A SHOPFLOOROPS FIELD BOOK

One Drifting Shaft. The Process Trail.

A field book for following a drifting process from the first sign to proof it is back under control.

8 STEPS · 13 TOOLS



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FIELD BOOK 03

Contents

8 STEPS · 13 TOOLS

01 **Spot the Drift**
Read the check sheet

02 **Contain It**
Red tag and quality alert

03 **Rule Out the Gage**
Gage and calibration

04 **Read the Chart**
The X-bar and R chart

05 **Measure Capability**
Cp and Cpk

06 **Find What Changed**
Cause on three legs

07 **Lock It In**
Control plan and reaction plan

08 **Prove It Held**
Capability, effectiveness and LPA

The part, the machine, the shift and every number in this book are a made-up example. The tool sidebars show ShopFloorOps tools, which I make and sell. Every chapter teaches the step itself, so you can use your own forms. New to a term? See the quality glossary.

CHAPTER 1

Spot the Drift

STEP 1 OF 8 | READ THE CHECK SHEET

It's noon on a Thursday. The operator on Lathe 3 measures the hourly check piece of shaft SH-3306 and writes 24.010 on the in-process inspection sheet. The outside diameter is 24.000 plus or minus 0.020. Every reading on the sheet is in tolerance.

The operator looks at the column anyway. Seven checks since 6:00 read 24.002, 24.006, 24.003, 24.006, 24.002, 24.008 and 24.010. Nothing is wrong by the drawing. But the last three go up, and the last one is halfway from nominal to the upper limit.

A drift passes every check

A part can drift for hours while every reading passes. Pass or fail against the print will not show it, because the print only tells you when you have already lost. What shows it is the direction of the numbers.

Three things to look for on any check sheet:

1. Readings moving one way for several checks in a row.
2. Readings using up more than half of the tolerance on one side.
3. A cluster near one limit that was not there at the start of the shift.

This sheet shows all three. Nobody is out of tolerance yet, and that is the point. The time to act is while the parts are still good.

Decide what "creeping" means before you need it

Operators hesitate to stop a machine that is making good parts. Take the argument away by writing the call rule on the sheet: three readings in a row rising, or any reading past halfway to a limit, means stop and call the lead. The operator here made the call because the numbers said to, not because of a feeling.

The mistake to avoid

Waiting for the first out-of-tolerance part. By then you are sorting, not preventing, and you have no idea how long it has been going on.

TOOL SIDEBAR

The tool: In-Process Inspection Sheet (QA-F-285)

A check sheet only works if someone reads the column. Record the number, not a tick. Put the limits at the top, with a line at half the tolerance and a written rule for when to call the lead. Use your own sheet if you have one, as long as it does those three things.

ON THE FLOOR MONDAY

- Pull this week's in-process check sheets for one machine.
- Look for readings moving one way across three checks in a row.
- Add a written call rule to any sheet that has none.

All 13 tools in this book: Process Trail Bundle

CHAPTER 2

Contain It

STEP 2 OF 8 | RED TAG AND QUALITY ALERT

The operator calls the shift lead. At 12:10 the lead stops Lathe 3. The last check that was good, with a reading in the normal range, was at 9:00: 24.006. Everything made since 9:00 is suspect.

That is 190 minutes at 36 pieces an hour, or 114 pieces. Containment answers one question: where are they?

Start the fence at the last good check

Do not start at the first bad reading. The drift began before anyone saw it. The last time you know the process was good is the edge of the fence, and everything after it is in until a trusted check says otherwise.

The lead and the operator found all 114:

1. Two bins at the cell, 38 pieces each, so 76.
2. One tote at the wash station, 38 pieces.
3. Nothing at final inspection or in shipping. Both were checked, and both were empty of this window.

76 plus 38 is 114. If your count does not match the production count for the window, keep looking before you tag.

Tag it, log it, tell the floor

Red tag every bin and tote. Write one line on the red tag log for each: tag number, the window, the location and the reason. Then send a quality alert to the wash station, final inspection, shipping, the next shift lead and maintenance. The alert says what the part is, what you suspect, which pieces, and what to do if you find some.

