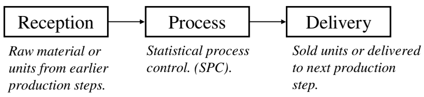
Lektion 2

2007-11-07

Chapter 14-15

Statistical acceptance sampling

Quality control



- Acceptance test at reception or delivery
- Statistical process control under the process.

Process control

- Control the process so that no bad units are produced
- Improve the processs
- Eliminate sources of variation.
- Maintain a good process.

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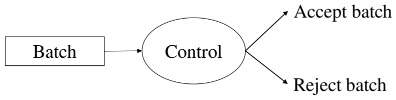
Acceptance control



- No control
- 100% control
- Statistical acceptance sampling.

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No control

- If the quality of the product is so high that in reality there does not exist any bad Units
- The producer uses statistical process control and can show that the quality is good.
- No serious consequences if bad units are shipped.

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100% control

- If the consequences of bad quality is not acceptable.
- The production is not capable.
- Automatically control is good.
- Example- ATM or metal detection in production.

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Statistical acceptance sampling

- Destructive testing
- When 100% test cost too much or is not practical.
- The product has high quality but unstable process and hence zero test is not acceptable.

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Statistical test versus 100%

+ Cost less due to less testing
+ Destructive testing is possible
+ Less handling with products and less transport damage.
+ The risk that the batch can be rejected drives quality.

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Statistical test versus 100%

- Risk of accepting bad batches and reject good ones.
- Less information of the product.
- Statistical testing demands more planning and documentation than 100% test.

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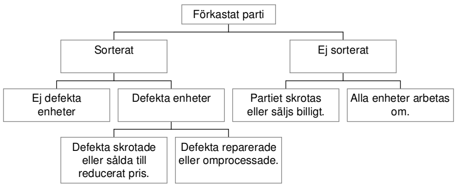
Actions for rejected batch (at producer)



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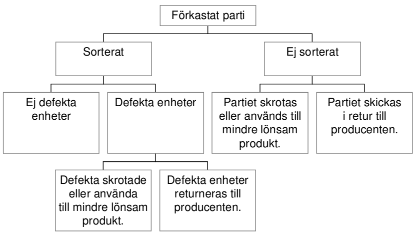
Actions for rejected batch (at consumer)



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Categorization of test plans

- Acceptance sampling and rectifying inspection
- Attribute control or variable controll.
- Simple-, double- or multiple test.

Batch

- The batches should be homogene. Units should be of same type, size and produced under the same time and condidtions.
- Large batchs are prefered over small ones.
- Batch size = the number of units ina batch.

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Random sample

- Very important that the sample is random
- Risk of ”salted” batches…
- Common sense sampling destroys the statistical analysis!
- Stratification is possible in some times.

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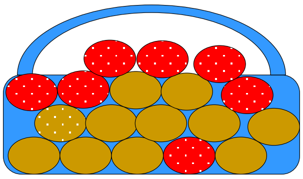
Berries



- The good ones are on the top.
- Random sample reveals the cheater!

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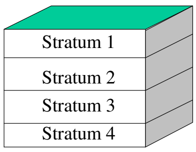
Stratify

- *Natural subbatches.*



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Attribut data

- Yes-no data.
- 15 bottles of 45 cracked.
- 2 bags of 300 did not contain exactly 10 screws.
- The fraction defects.
- Defect = not fulfilling the specification

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Single sampling plan for attributes

- n = sample size
- c = acceptance number
- Let d = number of observed defect units in the sample.
- d>c => reject the batch
- d≤c => accept the batch!

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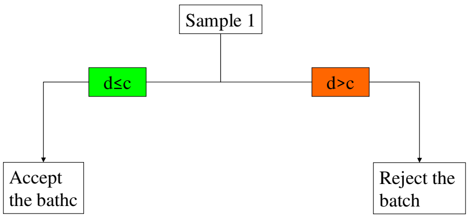
Single sampling plan for attributes



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Double plan for attribute data, ex.

