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Failure Mechanisms of Spring Pins – the Inside Story

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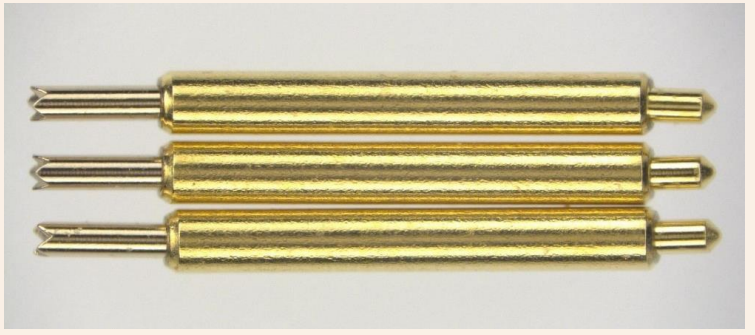
Introduction

The most discussed spring pin failure mechanism is:
plunger tip contamination

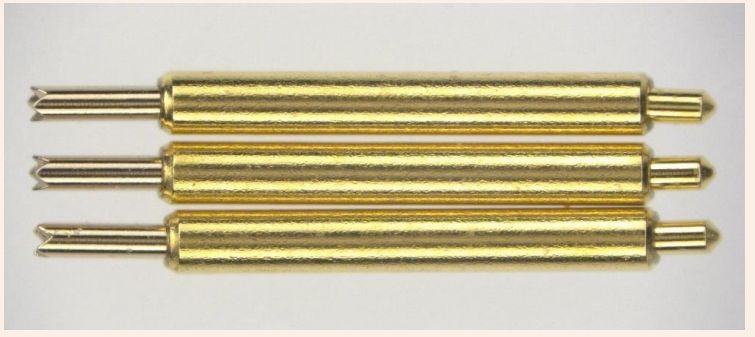
This presentation will look at failures inside the spring pin.

The photos and charts used in this presentation come from real case studies.