Do not sort yet. A sort with a gage nobody has checked is another guess. That comes next.

Read more: how to quarantine and red tag nonconforming material.

The mistake to avoid

Tagging only what you can see at the machine. Parts move. By the time someone calls the lead, part of the window is already downstream.

TOOL SIDEBAR

The tools: NCM Red Tag Log (QA-F-215) and Quality Alert Form (QA-F-200)

The red tag log records every tag, where it was applied and why, so you can show the fence is complete. The quality alert is the one page that tells every downstream department what to do. Field Book 2 uses the same two tools for a bad supplier lot.

ON THE FLOOR MONDAY

- Name the last good check for one process, and what you would count from it.
- Check every cell has red tags and a marked hold spot.
- Write down who can stop a machine and call a fence.

All 13 tools in this book: Process Trail Bundle

CHAPTER 3

Rule Out the Gage

STEP 3 OF 8 | GAGE AND CALIBRATION

With the lathe stopped, the first instinct is to touch it. The shift lead reaches for the wear offset and wants to bring the diameter back by 0.008. The operator asks a better question: is the micrometer telling the truth?

If the gage reads high, you will adjust a good machine to match a wrong number. Before anyone touches the lathe, the gage has to prove it can tell good from bad.

Three checks, in this order

1. **Is it in calibration?** The log shows the digital micrometer was calibrated six weeks ago and is not due for four and a half months.
2. **Does it read right on a known size?** A 24.000 gage block reads 24.001. The 12:00 check piece, measured again on the lab bench gage, reads 24.011 against 24.010 on the floor.
3. **Can it tell parts apart?** A Gage R&R study run last quarter used 10 shafts, 3 operators and 3 trials each.

The study results: repeatability 0.00040 mm, reproducibility 0.00030 mm, both as standard deviations. Combined, the gage variation is the square root of 0.00040 squared plus 0.00030 squared, which is 0.00050 mm.

Six times that is 0.0030 mm. The tolerance is 0.040 mm wide, so the gage uses 7.5 percent of it. A common rule of thumb says under 10 percent is good, 10 to 30 percent is a judgment call, and over 30 percent needs work. Check what your customer requires.

The gage is fit for this tolerance. The drift is real.

Now sort

With a trusted gage, the 114 pieces were measured one by one. The largest reads 24.017 and the smallest 23.998, so all 114 conform. 31 of them read 24.010 or higher, and 7 read 24.015 or higher. They are good parts that were close to the line. The tags came off after the log was updated and the sort record was attached.

Read more: Gage R&R explained. For any term you do not know, see the quality glossary.

The mistake to avoid

Trusting a gage because it has a calibration sticker. Calibration says the gage matches a standard. It does not say your operators get the same answer from it on your parts.

TOOL SIDEBAR

The tools: Gage R&R (QA-F-295) and Calibration Log (QA-F-230)

The calibration log shows the gage is in date and what it was checked against. The Gage R&R shows whether your operators get the same answer from it on your parts. You need both, because a gage can be in calibration and still be a poor fit for the tolerance.

ON THE FLOOR MONDAY

- Find the last Gage R&R for your most important gage.
- If the gage, the part or the operators have changed since, schedule a new one.
- Check the calibration log for any gage used this week that is past due.

All 13 tools in this book: Process Trail Bundle

CHAPTER 4

Read the Chart

STEP 4 OF 8 | THE X-BAR AND R CHART

The lathe has been charted all shift: five consecutive pieces every 20 minutes, 19 subgroups from 6:00 to noon. Now plot them in production order and ask two questions. When did it change, and is it a real signal or normal variation?

Set the limits from a stretch you trust

Control limits come from the process itself, not from the print. Take a stretch you believe was stable. Here that is subgroups 1 to 11, from 6:00 to 9:20, which is 55 pieces.

