10 CNC CRASH TRIGGERS

AND HOW TO CATCH THEM EARLY



REFERENCE / TOOL / CLEARANCE / MODAL STATE

Most crashes are preventable.
The machine usually does exactly what the setup allows.

THE CRASH HAPPENS LATER.
THE ERROR USUALLY STARTS EARLIER.

SWIPE. CHECK THE SETUP. →

01 / FAILURE MODE

WRONG ACTIVE WORK OFFSET

THE PROGRAM IS RIGHT. THE REFERENCE IS WRONG.



TRIGGER / MECHANISM

Program expects fixture B.
G54 remains active.

CHECK BEFORE MOTION

Call G55 explicitly.
Verify active offset and values.

CORRECT COORDINATES + WRONG ORIGIN = WRONG LOCATION.

THE PROGRAM CAN BE PERFECT AND STILL CUT THE WRONG PLACE.

02 / FAILURE MODE

DATUM SET ON THE WRONG REFERENCE

ONE TOUCH-OFF ERROR MOVES THE ENTIRE JOB.



EDGE FINDER / APPROACH

TRIGGER / MECHANISM

Wrong surface, or omitted edge-finder radius correction.

CHECK BEFORE MOTION

Check the setup reference. Cross-check a known feature.

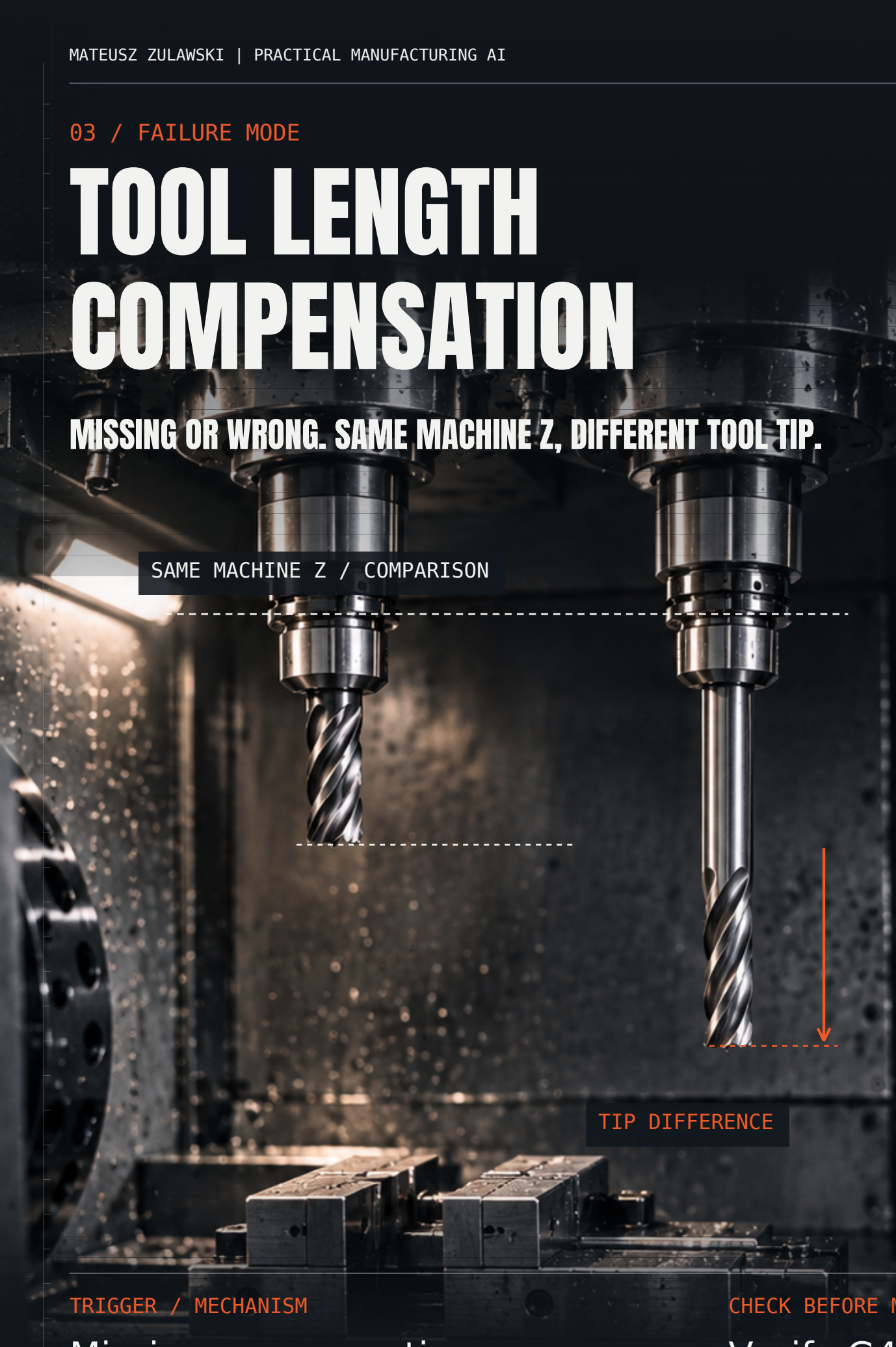
ILLUSTRATED: LEFT EDGE TOUCH-OFF; SIGN DEPENDS ON APPROACH.