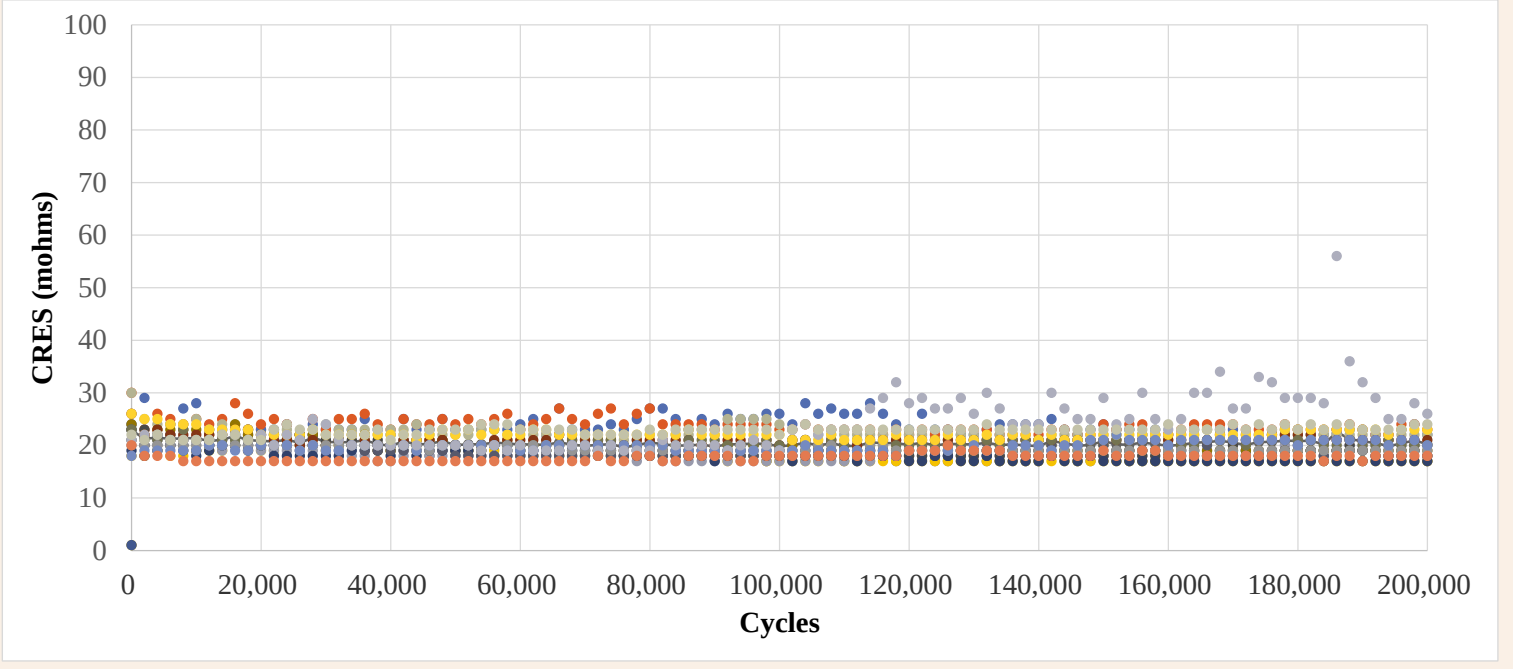
The good pins



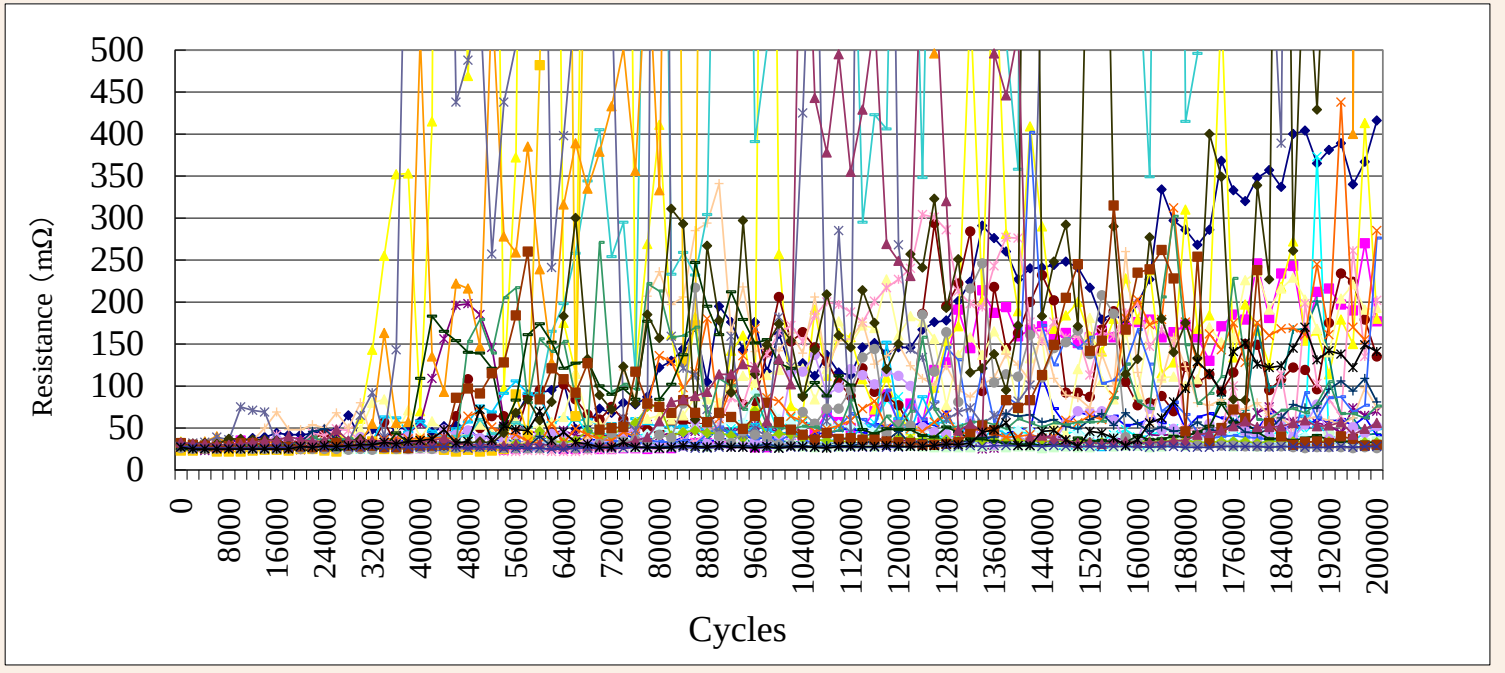
The good, the bad, and the ugly pins



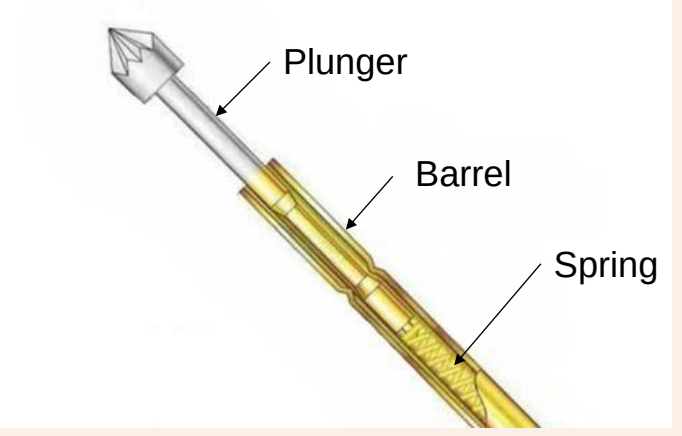
CRES/Durability – a good pin



CRES/Durability – a bad pin

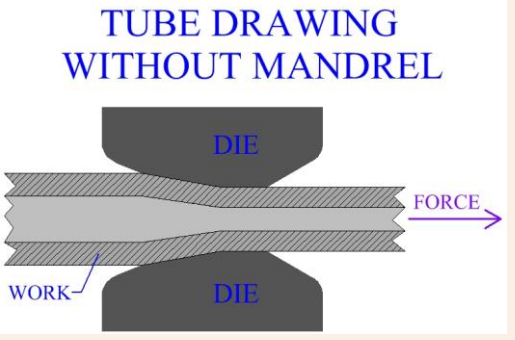


The Inside of a Spring Pin

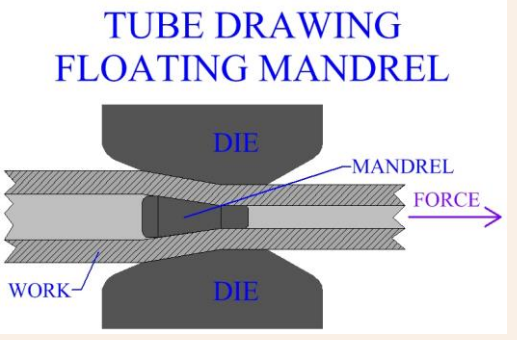


