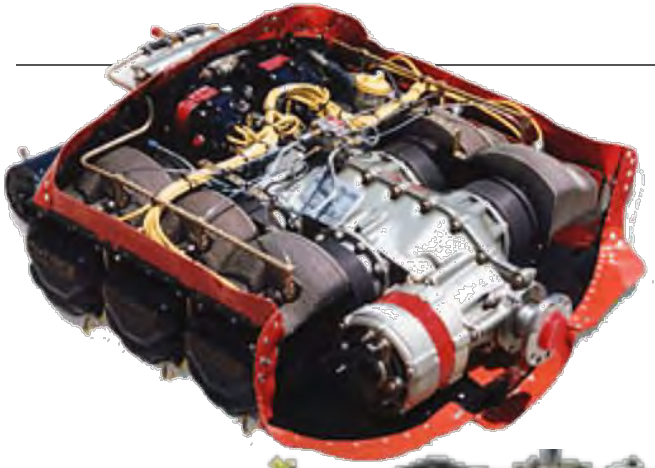
To TBO and Beyond…



Your presenter…

Mike Busch A&P/IA

Columnist — AOPA PILOT magazine

Instructor — EAA Webinars

Podcaster — Ask the A&Ps (AOPA)

National Aviation Maintenance Technician of the Year (2008)

President — Savvy Aviation, Inc.

Mo 1000 #7	The EGT Myth
Mo 1300 #7	How Healthy Is Your Engine?
Tu 0830 #7	To TBO and Beyond…
Tu 1000 #7	Leaning The Right Way
Tu 1300 #7	Destroy Your Engine in 1 Minute
We 0830 #7	Cylinder Break-In: Do It Right
We 1130 #7	What Is Preventive Maintenance?
We 1430 #7	Cylinder Work: Risky Business
Fr 0830 #7	It's Baffling
Fr 1000 #7	Where Fuel Meets Air
Fr 1300 #7	Benefits of Running Oversquare
Sa 1000 #7	How Mags Work…and Fail
Sa 1300 #7	Predictive Maintenance

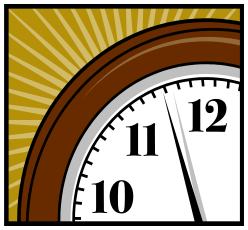
NEW!

To receive my AirVenture forum slides, my monthly e-newsletter and my weekly maintenance stories…

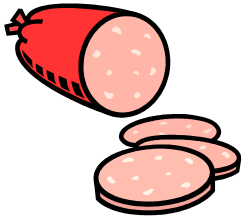
Why talk about TBO?

Engines are EXPENSIVE…

…and maintenance-INTENSIVE



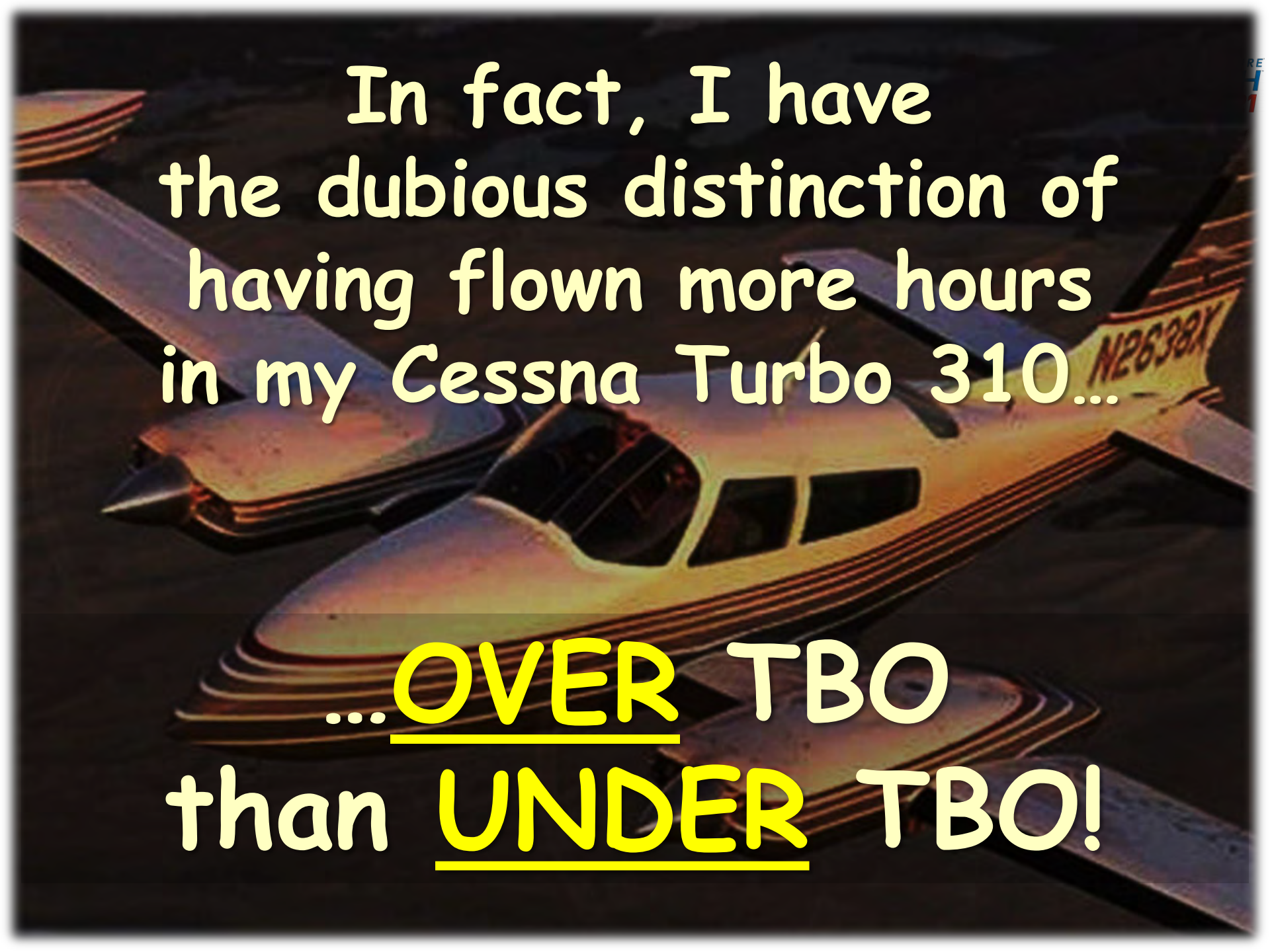
Longevity is largely UP TO YOU



Lots of BAD ADVICE out there

Why believe ME???

- I have a **55-year** track record flying piston singles and twins
- I've **never** failed to make TBO in **14,000+ engine hours**
- In 2015, I finally majored my twin's right engine and topped its left engine… **at 220% of TBO**


In fact, I have
the dubious distinction of
having flown more hours
in my Cessna Turbo 310…
N2638X
…OVER TBO
than UNDER TBO!

How long <u>should</u> engines last?

How long should engines last?

Wrong question!

Engine TBO is defined in terms of HOURS and YEARS

But HOURS and YEARS is NOT what wears out our engines…

But
YE
wee
out
engi

The **main factors** that influence how long our engines last are:

1. **DISUSE**
2. **CYCLES**

If you ran your engine continuously in a test cell, shutting it down only every 50 hours to change the oil…

…it would last nearly forever!

But we DON'T run them that way!