- n_1 = first sample size
- c_1 = acceptance number for first sample.
- n_2 = size of second sample.
- c_2 = acceptance number for both samples.
- d_1 = Number of defect observed in first sample.
- d_2 = Number of defect observed in second sample.

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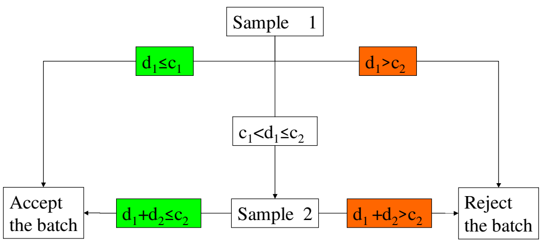
Double plan for attributes, ex.



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Variable data

- Data are continous
- The milk package should contain at least 1.0 liter.
- Max crash force should be under 10000N

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2 types of variable control

1. Control of fraction defect in the batch. (ISO 3951)
2. Control of some process parameter, eg. process average.

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Variable data vs attribute data

+ Less sample size for the same OC-curve.
+ More knowledge about the process. Mer kunskap om processen.
- Must know the distribution of the variable.
- One plan for each characteristics.
- A batch can be rejected with zero defect units. Bad for morale.
- Control often more difficult and expensive.

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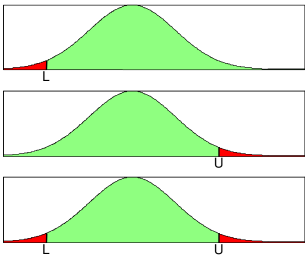
Specification limits

$X < L$:

$X > U$:

$X > U$ or $X < L$: μ_X



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Distribution assumption is important

- Assume an upper specification limit U=35.
- Take a sample of size 100 and analyze them.
- Average = 10.
- Standard deviation = 10.

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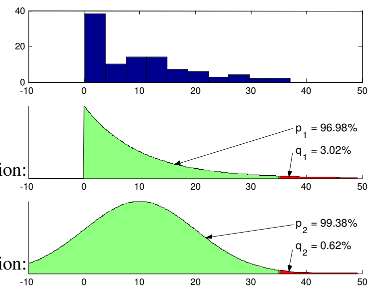
Distribution assumption is important

Exponential distribution:

Normal distribution:



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Is the batch accepted?

- Detote with θ the fractionndelen defect units int the batch.
- Test following hypothesis

$$\begin{cases} H_0: & \theta = \theta_1 \text{ (the batch is accepted)} \\ H_1: & \theta > \theta_1 \text{ (the batch is rejected)} \end{cases}$$

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Risks

	Keep H_0.	Reject H_0.
H_0 true	**OK**	**α-risk**
H_0 false	**β-risk**	**OK**

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OC-curve, single plan for attributes

- Chose a sample of size n from a batch with size N>>n. Accept the batch if the number of defects d≤c= acceptance numer.
- The probability to be accepted is.

$$P(\theta) = \sum_{k=0}^{c} \binom{n}{k} \theta^k (1-\theta)^{n-k}$$

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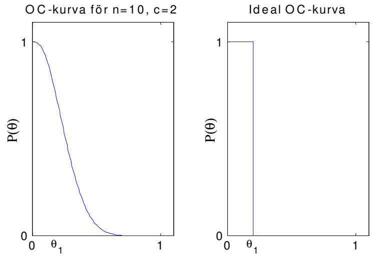
OC-kurva,



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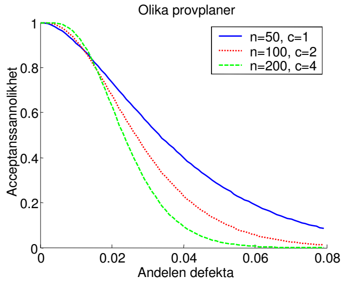
OC-curves exemple



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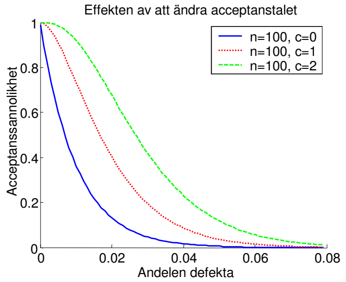
OC-kurves exemple



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Plans with c=0

- Very tought to the producer
- Sometimes not so economical for the consumer.

