Chart nonconformities per exposure

Distinguish counts of multiple nonconformities from affected-unit fractions and account for the actual opportunity exposed to inspection.

A larger inspected area offers more opportunities

Fictional case: a surface-inspection team counts blemishes, with several possible on one sheet. The core c chart is a separate fixed-exposure process with supplied cbar 9 and counts 8,12,7,9. The u example has supplied ubar .5 per square metre, areas 20,80,20,80 and counts 8,44,13,38. Analyst Hugo must keep the two baselines and scales separate.

Your role and the reference condition

Surface-quality analyst and inspection lead
Normal: The record defines a blemish, the inspected opportunity and comparable conditions. Counts and exposure remain available, even when rates are displayed.
Gap: The team calls 44 blemishes worse than 13 without considering 80 versus 20 square metres, and combines both fictional baselines into one calculation.

Work within these conditions

1. The two core panels are separate illustrative processes, not a common fitted dataset.

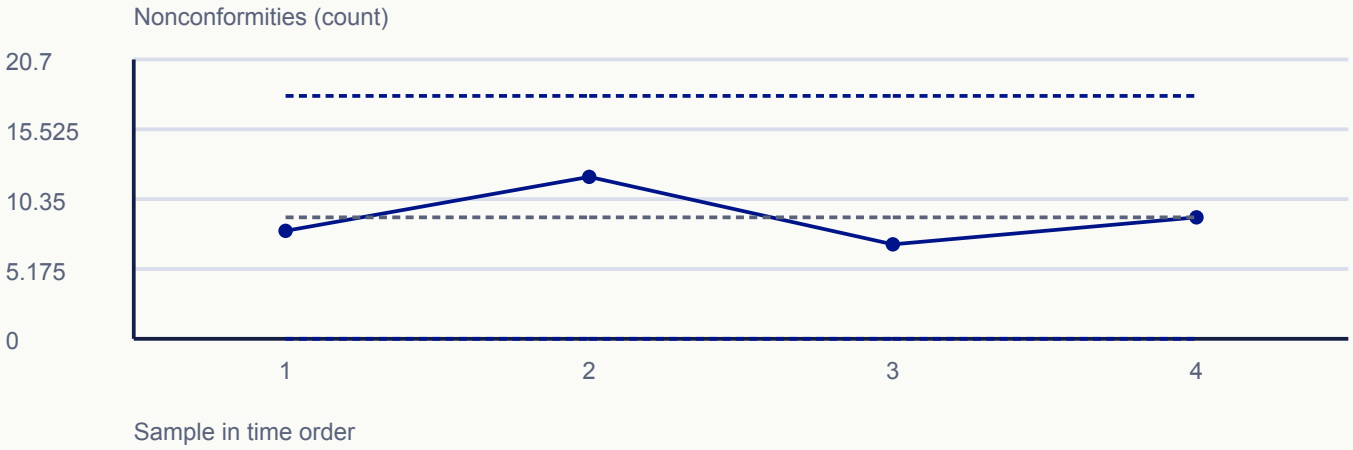
2. A suitable count model and comparable opportunity are assumptions to check; clustering or skewed rare counts need care.

Fictional teaching case. Supplied observations support the exercise; proposed actions are not verified customer results.

See how the method works

A nonconformity count is not restricted to one per product. A c chart is a basic candidate when inspection exposure and opportunity are comparable. A u chart expresses nonconformities per unit of exposure when the amount inspected varies. Keep the original count and exposure with every point so the displayed rate can be checked. The basic formulas rely on a suitable count model; clustering, changing opportunity and very low expected counts can invalidate a casual interpretation. Do not compare rates from incompatible definitions of area, time or opportunity. The two panels here describe separate fictional baselines and should not be combined into one process.