A 5 MM DATUM ERROR BECOMES A 5 MM ERROR EVERYWHERE.

03 / FAILURE MODE

TOOL LENGTH COMPENSATION

MISSING OR WRONG. SAME MACHINE Z, DIFFERENT TOOL TIP.



FAULT EXCERPT

```
T05 M06
G90 G54
G00 X0 Y0
G00 Z50.
```

MISSING / VERIFY

```
G43 H05
```

Illustration only.
Not a runnable start block.

TRIGGER / MECHANISM

Missing compensation or wrong active H shifts the tip.

CHECK BEFORE MOTION

Verify G43 H05 as applicable. Match T ↔ H and offset value.

AUTO-ACTIVATION VARIES BY CONTROL. CHECK THE ACTUAL STATE.

THE CONTROL MOVES THE SPINDLE. THE OFFSET LOCATES THE TOOL TIP.

04 / FAILURE MODE

RAPID BELOW CLEARANCE

THE FASTEST MOVE NEEDS THE CLEAREST PATH.



TRIGGER / MECHANISM

XY rapid crosses a clamp below its top surface.

CHECK BEFORE MOTION

1 RETRACT Z 2 MOVE XY
3 APPROACH Z at clear location

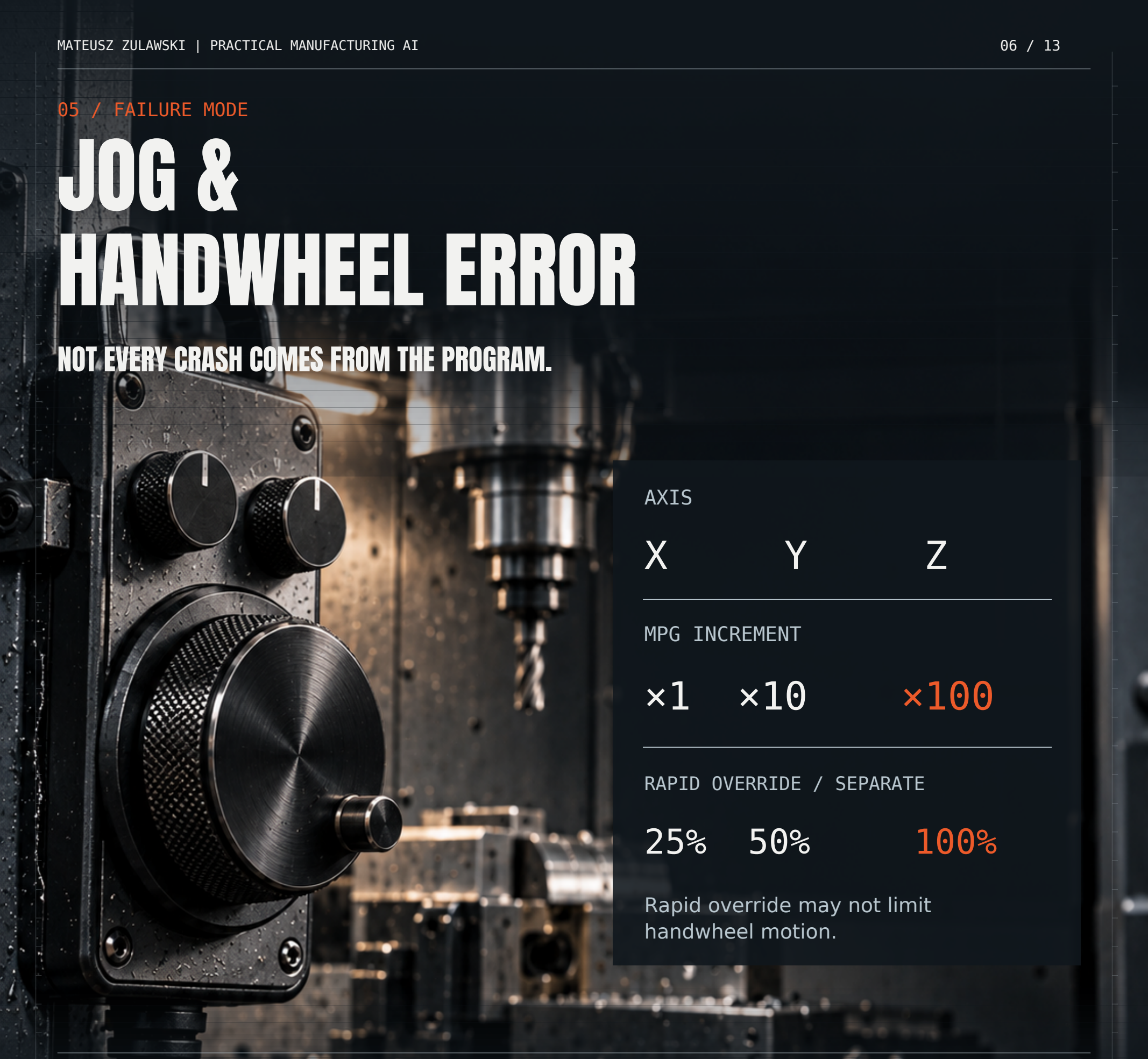
VERIFY THE WHOLE TOOL + HOLDER ENVELOPE, NOT ONLY THE TIP.