- ✓ Most flights last only an hour or two
- ✓ Most engines SIT way more than FLY

There's a HUUUGE difference between…

1,600 hours in 4 years vs.
1,600 hours in 40 years

12 years in Tampa vs.
12 years in Tucson

One TBO size does not fit all!

TBO is not a life limit

There are **no life-limited parts** in any Continental or Lycoming

Part 91:
TBO is a mere suggestion

Part 135:
Get extension from FSDO

Operating past TBO…

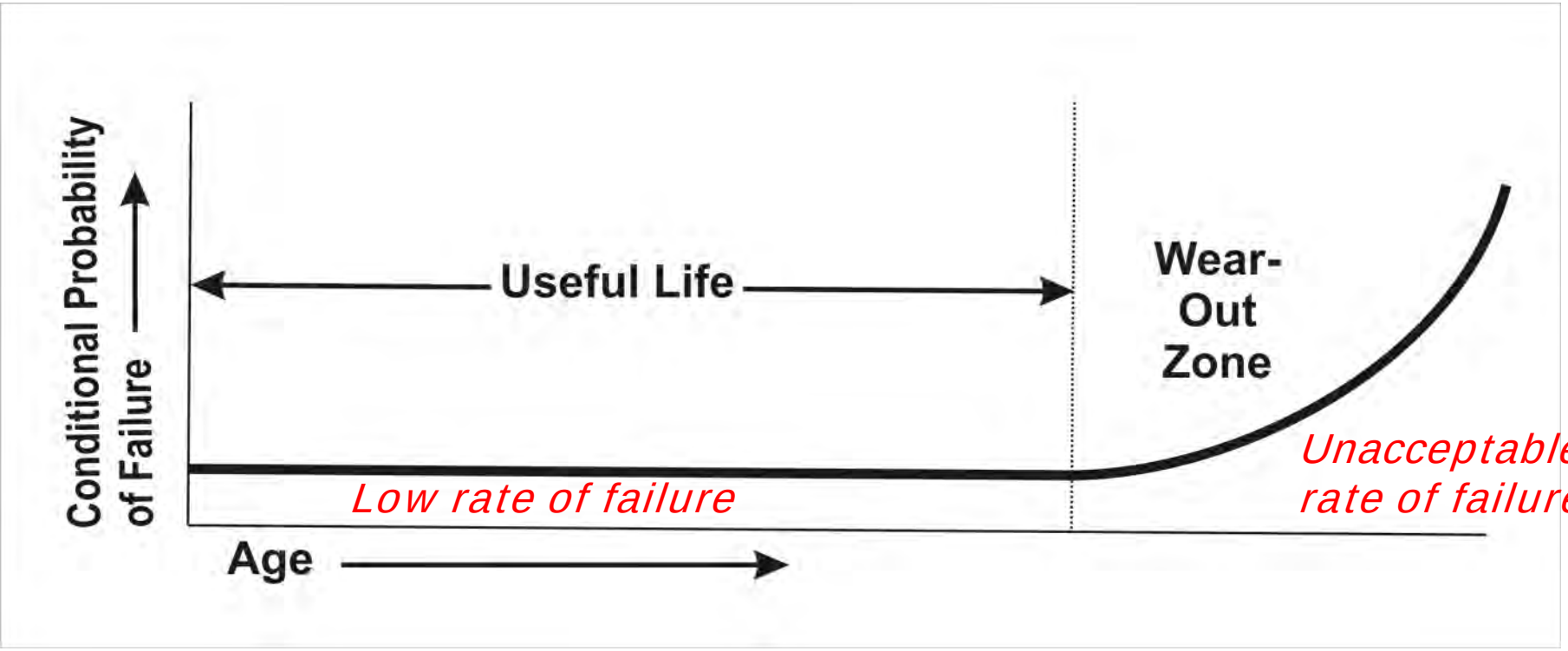
…will <u>not</u> void your insurance

…will <u>not</u> make a catastrophic engine failure more likely

In fact, it will do precisely the opposite!