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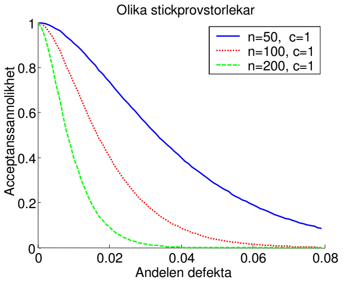
OC-kurvor exempel



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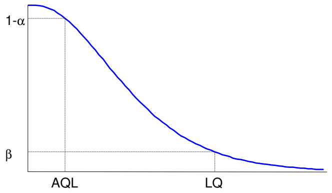
Four numbers specifies the plan

- Producer requirement: (AQL, 1−α)
- Consumer requirement: (LQ, β)



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Type A & Type B plans Attribute data

- If the batch size is **finite**, the number of defect units is hypergeometrically distributed. => Type A.
- If the batch size is **infinite** the number of defects are binomially distributed. => Typ B.

- **Rule:** If the batch is big or if the sample is taken from a series of batchs then Type B can be used.

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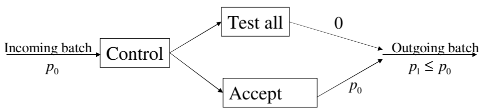
Rectifying control and AOQ



- Improves the quality
- Average outgoing quality:

$$AOQ = \frac{P_a \cdot p \cdot (N-n)}{N} \approx P_a \cdot p \text{ when } N \gg n$$

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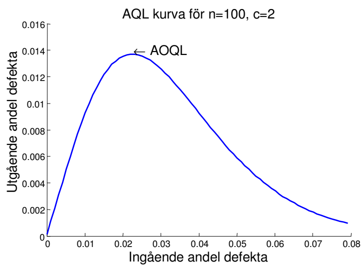
AOQ and AOQL at rectifying control



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Standarder

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Standards

Attribute control

- ISO-2859-1
- ISO-2859-2
- SS 02 01 30
- SS 02 02 31
- MIL STD 105E
- Dodge-Romig planer
- ….

Variable control

- ISO 3951
- SS 02 01 40
- MIL STD 414
- …

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ISO 2859-1 och ISO 3951

- Are a collection of test plans
- Based on AQL (Acceptance Quality Limit)
- Inspection levels (S-1, S-2, S-3, S-4, I, II, III)
- Switching rules (normal, tightened and reduced)
- Can be used for a continous stream of batches.

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Felkvot och fel per hundra enheter

$$\text{percent defective (in percent)} = \frac{\text{number of defect units}}{\text{total number of units}} \times 100\%$$

$$\text{Defect per 100 units} = \frac{\text{number of defects}}{\text{total number of units}} \times 100$$

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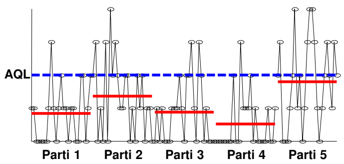
AQL (Acceptance Quality Limit)

AQL is the highest percent defective that could be considered acceptable as an process average.



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The meaning of AQL

- At AQL most of the batches will be accpted.
- Acceptance increases with batch sizes.
- AQL does not give consumer protection.
- AQL does not give the producer right to deliver bad units.

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Classification

Defect: *Any non-conformance of the unit to specified requirements.*

Critical defect: *Likely to result in hazardous or unsafe conditions for individuals.*

- Major defect: *Likely to result in failure or reduce the function of the product.*
- Minor defect: *Not likely to reduce the usability of the product.*

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Acceptance and rejection

- Acceptability of batches will be judged by using sampling plans according to AQL.
- The buyer has always the right to reject any defect unit found during test.
- A rejected batch may be reinspected only after all units have been reexamined and all defective units are removed.

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Inspection levels

- Determines the relationship between the batch size and the sample size.
- Gives different discriminations
- Denotation: S1, S2, S3, S4, I, II, III
- Inspection II is normally used.
- S1 – S4 may be used where small sample sizes are neccessary and large sampling risks can be accepted.