- Average of the 11 subgroup means: 24.0040.
- Average of the 11 subgroup ranges: 0.00764.
- For subgroups of five, A2 is 0.577 and D4 is 2.114.
- Upper control limit: 24.0040 plus 0.577 times 0.00764, which is 24.0084. Lower control limit: 23.9996.
- Upper limit on the range chart: 2.114 times 0.00764, which is 0.0162.

Read it in order

Subgroup means 12 to 19, from 9:40 to noon, in order: 24.0042, 24.0046, 24.0080, 24.0070, 24.0094, 24.0108, 24.0124, 24.0124.

Two things stand out. Subgroup 16, at 11:00, is the first mean above the upper limit of 24.0084. And subgroups 12 to 19 are all above the center line, a run of eight, which completes at noon. Either one is a signal. Normal variation scatters points on both sides of the center line inside the limits. It does not climb for two hours.

When did it change? The run starts at subgroup 12, 9:40. Write that time down. Chapter 6 needs it.

The range chart tells you the other half. The largest range all shift is 0.012, well under the limit of 0.0162. The spread inside each subgroup did not change. The whole group of pieces moved up together.

Read more: SPC control charts for beginners.

The mistake to avoid

Reading the chart against the print tolerance. The limits on the chart are the process's own voice, and the tolerance is the customer's. This chart was signaling at 11:00, while every part was still far inside tolerance.

TOOL SIDEBAR

The tool: SPC Control Chart (QA-F-270)

Use a chart with the limits drawn on it, not just the dots. Calculate the limits from a stretch you know was stable, and write the signal rules on the chart so the operator can read it without you. A chart nobody can read is a drawing.

ON THE FLOOR MONDAY

- Pull one live control chart and check the limit lines are drawn on it.
- Check the limits came from a stable stretch, not from the print.
- Count the last eight points. Are they all on one side of the center line?

All 13 tools in this book: Process Trail Bundle

CHAPTER 5

Measure Capability

STEP 5 OF 8 | CP AND CPK

The chart says the process moved. Capability says how much room is left. Two numbers answer it: Cp, which compares the tolerance to the spread, and Cpk, which also looks at where the center sits.

The inputs

The tolerance runs from 23.980 to 24.020, a width of 0.040. Estimate the process spread from the average range: sigma is the average range divided by 2.326, the constant for subgroups of five.

- Cp is the tolerance width divided by six sigma.
- Cpk is the smaller of two numbers: the upper limit minus the average, over three sigma, or the average minus the lower limit, over three sigma.

Before and after

Stable stretch, subgroups 1 to 11, 55 pieces. Average 24.0040, average range 0.00764, sigma 0.00328. Cp is 2.03 and Cpk is 1.63.

Recent stretch, subgroups 15 to 19, 10:40 to noon, 25 pieces. Average 24.0104, average range 0.00760, sigma 0.00327. Cp is 2.04 and Cpk is 0.98.

What the gap says

Cp barely moved, from 2.03 to 2.04. The spread is the same. Cpk fell from 1.63 to 0.98, so the whole distribution slid toward the upper limit. A Cpk under 1.00 means the nearest limit is less than three sigma away. If this continues, parts will go over.

The gap between the two is the diagnosis. A small gap means the process is centered. A large gap means a centering problem: look for what moved the average. Both low means a spread problem: look for what is adding variation. Here the gap grew from 0.40 to 1.06. This is centering.

Do not recenter yet. An offset change would pull the average back and hide the cause, and the lathe would drift again.

One caution. This is a quick look at 25 pieces, not a formal study. It tells you where to look. Use a larger run when you need a number to show a customer, and ask your customer what minimum they want.

Read more: Cpk vs Ppk.

The mistake to avoid

Reading Cpk without Cp. One number cannot tell you whether to look at centering or at spread, and that is the difference between a ten minute fix and a week of searching.

TOOL SIDEBAR

The tool: Process Capability Study (QA-F-250)

Run the quick look in this chapter to decide where to look. Use a proper study, with more data, when you need a number to show a customer or to sign off a change. Keep the inputs with the result so anyone can check it.