CLEARANCE IS PART OF THE TOOLPATH.

05 / FAILURE MODE

JOG & HANDWHEEL ERROR

NOT EVERY CRASH COMES FROM THE PROGRAM.



AXIS

X Y Z

MPG INCREMENT

×1 ×10 ×100

RAPID OVERRIDE / SEPARATE

25% 50% 100%

Rapid override may not limit handwheel motion.

TRIGGER / MECHANISM

Expected: tiny movement.
Actual: wrong axis or increment.

CHECK BEFORE MOTION

Verify axis, direction, increment.
Use the smallest suitable step.

MULTIPLIERS ARE NOT DISTANCES: CHECK mm OR inch PER CLICK.

BEFORE YOU TURN THE HANDWHEEL, READ WHAT ONE CLICK MEANS.

06 / FAILURE MODE

MODAL LEFTOVERS & RESTARTS

G-CODE REMEMBERS WHAT YOU FORGOT.

STILL ACTIVE / EXAMPLE STATES

G91	Incremental positioning
G41	Cutter compensation active
G81	Drilling cycle active
G95	Feed per revolution

ESTABLISH A KNOWN STATE - NOT A BLIND RESET

G17 G40 G49 G80 G90 G94

G49 cancels tool length compensation. Re-establish it before approach.

TRIGGER / MECHANISM

Restart skips the blocks that establish tool and modes.

CHECK BEFORE MOTION

Use the approved restart routine. Confirm modes, offsets and path.