Barrels from gold-lined tubes

Gold-filled tube for Jewelry

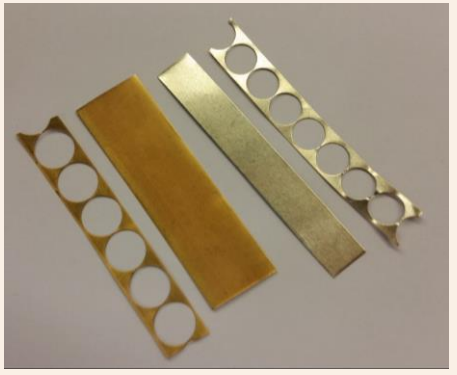


Extrusion process for jewelry

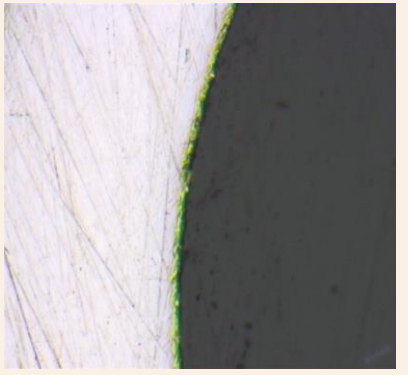


Extrusion process for spring pins

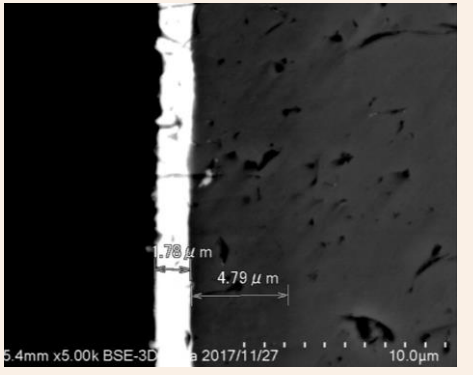
Barrels from deep-drawn strip stock



Au plated or Au clad strip stock

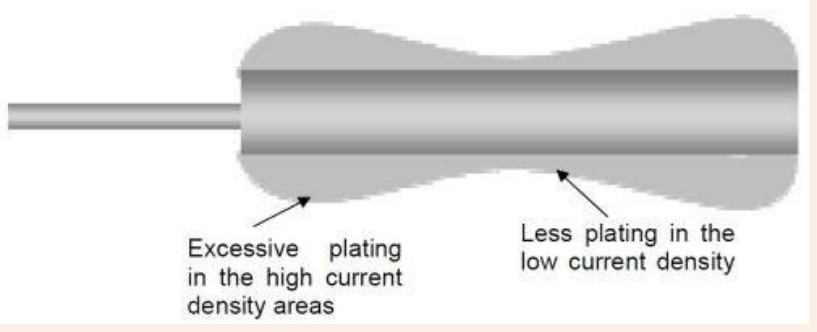