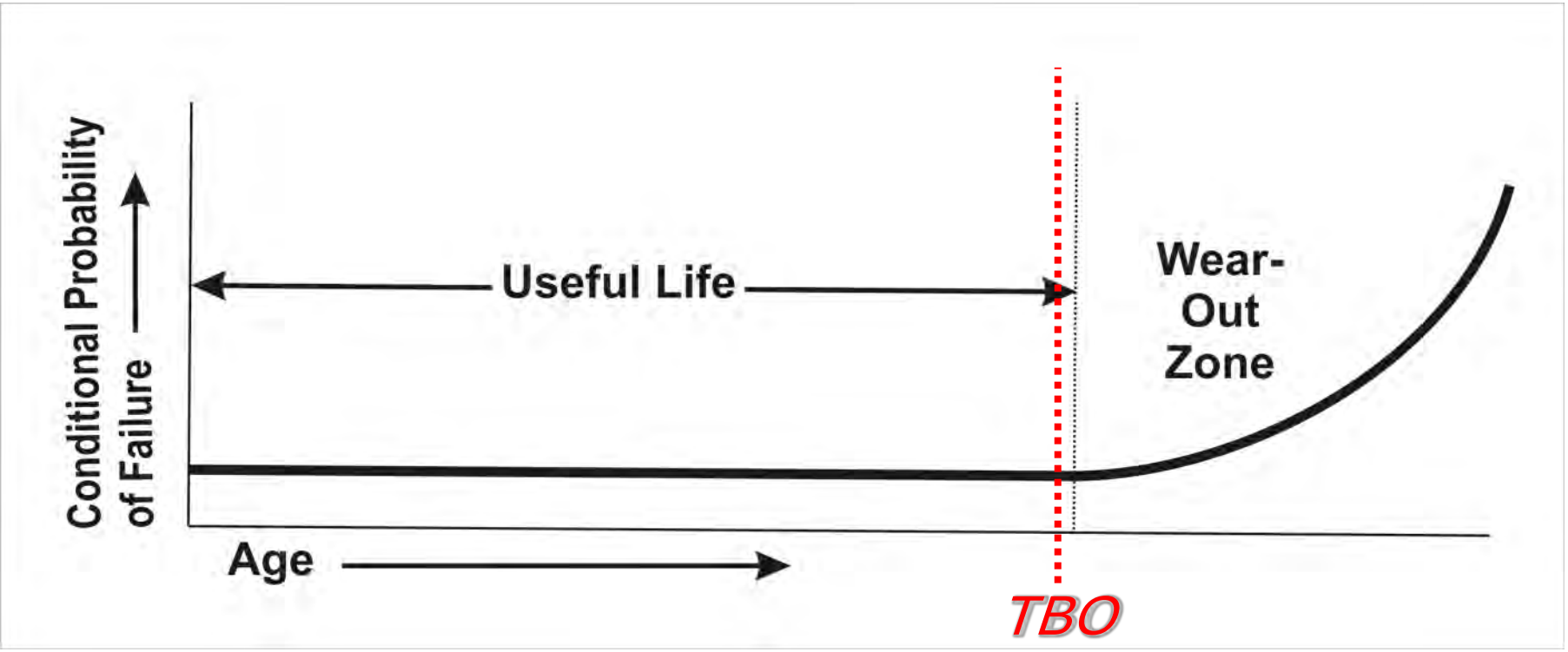
Age-related failures

Traditional view…



Age-related failures

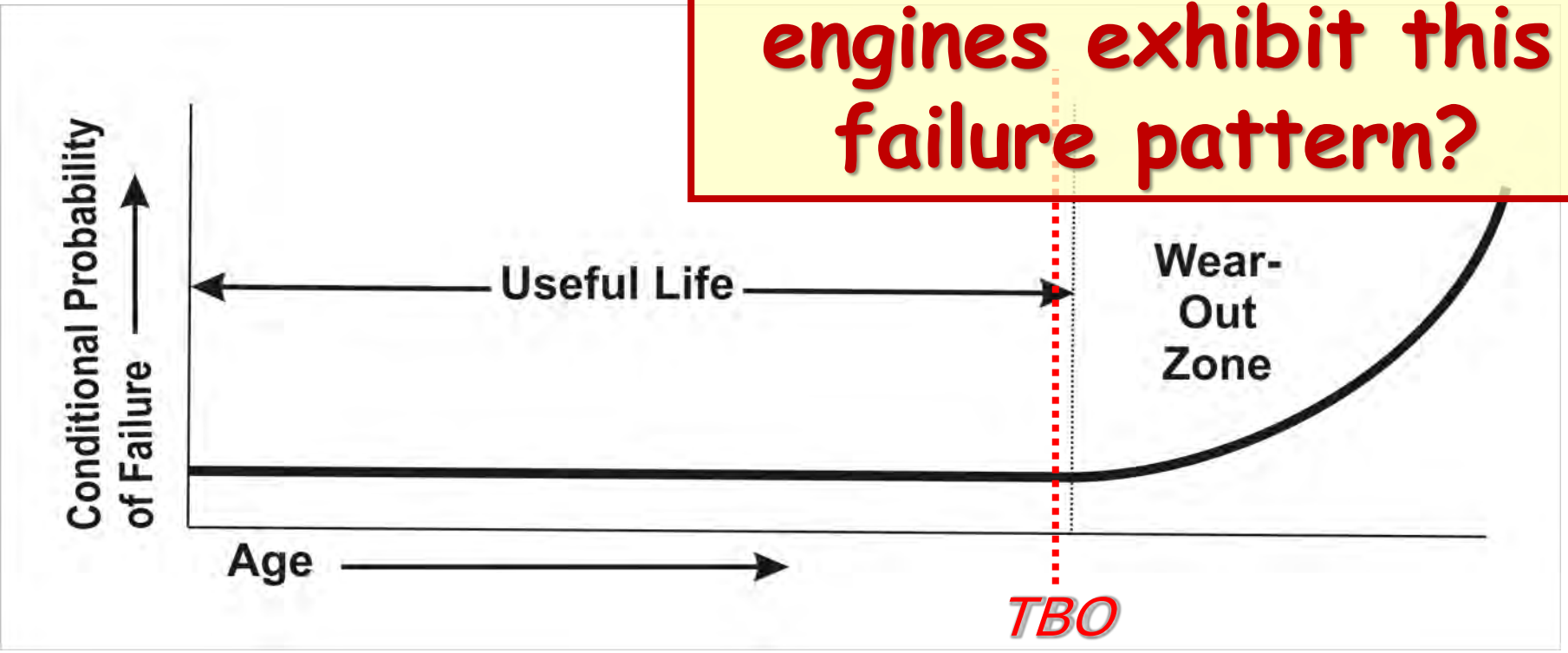
Traditional view…



Age-related failures

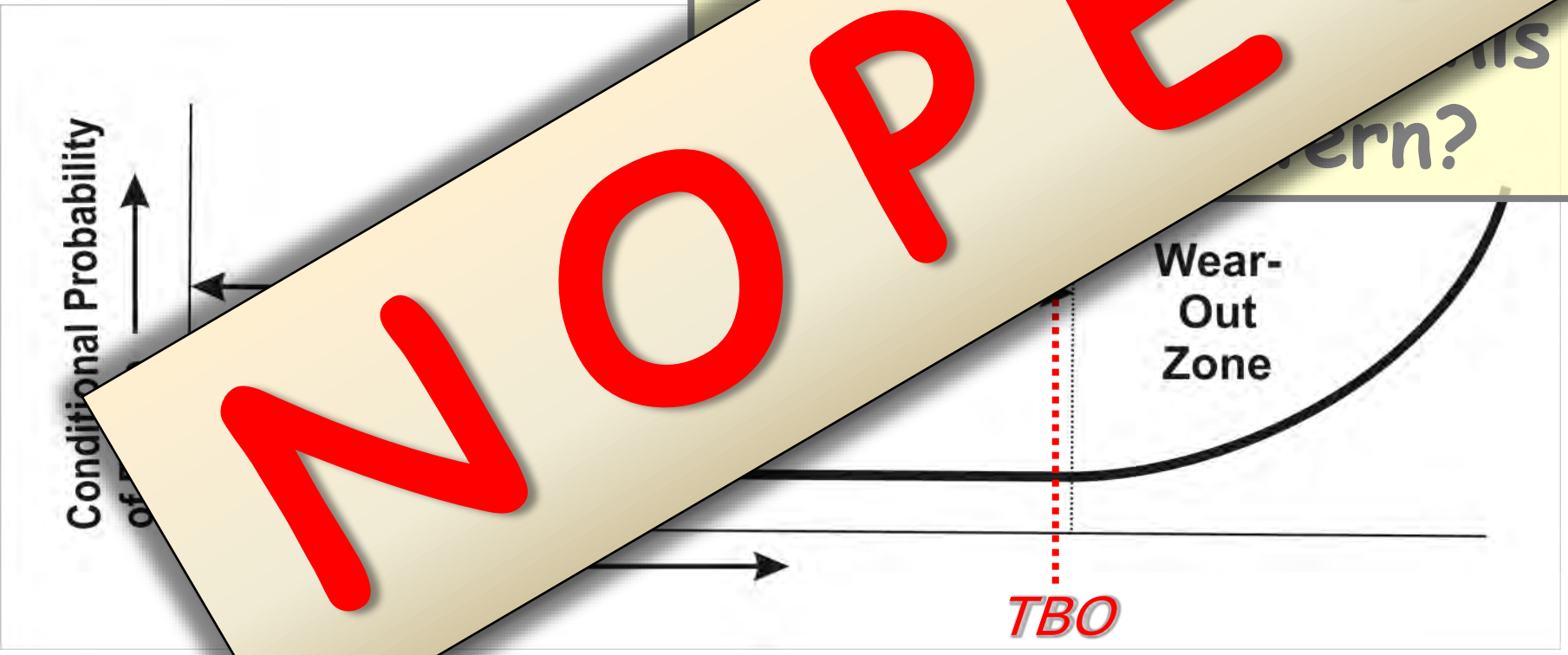
Traditional view...

Do our piston aircraft engines exhibit this failure pattern?



Age-related failu

Traditional view...