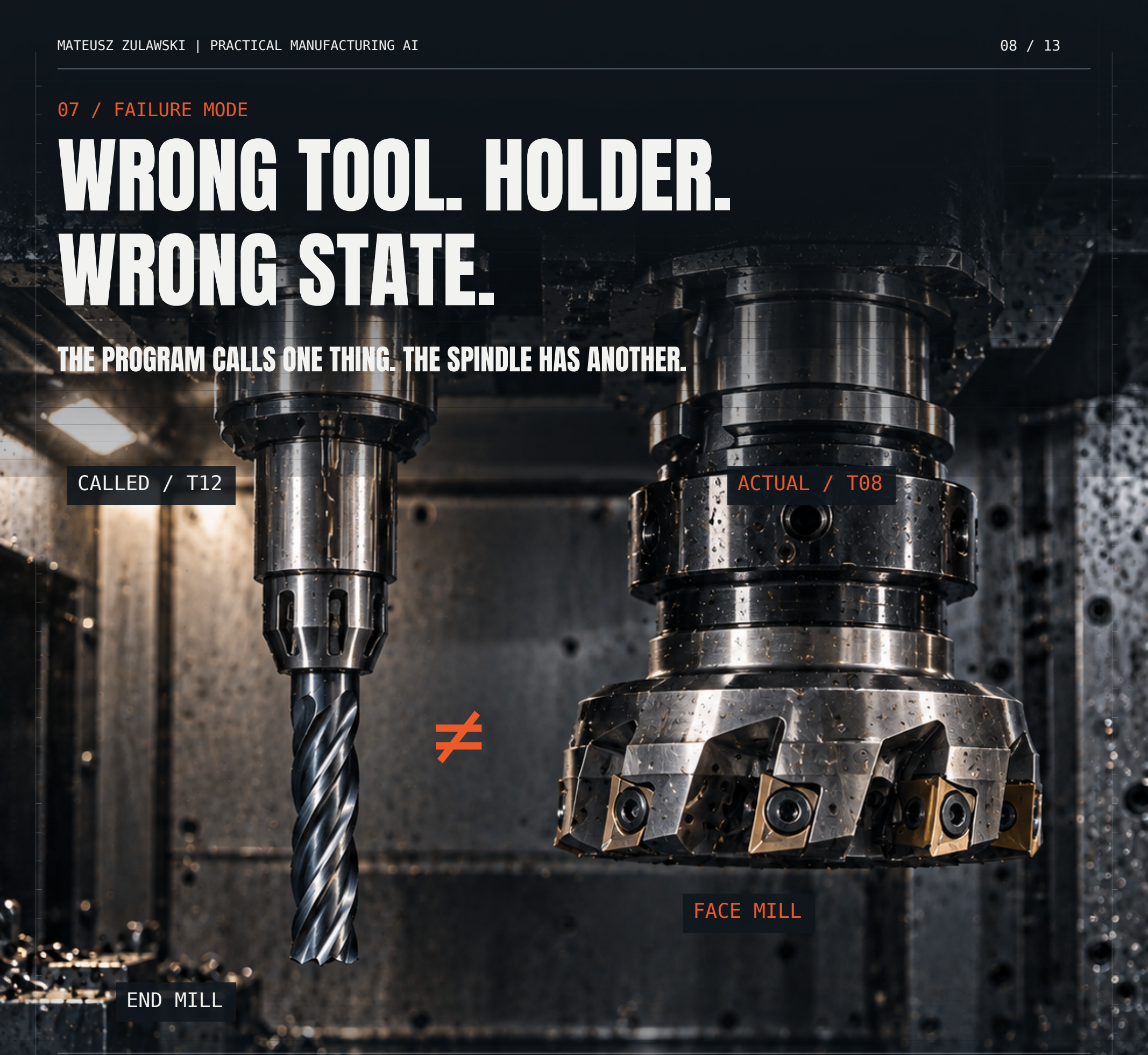
CANCEL COMPENSATION ONLY AT A VERIFIED CLEAR POSITION.

THE LINE YOU START FROM MATTERS AS MUCH AS THE LINE YOU RUN.

07 / FAILURE MODE

WRONG TOOL. HOLDER. WRONG STATE.

THE PROGRAM CALLS ONE THING. THE SPINDLE HAS ANOTHER.



TRIGGER / MECHANISM

Different diameter, length or holder changes the envelope.

CHECK BEFORE MOTION

Verify physical tool against T#. Check diameter, length, holder.

CHECK CUTTING DIRECTION: M03 / M04. VERIFY REQUIRED RPM.

TOOL NUMBER ALONE DOES NOT DEFINE THE TOOL.

08 / FAILURE MODE

FEED MODE & UNITS

THE NUMBER LOOKS NORMAL. THE MODE MAKES IT DANGEROUS.

`G21 G94  F0.05`

0.05 mm/min

RUBBING / HEAT RISK

`G21 G95  F400`

400 mm/rev

EXCESSIVE FEED REQUEST

`G20 G90  X100.`

2,540 mm

INCH COORDINATE / TRAVEL RISK

`mm/min = mm/rev × RPM`

`0.05 × 8000 = 400 mm/min`

TRIGGER / MECHANISM

Units or feed mode differ from the programmed assumption.

CHECK BEFORE MOTION

Confirm G94 / G95 + G20 / G21. Sanity-check feed before entry.