Au lining on barrel ID

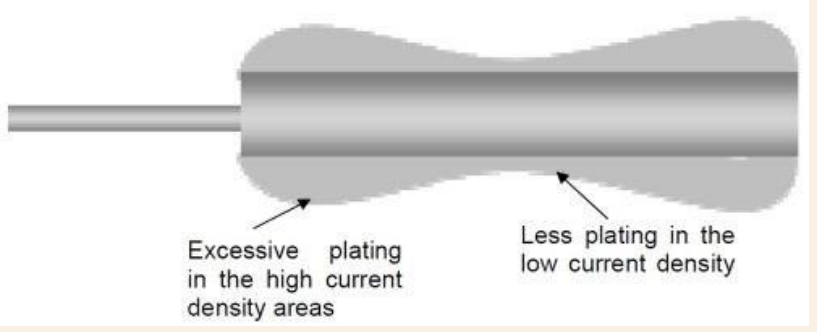


Au and Ni thickness

Barrels plated after fabrication

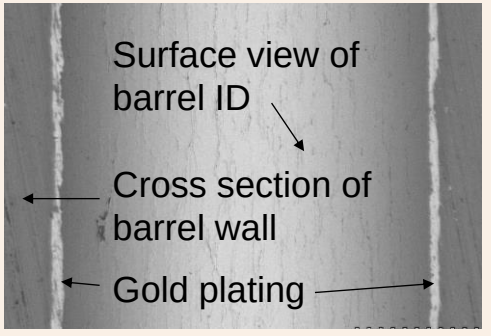


Barrels plated after fabrication

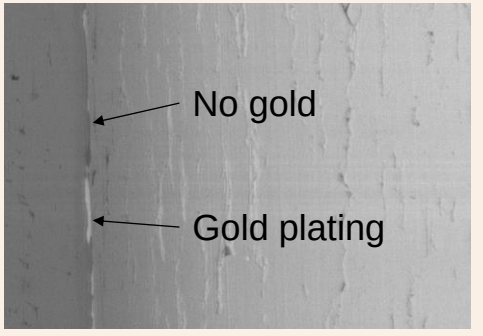


Worst Case: $\frac{\text{OD ends plating thickness}}{\text{ID middle plating thickness}}$ = 5:1