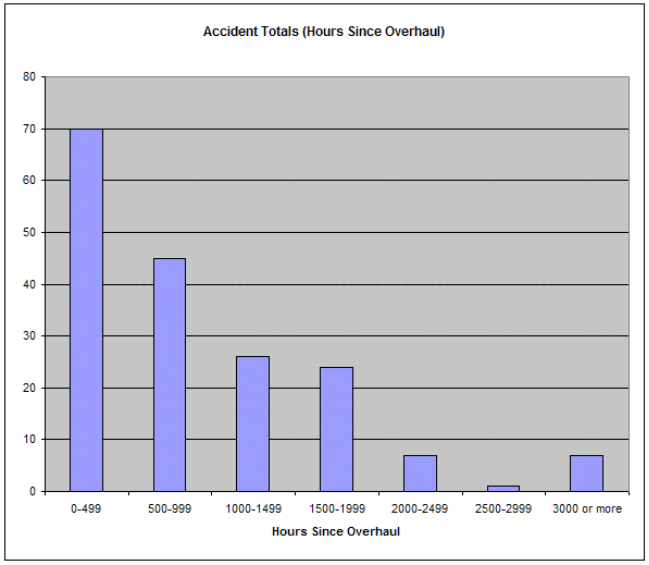


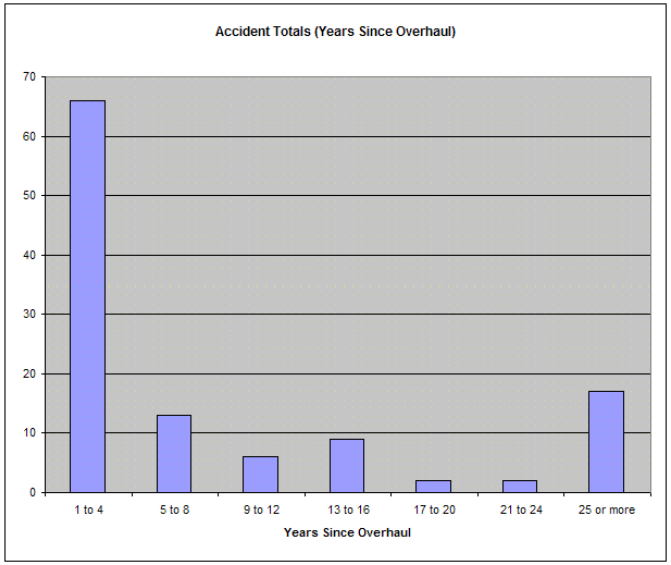
NOPE!