EXCESSIVE REQUESTS MAY ALARM OR BE LIMITED; NEVER RELY ON THAT.

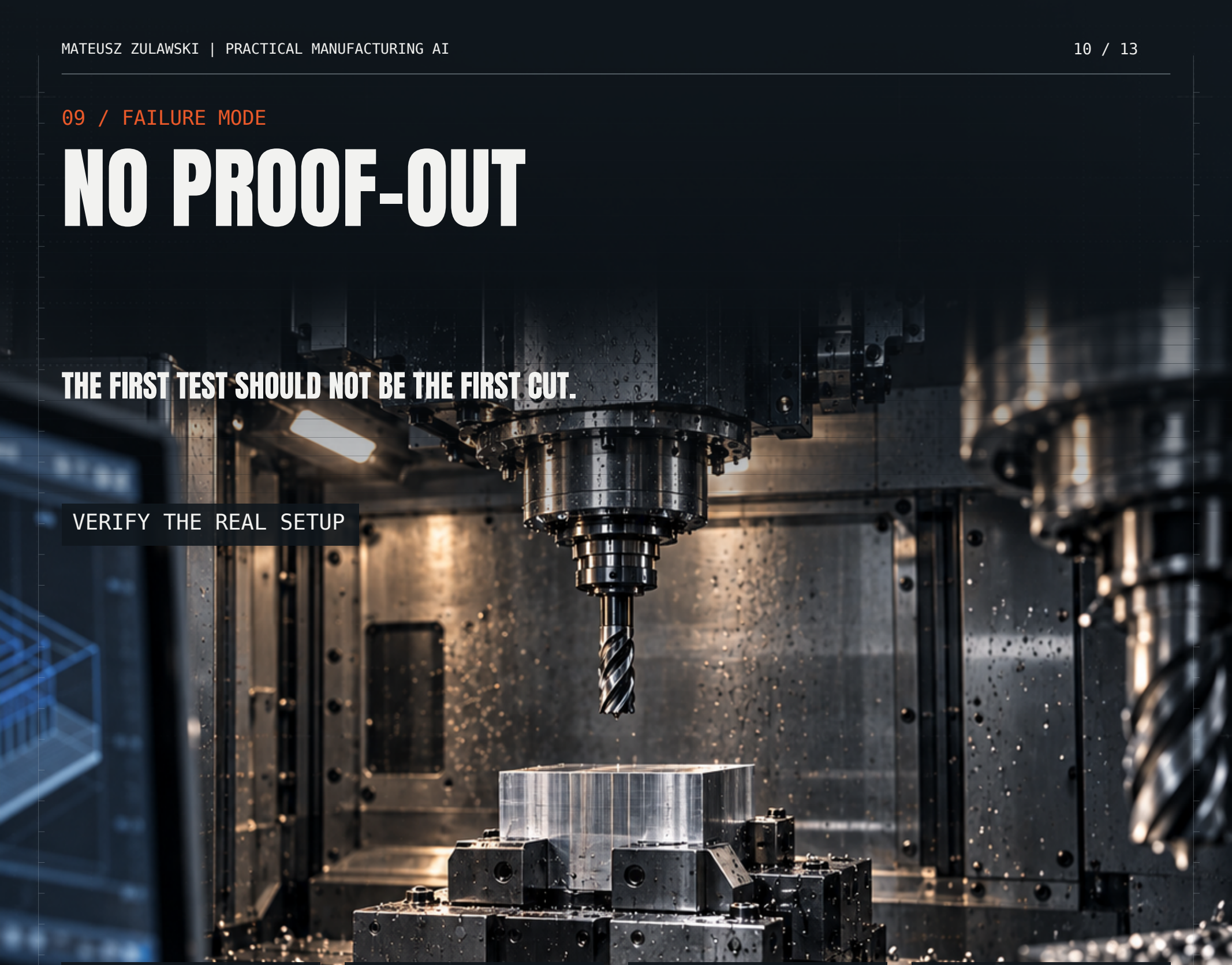
NEVER READ THE NUMBER WITHOUT READING THE MODE.

09 / FAILURE MODE

NO PROOF-OUT

THE FIRST TEST SHOULD NOT BE THE FIRST CUT.