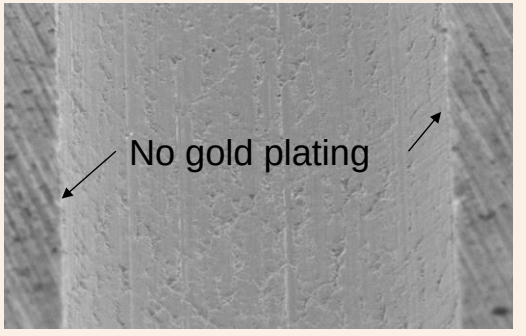
Barrels plated after fabrication



Normal Au plating on barrel ID



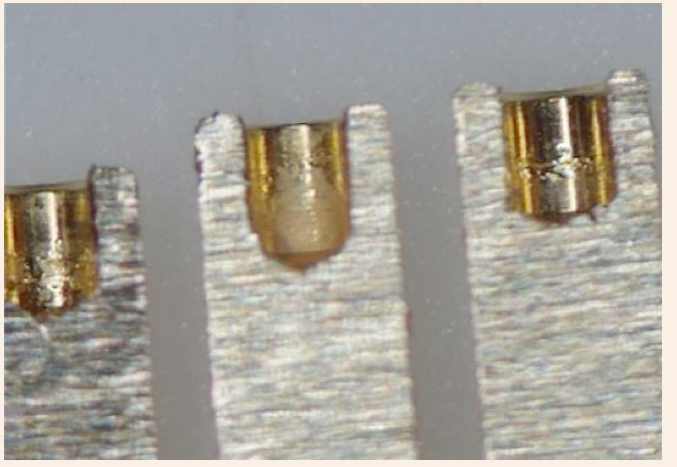
Only spots of gold plating



No detectable gold

Barrels plated after fabrication: blind holes

Good Au plating



Poor Au plating

Electroformed Barrels

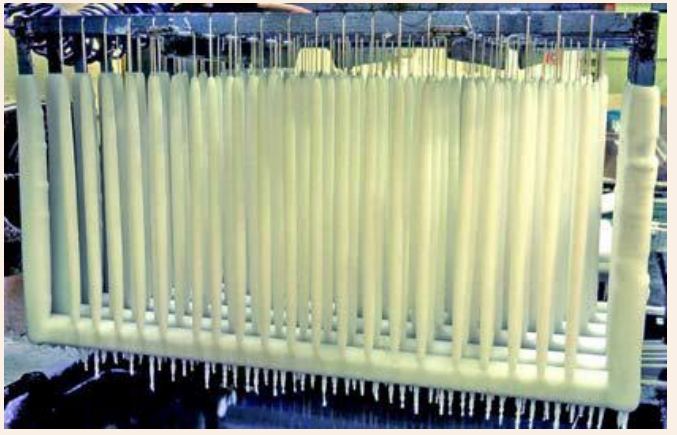
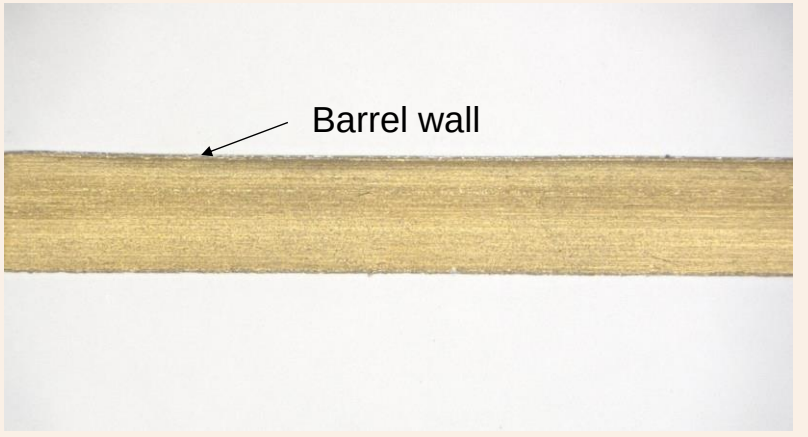
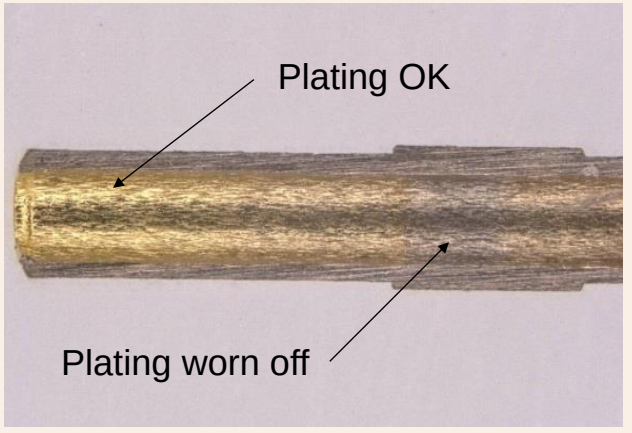