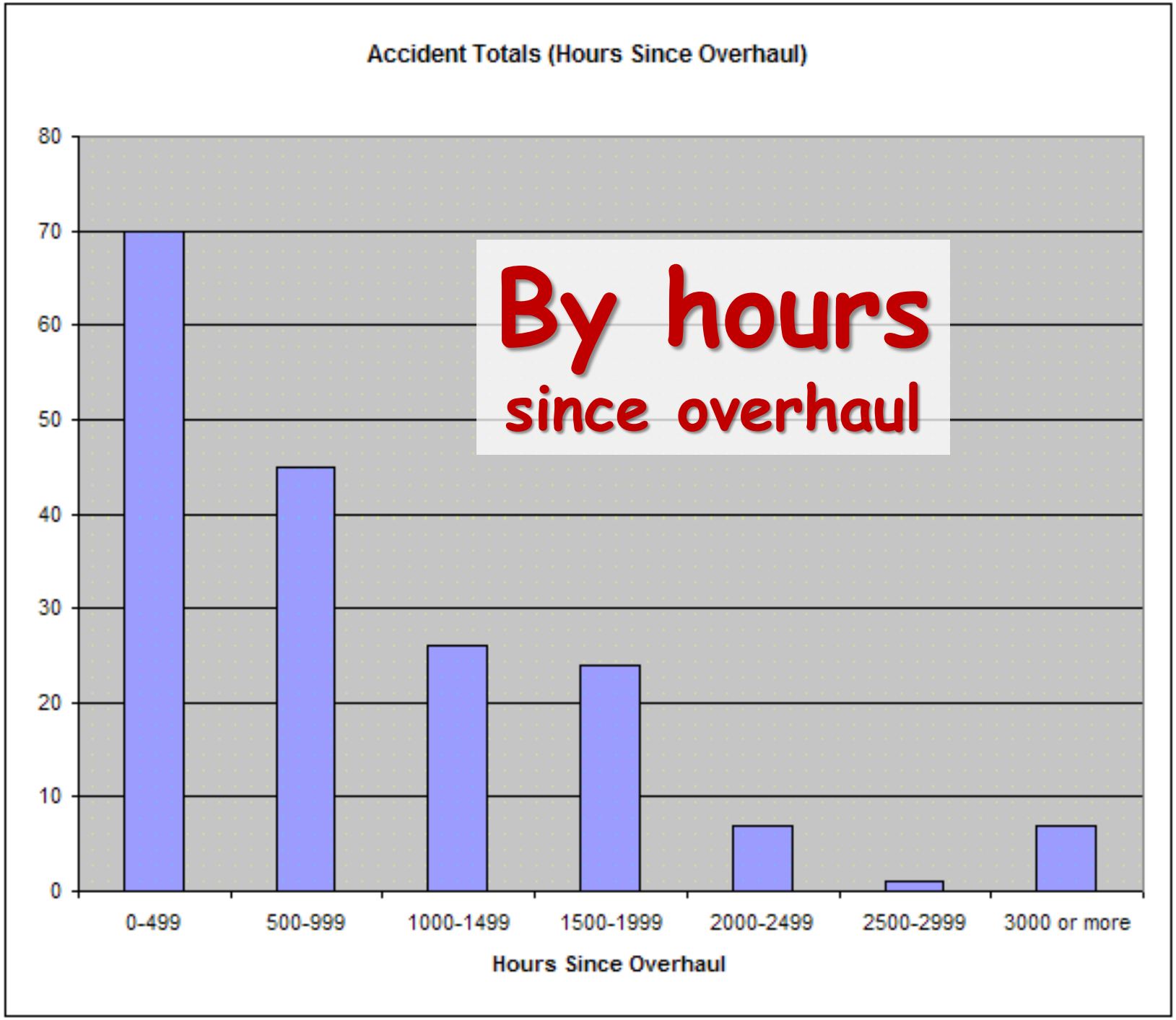
Look at the NTSB accident data…

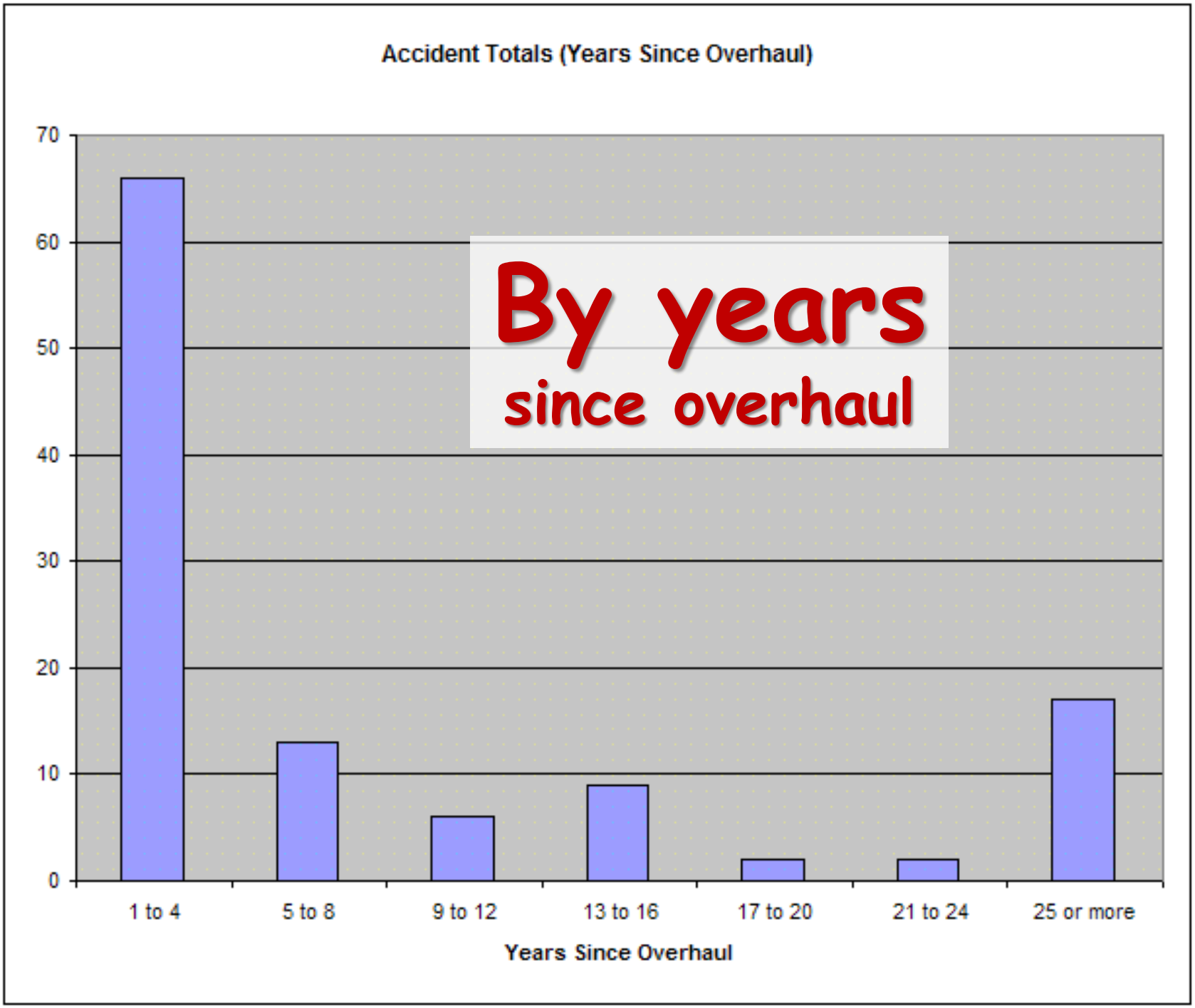
Piston GA engine-failure accidents

2001-2005 small piston airplanes—analysis by Nathan Ulrich, Ph.D.

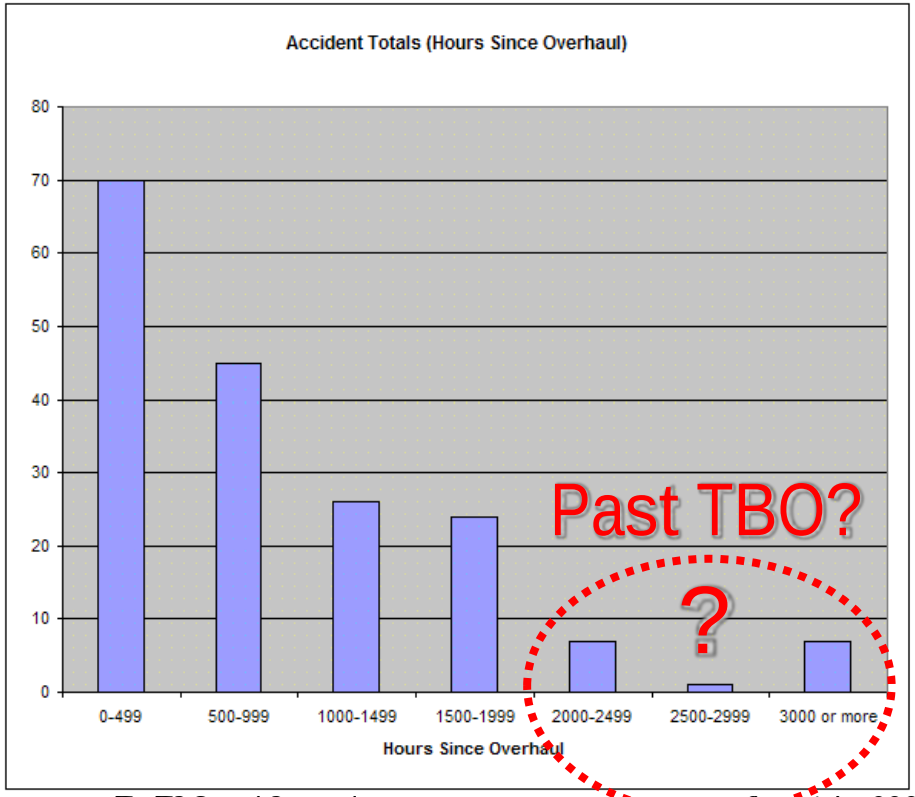


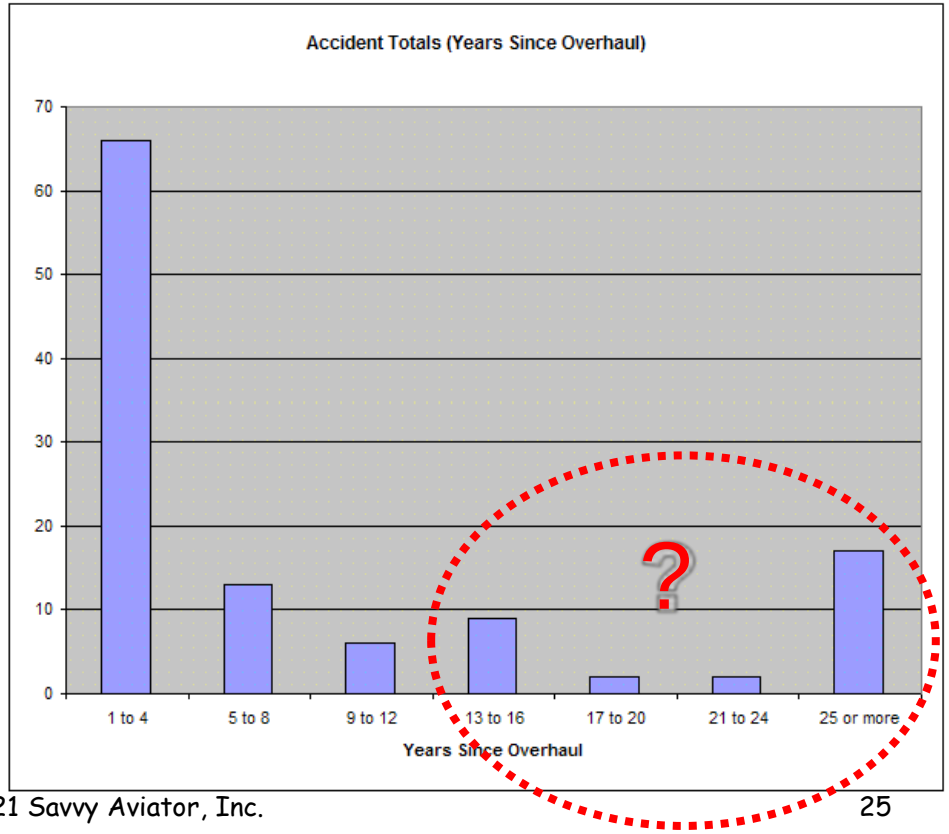



Accident Totals (Hours Since Overhaul)
80
70
60
50
40
30
20
10
0
0-499
500-999
1000-1499
1500-1999
2000-2499
2500-2999
3000 or more
Hours Since Overhaul
By hours
since overhaul