VERIFY THE REAL SETUP



SIMULATE → **AIR RUN** → **SINGLE BLOCK** → **FIRST CUT**

SIMULATE	AIR RUN	SINGLE BLOCK	FIRST CUT
Model + offsets	Verified clearance	Observe each move	Controlled overrides

TRIGGER / MECHANISM

An unproven program makes the machine the error detector.

CHECK BEFORE MOTION

Use the approved air-run method. Check travel, return and offsets.

SIMULATION IS ONLY AS COMPLETE AS ITS MODEL AND SETUP DATA.

No generic Z +100 shift. Restore and re-verify any approved temporary changes.

CATCH THE ERROR BEFORE THE MACHINE HAS TO.

10 / FAILURE MODE

POOR WORKHOLDING

THE TOOLPATH CAN BE PERFECT. THE PART CAN STILL MOVE.



TRIGGER / MECHANISM

Chips, weak engagement or clamp interference defeat the setup.

CHECK BEFORE MOTION

Clean. Seat. Approved torque. Check engagement and clearance.

A TUG-TEST DOES NOT PROVE RESISTANCE TO CUTTING LOAD.

WORKHOLDING IS NOT JUST HOLDING. IT IS RESISTING THE PROCESS.

SAVE THIS.

CNC PRE-FLIGHT REFERENCE

BEFORE YOU PRESS CYCLE START.

01 **DATUM**
Work offset / reference / orientation

02 **TOOL LENGTH**
T ↔ H / tool tip / active offset value

03 **TOOL / SPINDLE**
Tool / holder / M03 / M04 / RPM

04 **MODAL STATE**
Plane / compensation / cycles / distance / feed / units

05 **CLEARANCE**
Safe Z / clamps / entire rapid path

06 **WORKHOLDING**
Clean / seat / approved torque / engagement

07 **PROOF-OUT**
Simulate / approved air run / single block / overrides

MODES TO VERIFY: G17 G40 G49 G80 G90 G94 + G20/G21

G49 cancels length compensation: restore the required state before approach.

REFERENCE → TOOL → STATE → CLEARANCE → VERIFY

MOST CNC CRASHES ARE PREVENTABLE.

SAVE / SHARE • FOLLOW MATEUSZ ZULAWSKI

PRACTICAL MANUFACTURING AI

Fanuc-style ISO milling examples. Siemens, Heidenhain and lathe controls differ.
Follow your machine manual and approved setup / restart procedures.

BONUS / SAVE THIS. THE FULL CNC CRASH-TRIGGER MAP

REAL PROBLEMS. REAL EXPERIENCE. PRACTICAL SOLUTIONS.

10 CNC CRASH TRIGGERS AND HOW TO CATCH THEM EARLY

Most crashes are preventable. The machine usually does exactly what the setup allows.



BETTER SETUPS
SAFER PARTS
STRONGER SHOPS

THE MACHINE DOES WHAT THE SETUP ALLOWS.

Most CNC crashes begin with one of five things: wrong reference, wrong state, wrong motion, wrong tool, or wrong verification.

PLAN.
SET.
VERIFY.
MACHINE.

01 WRONG ACTIVE WORK OFFSET

Trigger: Program is for fixture B, but G54 is still active.

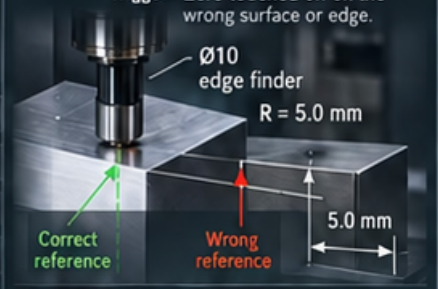


WHAT GOES WRONG:
Cuts in the wrong place. Hits the wrong fixture.

CHECK BEFORE START:
Call G55 in the program. Read the active work offset before Cycle Start.

02 DATUM SET ON THE WRONG REFERENCE

Trigger: Zero touched off on the wrong surface or edge.

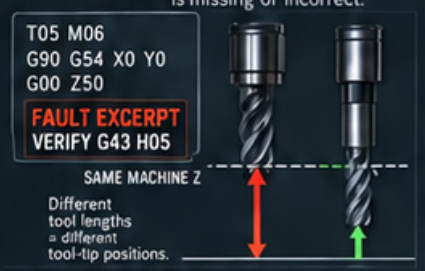


WHAT GOES WRONG:
Every move is shifted by the same error. Part or fixture can be hit.

CHECK BEFORE START:
Verify against the setup sheet. Cross-check with a second reference.