Image from BITS 2011 Presentation

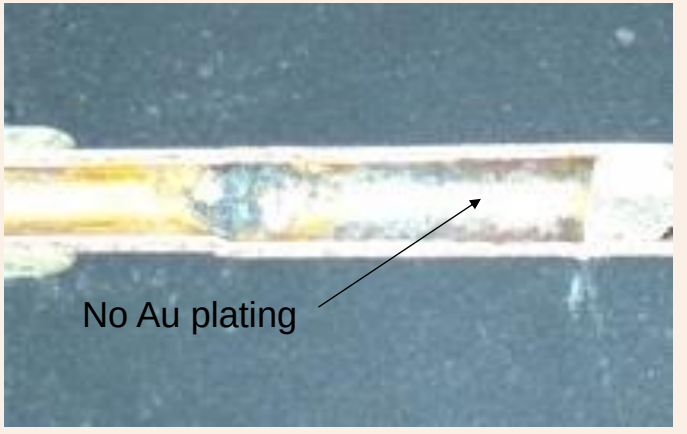


Gold plating on ID of e-barrel

Plating failure on barrel ID

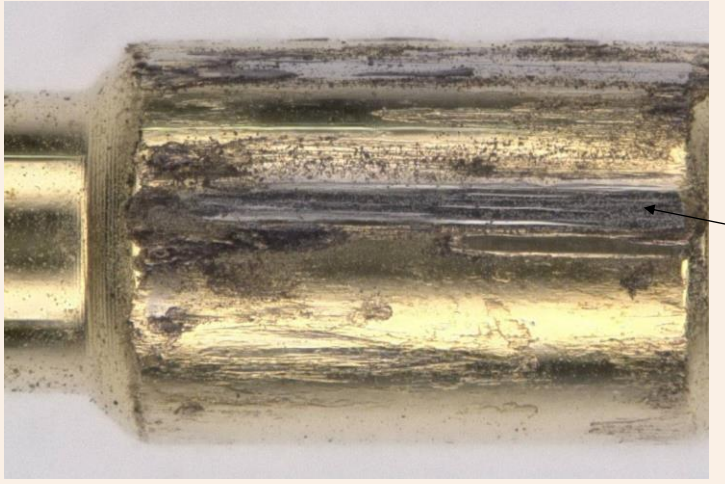


Plating worn off at base of plunger



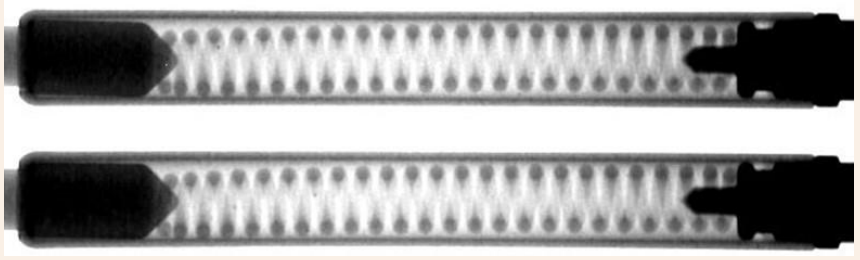
Plating worn off by biased ball

Plating damage to the plunger

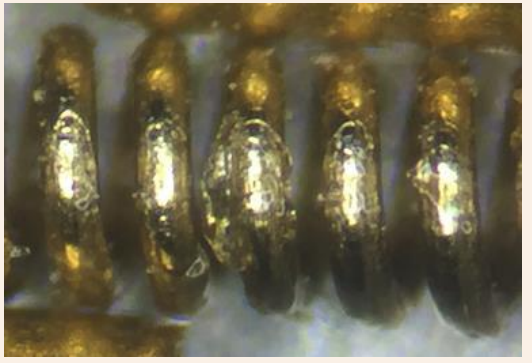


Plating failure due to side loading or internal contamination

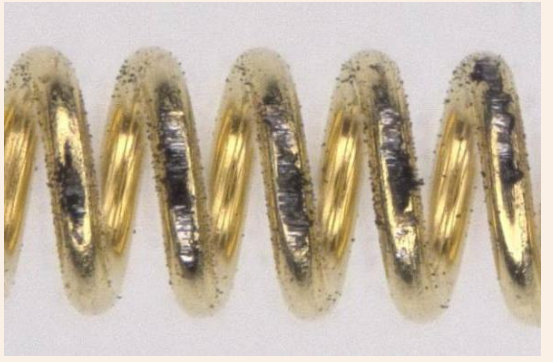
X-ray of a normal spring



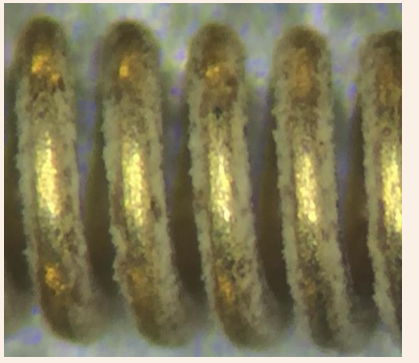
Springs: plating failures and contamination