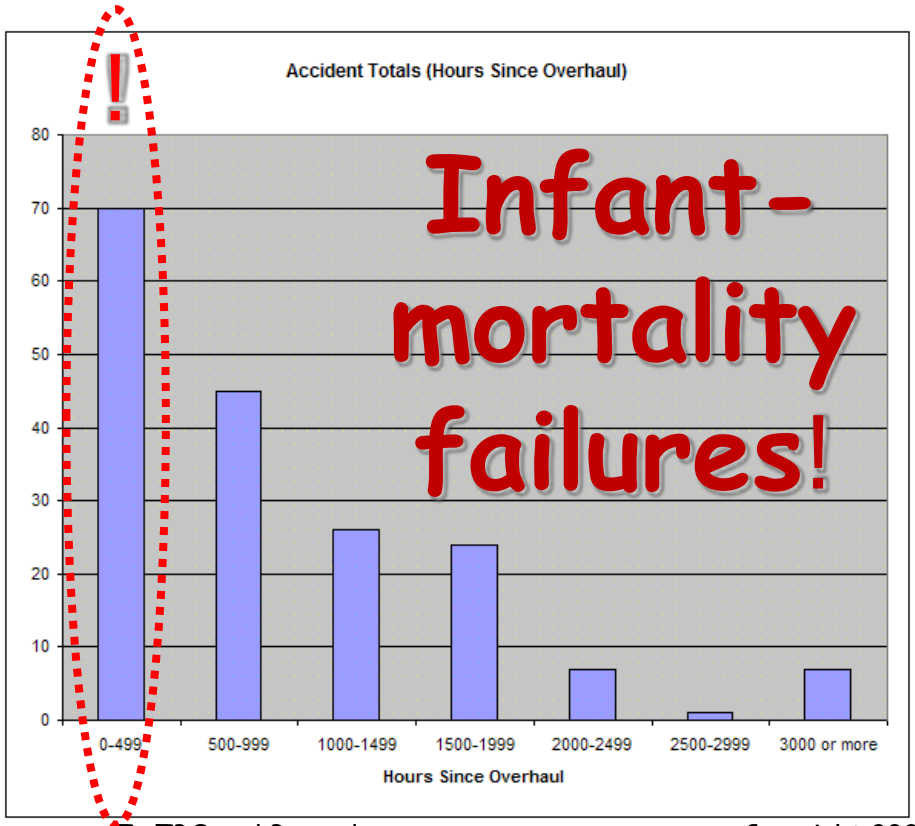

Accident Totals (Years Since Overhaul)
70
60
50
40
30
20
10
0
1 to 4
5 to 8
9 to 12
13 to 16
17 to 20
21 to 24
25 or more
Years Since Overhaul
By years
since overhaul