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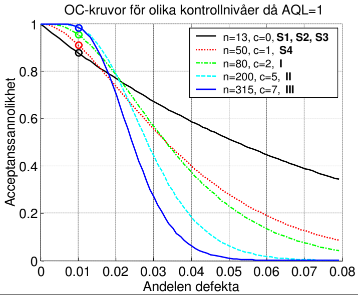
Inspection levels, example ISO 2859



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ISO 2859
(MIL105E)

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How to use ISO 2859-1

1. Choose a suitable code letter (table 14-4) depending on batch size and inspection level.
2. Choose suitable sampling table II, III or IV depending on single, double or multiple plans are wished. (Montgomery has table II-plans in 14-5→14-7)
3. Choose plans for normal (A), tightened (B) or reduced (C) control.
4. Start with normal control and use the switching rules!

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Code letters ISO 2859

Partistorlek	Speciella kontrollnivåer				Normala kontrollnivåer		
	S-1	S-2	S-3	S-4	I	II	III
2-8	A	A	A	A	A	A	B
9-15	A	A	A	A	A	B	C
16-25	A	A	B	B	B	C	D
26-50	A	B	B	C	C	D	E
51-90	B	B	C	C	C	E	F
91-150	B	B	C	D	D	F	G
151-280	B	C	D	E	E	G	H
281-500	B	C	D	E	F	H	J
501-1200	C	C	E	F	G	J	K
1201-3200	C	D	E	G	H	K	L
3201-10000	C	D	F	G	J	L	M
10001-35000	C	D	F	H	K	M	N
35001-150000	D	E	G	J	L	N	P
150001-500000	D	E	G	J	M	P	Q
500001-	D	E	H	K	N	Q	R

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ISO 2859: Sampling plans

- Single plan: Tabell II.
- Double plan Tabell III.
- Multiple plan Tabell IV.
- The tables are divided into normal, tightened and reduced control.

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ISO 2859: Choosing sampling plans

- Batch size + inspection level ⇨ code letter
- Code letter + AQL ⇨ sampling plans in table II, III or IV.

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ISO 2859: Acceptance criteria Single plan

- n = sample size
- c = acceptance number
- r = rejection number
- Let d = number of observed defect units in the sample.
- If d≥r => reject the batch!
- d≤c => accept the batch!

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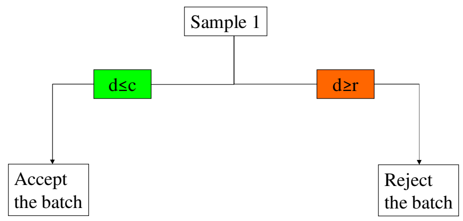
ISO 2859: Acceptance criteria Single plan



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ISO 2859: Exampel single plan

- Batch size N=5000 & AQL = 1%.
- Normal inspectionlevel II.
- Table 14-4 gives code letter L.

Normal
n=200
c=5
r=6

Tightened
n=200
c=3
r=4

Reduced
n=80
c=2
r=5

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ISO 2859. Acceptance at reduced control

- Let d be the number of defect units in the sample.
- If c<d<r then accept the batch. Change to normal inspection.

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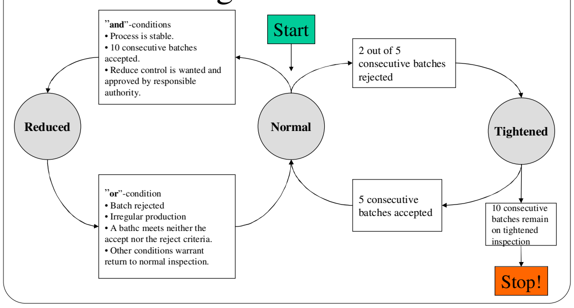
Switching rules ISO 2859-1



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The switching rules are important!

- The switching rules protects the consumer in both ISO 2859 and in ISO 3951.
- There are no switchin rules in ISO 2859-2, since the consumer protection is dealt with a liminting quality (LQ).