts interact with each other in a lock
  - How machines function (hydraulics, electronics, motors and robotics)
  - How materials interact (corrosion, wear, conductivity, strength)
- High level Machine operators or one of the trades (Electrician, technicians, Mechanics, Tool and Die Makers)
  - Need to be close to the level of an Engineer for problem solving
    - Do not need the Calculus or high level math skills

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## Staffing

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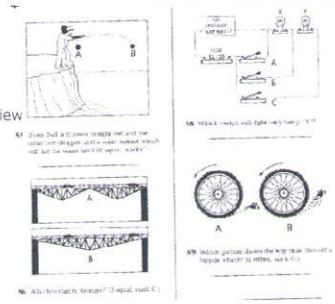
Sample Questions
- Logic Testing
- 68 Questions
- No actual math
- A math test is under review







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## Staffing

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**Skills we look for in a new hire**

Ability to understand complex systems and information
- PROBLEM SOLVING SKILLS

- Entry level machine operators or assembly
  - need basic math skills
  - strong skills for understanding complexity as far as the operation they are performing, recognizing issues
  - Much of this work is repetitive - people with good problem solving skills and good understanding of how things work are much more valuable because they think about what they do. Not just "do".

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