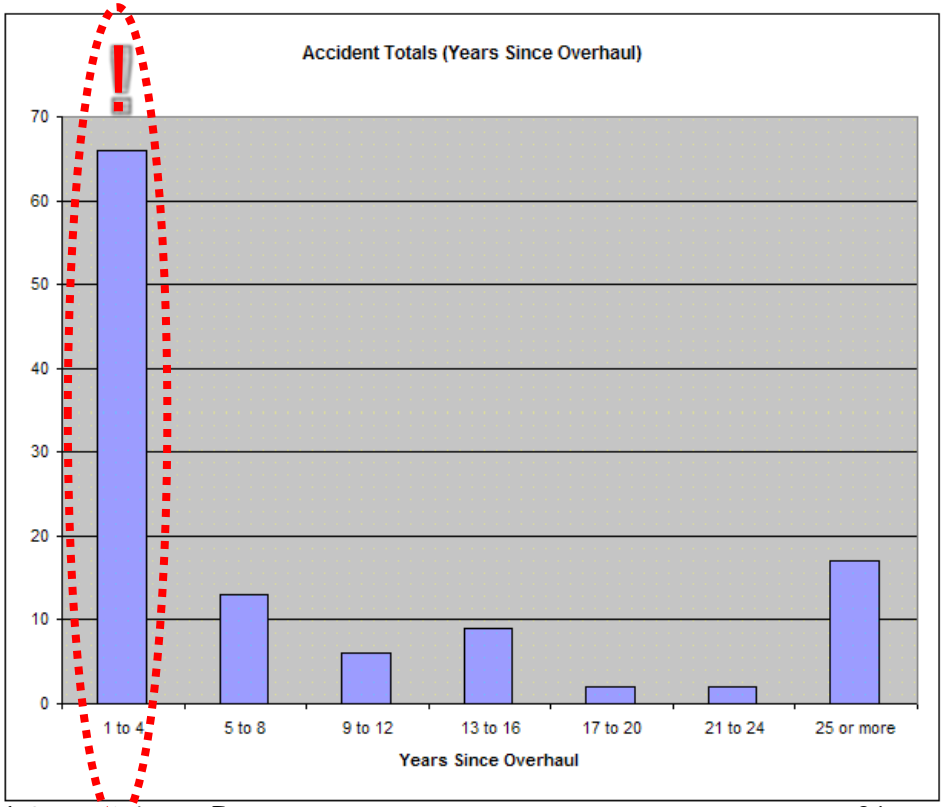
Let's be careful how we interpret this…





Here's what the data tells us for sure…





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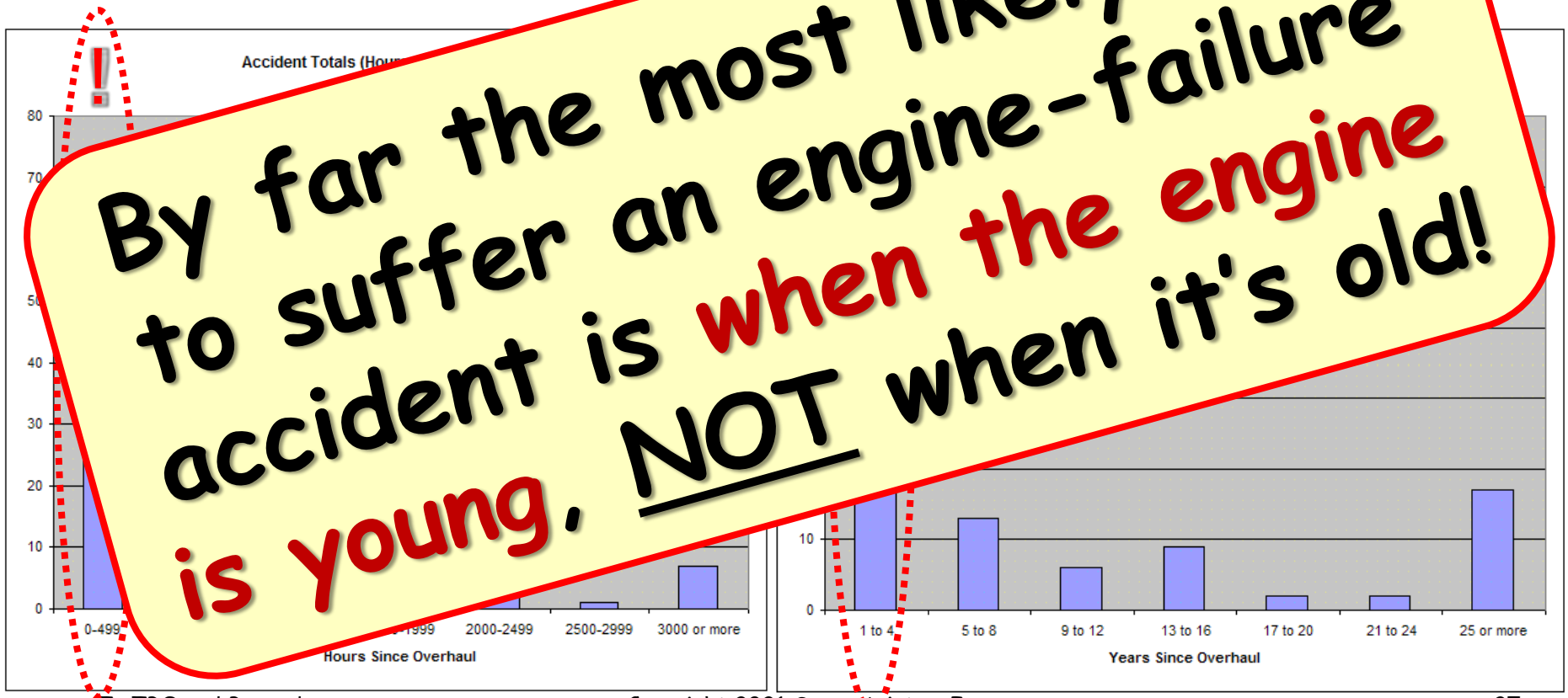
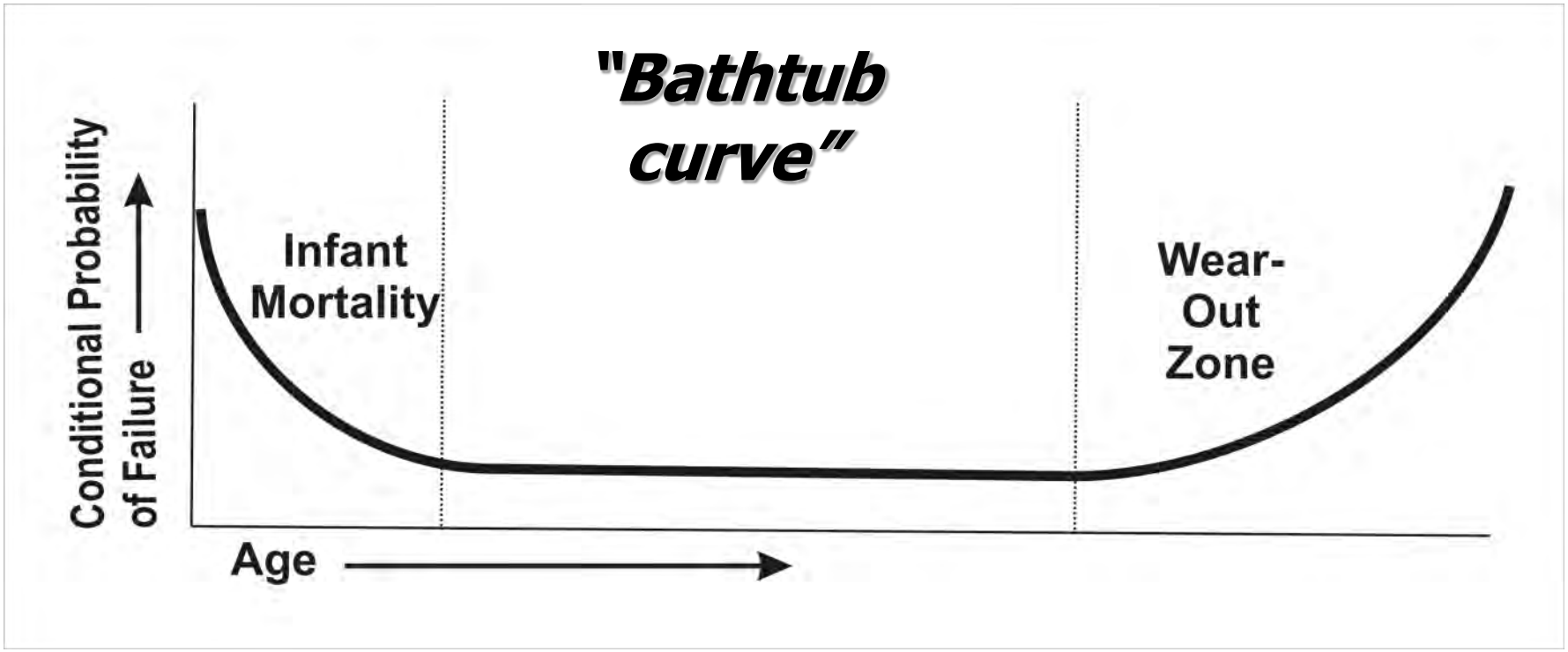


By far the most likely time to suffer an engine-failure accident is when the engine is young, NOT when it's old!