ON THE FLOOR MONDAY

- Pick one characteristic and list its last 25 pieces in order.
- Work out Cp and Cpk, and write down the gap between them.
- Decide whether the next question is about centering or about spread.

All 13 tools in this book: Process Trail Bundle

CHAPTER 6

Find What Changed

STEP 6 OF 8 | CAUSE ON THREE LEGS

The chart says the change began at 9:40. Now find what happened to the process around then. Check the usual five, one at a time, against the records:

1. **Tool.** The insert was changed at 5:50, before the shift. Planned life is 400 pieces, and the lathe has made 222. Not this.
2. **Material.** One bar lot all shift, same certificate. No change at 9:40. Not this.
3. **Setup.** First-off was approved at 5:55, and the offset history for the shift has no entries after it. Not this.
4. **Operator.** The same operator since 6:00, no relief. Not this.
5. **Environment.** The coolant chiller tripped a high pressure alarm at 9:35, which is five minutes before the run began. The panel is on the chiller, not at the lathe. Coolant read 21 degrees C at 6:00 and reads 29 at noon.

Four were ruled out by records. One lines up with the chart. That is the lead.

Run it on three legs

Why it drifted, why you did not catch it sooner, and why the system allowed it.

- **Occurrence.** Why did it drift? The chiller tripped on high pressure at 9:35 because the condenser filter was packed with oil mist. The coolant warmed, the spindle and slide grew with it, and the diameter climbed toward the upper limit.

- **Detection.** Why did we not catch it sooner? The sheet was one piece an hour, read as pass or fail. The chart had dots but no limit lines drawn on it, so the point at 11:00 above the upper limit meant nothing to anyone.
- **System.** Why did the system allow it? The chiller is on no preventive maintenance list. The alarm shows only on the chiller panel. The control plan says nothing about coolant temperature, and nobody owns the condenser filter.

Each leg points at an action, and none of them is "retrain the operator." Field Book 1 goes deeper on the three legs.

Read more: how to do a 5 why and how to make a fishbone diagram.

The mistake to avoid

Stopping at the first thing that looks plausible. Check all five against the timing. If two line up, you do not have a cause yet, you have a shortlist.

TOOL SIDEBAR

The tools: 3-Legged 5 Why Analysis (QA-F-310), Fishbone Diagram (QA-F-365) and Setup & First-Off Inspection Report (QA-F-280)

The fishbone lists what could have changed. The first-off report and the offset history prove what did not. The 3-legged 5 why takes the one change that matches and runs it down on all three legs.

ON THE FLOOR MONDAY

- Take your last drift or shift in a process and write the time it started.
- List what changed within an hour of that time, from records, not memory.
- Check that your cause answers why it was not caught and why the system allowed it.

All 13 tools in this book: Process Trail Bundle

CHAPTER 7

Lock It In

STEP 7 OF 8 | CONTROL PLAN AND REACTION PLAN

The condenser filter is cleaned, the chiller is reset, and the coolant is back at 21 degrees. That fixes today. The next drift will come from somewhere else, and the way to be ready is to write the row that catches it early.

What the control plan row holds

- **Characteristic:** shaft SH-3306 outside diameter, 24.000 plus or minus 0.020.
- **Method and frequency:** X-bar and R chart, five consecutive pieces every 20 minutes, with the control limits drawn on the chart: upper 24.0084, lower 23.9996, range limit 0.0162.
- **Early warning item:** coolant temperature at the lathe, read every hour, limit 25 degrees C. On the day, the coolant crossed 25 a little before 11:00.
- **Signals:** one mean beyond a control limit, eight in a row on one side of the center line, or coolant above 25.

The reaction plan

The plan must say who does what and how fast, with the authority to stop written into it:

1. The operator stops the lathe and red tags everything made since the last good check.
2. The operator calls the shift lead, who sends a quality alert.
3. Maintenance checks the chiller and the coolant before the lathe restarts.
4. The lathe restarts only after a five piece check shows the mean back inside the limits.