c: equal exposure / Exposure: 1, 1, 1, 1 equal units

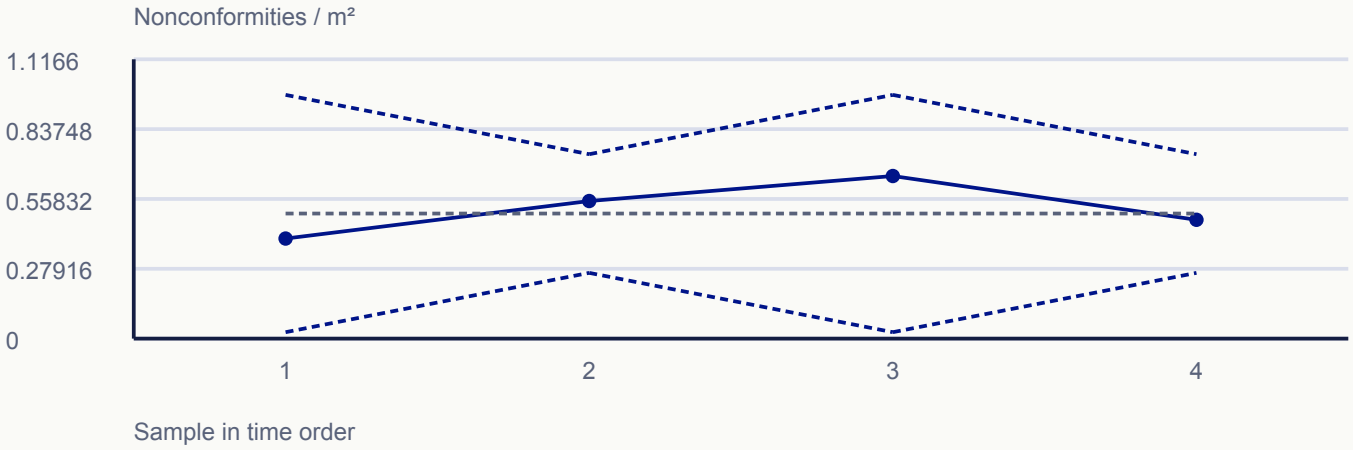


Center: 9

LCL: 0

UCL: 18

u: variable exposure / Exposure: 20, 80, 20, 80 m²



Center: 0.5

LCL: 0.0256584 / 0.262829

UCL: 0.974342 / 0.737171

c limits = 9 ± 3 sqrt(9), lower clamped to 0

u limits = 0.5 ± 3 sqrt(0.5 / exposure)

Given cbar=9 at fixed exposure and ubar=0.5/m². Separate fictional processes. Poisson model requires suitable opportunity and independent events.

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Follow the evidence and decisions

Inspect the supplied case inputs

u sample	Count / area	Rate per m²
1	8 /20	.40
2	44 /80	.55
3	13 /20	.65
4	38 /80	.475

01 / Define the event and opportunity

Hugo specifies a blemish category and square metres actually examined under the same inspection definition. He distinguishes these multiple events from a pass/fail classification of each sheet.

Why: A sheet may contain several events. A p chart of affected sheets would answer a different question from blemishes per area.

Evidence / check: The collection record contains count, actual area and inspection context.

02 / Use c only for its fixed comparable exposure

For the separate fixed-exposure example, limits are 9 ±3√9, or 0 and 18 counts. He retains cbar 9 as the supplied historical baseline.

Why: A count comparison assumes the opportunity is comparable. Applying it to a much larger inspected area could produce a signal caused merely by exposure.

Evidence / check: The c panel is labelled counts at fixed exposure, with no borrowed u baseline.

03 / Calculate the u rates

Hugo divides count by area:8/20=.40,44/80=.55,13/20=.65 and 38/80=.475 per m². He checks each numerator against its inspection record.

Why: The largest count is not necessarily the largest rate. Area units must remain consistent; square centimetres cannot silently be used in a per-square-metre calculation.

Evidence / check: Four point-specific rates retain their actual areas.

04 / Apply exposure-specific uncertainty

For ubar .5, limits are .5 ±3√(.5/area). Area 20 gives approximately .02566-.97434; area 80 gives .26283-.73717 per m².

Why: Larger exposure narrows the rate limits under the assumed count model. The center remains the supplied rate; the changing limits are not product specifications.