Plating delamination

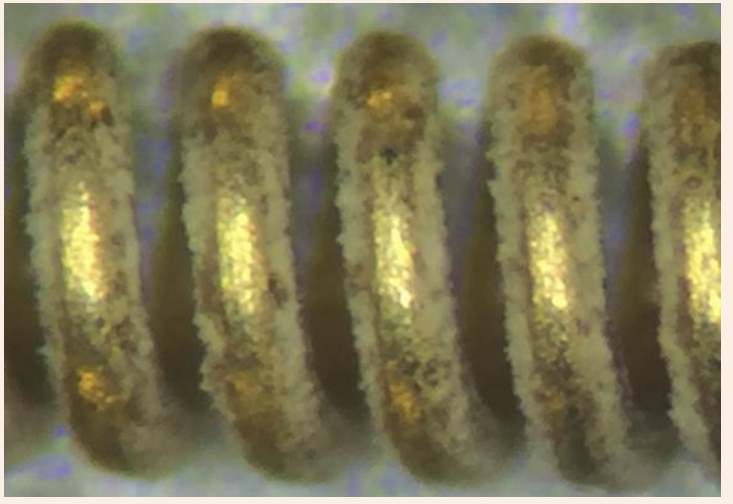


Metal contamination



Mystery contamination

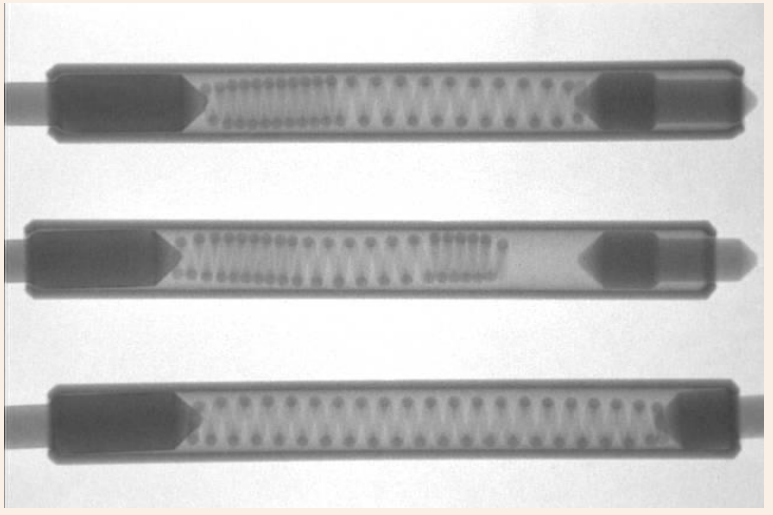
Spring pin or bacteria ?