Notice where the trigger sits. A mean above 24.0084 trips the plan, which is 0.0116 inside the upper tolerance of 24.020. The plan catches the drift while every part is still good.

The fixes behind it: the chiller goes on the weekly preventive maintenance list, the filter is cleaned weekly, and the chiller alarm gets a light at the lathe.

Read more: how to write a control plan and a control plan example.

The mistake to avoid

A reaction plan that says "notify supervisor." That is a phone call, not a plan. Write the trigger, the first three actions, who owns each one, and who can stop the machine.

TOOL SIDEBAR

The tool: Control Plan (QA-F-350)

The control plan row ties the characteristic to its check, its limits and its reaction plan. If the reaction plan lives in someone's head or in a separate procedure, put the trigger and the first three actions in the row itself.

ON THE FLOOR MONDAY

- Pick one control plan row and read its reaction plan.
- Check it names a trigger, an owner and who can stop the machine.
- If it says "notify supervisor," rewrite it this week.

All 13 tools in this book: Process Trail Bundle

CHAPTER 8

Prove It Held

STEP 8 OF 8 | CAPABILITY, EFFECTIVENESS AND LPA

The lathe is running again and the chart looks fine. That is one good shift. Proof is a run long enough to be convincing, measured against criteria you set before you started.

Re-run capability

Fresh run, same lathe, coolant held at 21 to 22 degrees: 20 subgroups across four shifts, 100 pieces. Average 24.0039, average range 0.00655, sigma 0.00282. Cp is 2.36 and Cpk is 1.90.

Compare it with the stable stretch before the drift: Cp 2.03 and Cpk 1.63. The difference in Cp is within what samples of 55 and 100 pieces can show by chance, so call the spread unchanged. What matters is that Cpk is back, and well above the 0.98 of the drifted stretch.

Set the proof before you look

1. A fresh capability run of at least 20 subgroups with Cpk of 1.67 or higher. Your customer may set another number.
2. No mean beyond a limit and no run of eight for 30 days.
3. The coolant log shows no reading above 25 and no unacknowledged chiller alarm for 30 days.

The first is met today. The other two need the calendar. At day 30 the chart has no point beyond a limit and no run of eight, the highest coolant reading in the log is 22 degrees, and the chiller alarm log is clean. Now the corrective action can close.

Add the question that keeps it fixed

One question joins the layered process audit for Lathe 3: "Is the coolant at the lathe at or below 25 degrees, and is there a reaction on the sheet for any reading above?" The shift lead asks it each shift, the supervisor weekly. Layers matter because the person who owns the process is the one least likely to see the slip.

Read more: how to run an effectiveness check and how to run a layered process audit.

The mistake to avoid

Closing the action on the day the fix goes in. A fix that has run one good shift has not been tested by a bad one. If it fails inside the window, go back to the cause, not to the next restart.

TOOL SIDEBAR

The tools: Effectiveness Verification Tracker (QA-F-393) and Layered Process Audit (QA-F-205)

The tracker holds the proof criteria, the window and the results, so nothing closes on hope. The layered process audit keeps the fix alive by asking the same short question at several levels on a schedule.

ON THE FLOOR MONDAY

- Pick your last drift fix and find the proof it held.
- If there is none, write the criteria and the window this week.
- Add one question about it to your layered process audit.

All 13 tools in this book: Process Trail Bundle

Monday Board

One action per step. Pick one and do it this week.

1. Look at this week's check sheets for readings moving one way, and add a call rule to any sheet without one. ☐
2. Name the last good check for one process, and check every cell has red tags and a hold spot. ☐
3. Find the last Gage R&R on your key gage and check no gage in use is past its calibration date. ☐
4. Pull one live control chart and check the limit lines are drawn and the last eight points are not all on one side. ☐
5. Work out Cp and Cpk from 25 pieces and write down the gap. ☐
6. Write down when your last drift started and list what changed within an hour of it. ☐
7. Read one reaction plan and rewrite it if it says only "notify supervisor." ☐
8. Find the proof your last drift fix held, and add one question about it to the layered process audit. ☐