Evidence / check: The native record displays the correct limits beside each observation.

05 / Qualify the interpretation and response

Hugo checks whether blemishes cluster or opportunities differ by product/area. He records signals and asks the owner to review the model if those conditions undermine it.

Why: A computed limit is not proof that the count model fits. A response should preserve the event and exposure records and use authorized product/operating decisions.

Evidence / check: The investigation separates model adequacy, signal evidence and disposition authority.

Completed opportunity-to-rate record

Case	Calculation	Interpretation
Fixed exposure c	9 ±3√9 =0-18	Counts for a separate supplied baseline
u, area 20	.5 ±3√(.5/20)	.02566-.97434 per m²
u, area 80	.5 ±3√(.5/80)	.26283-.73717 per m²
Sample comparison	.65 at 20 vs .55 at 80	Rate and uncertainty both matter

Inspection includes a different surface type

An 80 m² observation combines a smooth coating with a textured surface having different inspection difficulty and opportunity.

Decision

Preserve the record and review stratification and opportunity definitions before treating the combined area as comparable exposure.

Reasoning

A numerical area alone may not represent equivalent opportunity. A larger denominator can conceal a collection or process mixture.

What would change the decision?

The revised collection plan identifies surface type and comparable exposure.

Practise with a changed case

A new high-rate observation

Under supplied ubar .5 per m², a new inspection finds 68 blemishes in 80 m². In the separate fixed-exposure c process, a new count is 20.

Process	New observation
u	68 blemishes /80 m²
c	20 blemishes at the same fixed exposure

Your task

1. Calculate the u rate and compare its applicable limits.
2. Compare the c count with its supplied limits.
3. State why these are not two estimates of the same process baseline.

Use the next page to record your reasoning before reading the answer.

Your practice worksheet

A new high-rate observation

Event definition

Exposure

Rate or count

Applicable limit

Bounded response

Complete your reasoning before turning to the answer. Use the separate learner workbook for group practice.

Check your reasoning and transfer it

1. The u rate is 68/80=.85 per m², above its .73717 upper limit. The c count 20 is above 18 at the defined fixed exposure.

2. Both signal under the stated point rule, but their centers and exposure definitions belong to separate fictional processes. Neither result identifies a cause or product disposition.

Suggested completed record

Process	Observation	Comparison
u	.85 per m²	Above .73717
c	20 counts	Above 18

Plausible wrong turns

1. Fault rate is not the fraction of affected sheets.

2. Dividing by area does not automatically guarantee comparable opportunity.

Evidence of a sound answer

1. Keep count and exposure together.

2. Use the correct process baseline.

3. Name model and response limitations.

Take the learning back to work

Commitment	Agreed follow-through
Owner	Inspection-method and SPC owners
Record	Event/exposure record, model rationale and reaction log
Review	At each observation and after surface or inspection changes
Verification evidence	Comparable opportunity, traceable counts and appropriate response
If unresolved	Revisit sampling or model choice if clustering, exposure or classification changes invalidate the comparison.

Help someone else apply the method

Prepare

1. Area/count cards
2. Calculator
3. Two separately titled process records

Minutes	Activity and coaching prompt
5	Define a blemish event How can one sheet contribute several?
8	Compare rate and count Why is 44 not automatically worse than 13?
10	Work the changed observations Which baseline belongs to each?
5	Debrief opportunity When does equal area fail to mean equal opportunity?

Debrief

1. Ask for per-m² units on the u calculation.
2. Keep the c and u examples physically separate during the exercise.

Individual or remote practice

Calculate each rate from its own count and area before examining limits.

Connect the method and check its boundaries

Before application

1. A defined inspection exposure
2. Suitable count-model assumptions

Outside this lesson

1. A fraction of failed products
2. Automatic handling of clustering or low counts

NIST: Counts charts

NIST: Counts charts

Count-chart interpretation requires a defined inspection unit and a plausible count model; very small/skewed counts need care.

Public primary-source summary; underlying paid standards/forms are not reproduced.

Open this lesson and its visual aids