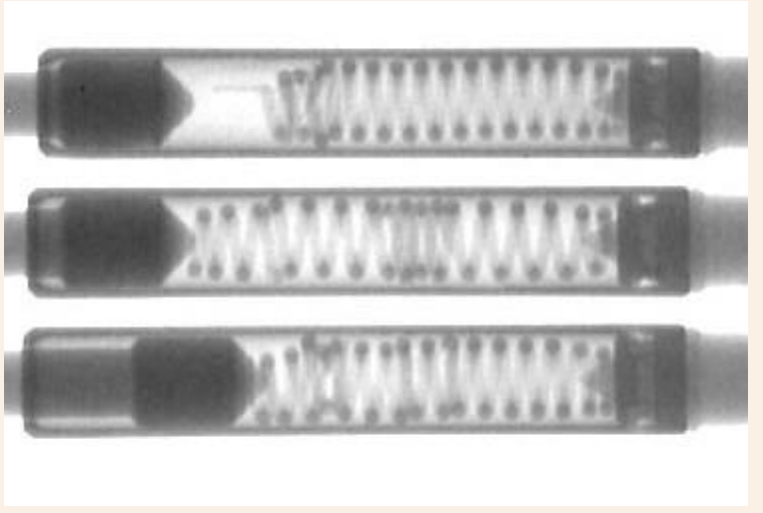
Spring with mystery contamination

Bacteria

Spring failures - mechanical



Taking a set



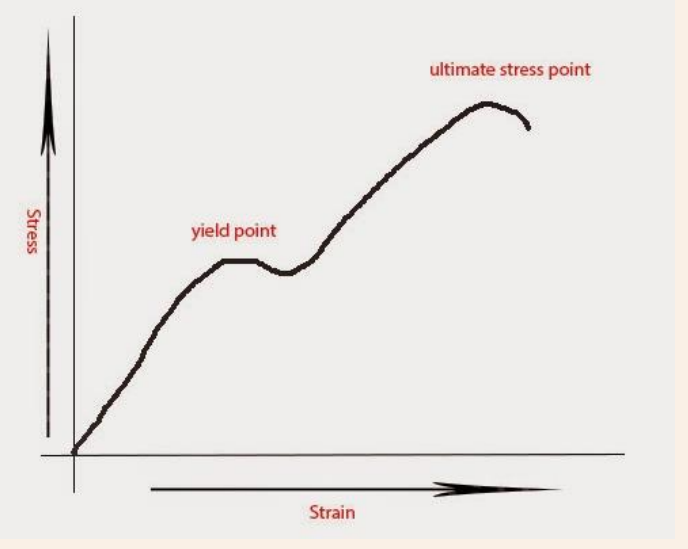
Broken due to over-stressing

Spring failures: set or break ?

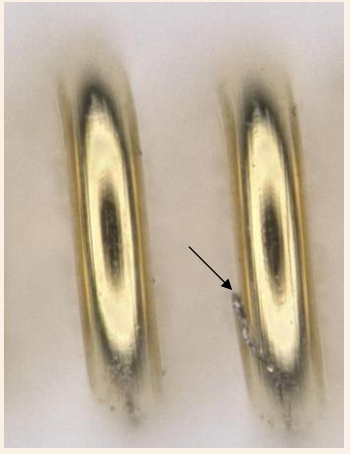
Spring will break →

Spring will take a set →

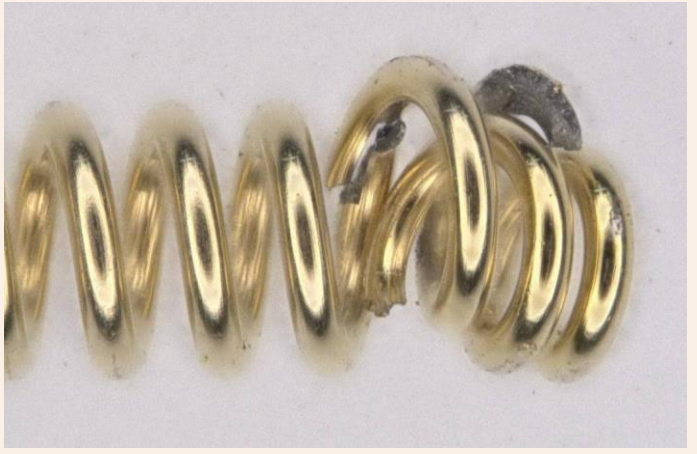
Proper operating range →



Spring failures: cracked and broken



Starting to crack



Cracked and mangled

Separated and free to move around

Checklist: Inside barrels

Observation	Cause	Corrective Action
Poor plating on ID	Dog boning Improper solution circulation Improper pre-cleaning	Balance the current density during plating Improve the circulation of plating liquids Careful attention to cleaning steps Use pre-plate or pre-clad strip material Use e-barrels
Side load plating wear	Not straight in socket cavity	Improve machining tolerances Improve alignments of socket plates
Visible contamination	Delamination of plating Side load	Improve plating layers underneath gold Straighten up the socket cavity

Checklist: Springs

Observation	Cause	Corrective Action
Poor plating	Poor cleaning	Remove wire lubricants before plating
	Brittle nickel interlayer	Don't use electroless nickel
	Tangling in plating tank	Smaller plating lot
Spring takes a set	High temperatures	Stainless steel wire
	High stress levels (< UTS)	High tensile strength wire
Broken spring	Overstressing (> UTS)	Lower spring force or plunger travel
		Increase spring cavity size
		Keep stress at ½ UTS
	Poor quality wire	

Other "inside" topics for BiTS2019

Gaps between plunger OD and barrel ID

Diffusion of base metal elements up to the barrel ID surface at elevated temperatures.

Poor crimp geometry resulting in wedged plungers

Poorly shaped end coils of the compression spring

Barrel damage due to mishandling with tweezers or fingers