03 TOOL LENGTH COMPENSATION MISSING OR WRONG

Trigger: Tool length compensation is missing or incorrect.

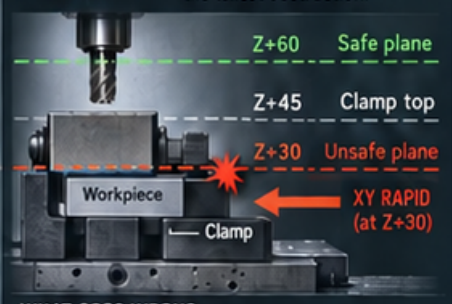


WHAT GOES WRONG:
Tool plunges into part or vise. Tool cuts air.

CHECK BEFORE START:
Verify active H and offset value. Compensation behaviour varies by control.

04 RAPID BELOW CLEARANCE

Trigger: XY rapid occurs below the tallest obstruction.



WHAT GOES WRONG:
Tool or spindle hits the clamp. Rapid motion leaves almost no reaction time.

CHECK BEFORE START:
Safe Z above the tallest clamp. Retract Z first. Then move XY.

05 JOG & HANDWHEEL ERROR

Trigger: The crash happens before the program even runs.



AXIS: X Y Z
INCREMENT: ×1 ×10 ×100
RAPID OVERRIDE: 25% 50% 100%

WHAT GOES WRONG:
One handwheel click moves much farther than expected. Tool is driven into the workpiece.

CHECK BEFORE START:
Verify axis, direction and mm per click. Rapid override may not limit MPG motion.

06 MODAL LEFTOVERS & MID-PROGRAM RESTART

Trigger: A previous code remains active.

ACTIVE STATE (from previous run)
G91 G41 G81 G95

MODES TO VERIFY - NOT A RESET
G17 G40 G49 G80 G90 G94

WHAT GOES WRONG:
Absolute moves become incremental. Canned cycle continues. Offsets remain active. Feed mode is wrong.

CHECK BEFORE START:
Use the approved restart procedure. G49 cancels length compensation.

07 WRONG TOOL, HOLDER OR SPINDLE STATE

Trigger: T12 called. T08 physically in the spindle.



WHAT GOES WRONG:
Wrong feature is machined. Longer assembly hits clamps or walls.

CHECK BEFORE START:
Match T#, diameter and assembly length. Verify M03 / M04.

08 FEED MODE & UNITS

Trigger: The numeric value looks normal. The active mode makes it dangerous.

EXAMPLE	RESULT	NOTES
G21 G94 F0.05	0.05 mm/min	HEAT RISK
G21 G95 F400	400 mm/rev	FEED RISK
G20 G90 X100.	2,540 mm	TRAVEL RISK

F mm/min = F mm/rev × RPM
0.05 × 8000 = 400

WHAT GOES WRONG:
Tool rubs. Tool burns. Tool breaks. Machine overtravels.

CHECK BEFORE START:
Confirm G94 / G95. Confirm G20 / G21. Sanity-check the first programmed feed.

09 NO PROOF-OUT

Trigger: The first real test happens in material.



SIMULATION DEPENDS ON MODEL AND SETUP DATA.
WHAT GOES WRONG: The machine becomes the error detector. Mistakes are found after cutting begins.
CHECK BEFORE START: Approved air run. Single block. Controlled overrides. Verify any temporary changes.

10 POOR WORKHOLDING

Trigger: The toolpath is correct. The part is not secure.



WHAT GOES WRONG: Part moves. Part lifts. Tool breaks. Clamp enters the toolpath.
CHECK BEFORE START: Clean. Seat. Approved torque. Check engagement and clamp clearance.

CNC PRE-FLIGHT
BEFORE CYCLE START

01 DATUM ✓ | 02 TOOL LENGTH ✓ | 03 TOOL / SPINDLE ✓ | 04 MODAL STATE ✓ | 05 CLEARANCE ✓ | 06 WORKHOLDING ✓ | 07 PROOF-OUT ✓

SAVE / SHARE

FIVE MINUTES OF CHECKING CAN SAVE HOURS OF RECOVERY.
And sometimes a tool, a fixture, a spindle, or a part worth thousands.

G-code shown in Fanuc-style ISO. Siemens, Heidenhain and lathe controls differ - follow your machine manual.

Mateusz Zulawski

Practical Manufacturing AI