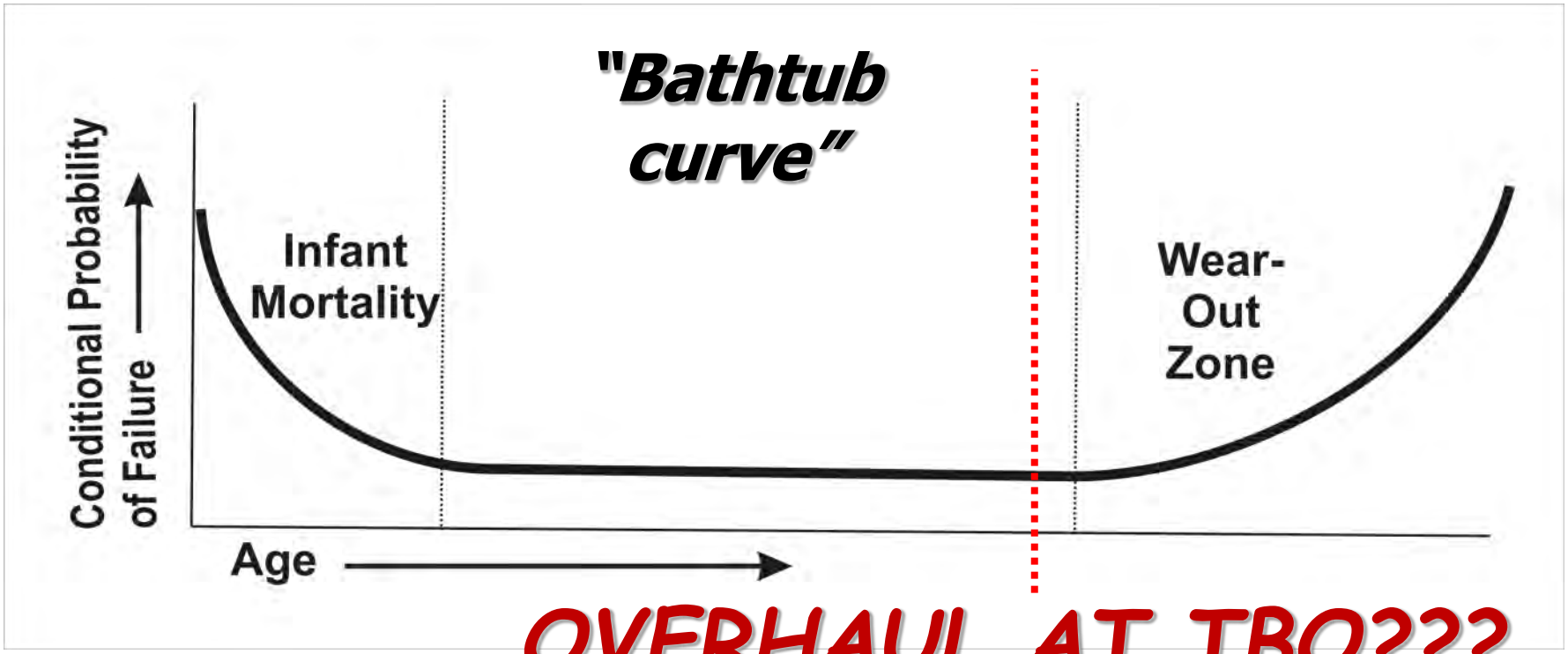
Age-related failures

A more realistic view…



Age-related failures

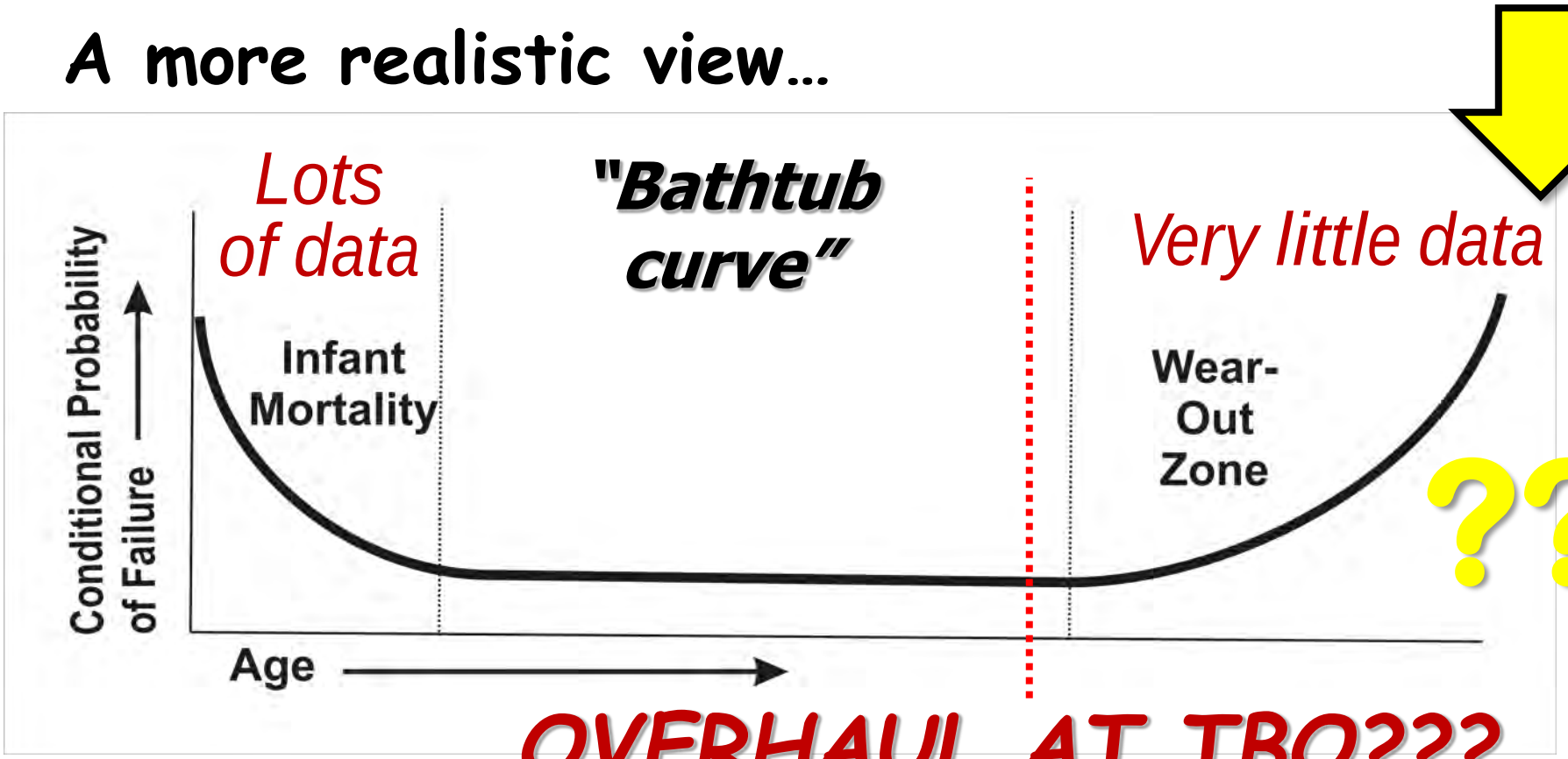
A more realistic view…



OVERHAUL AT TBO???

Age-related failures

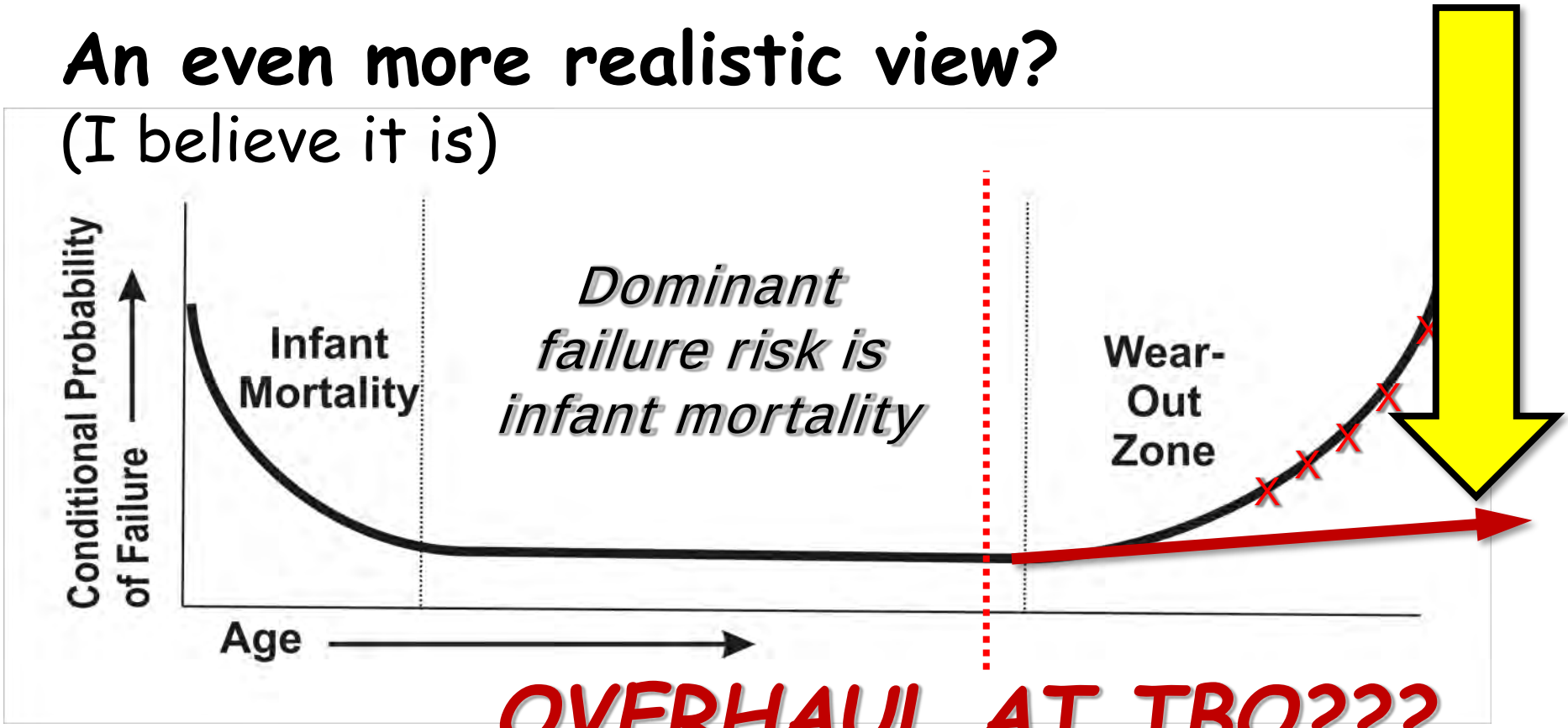
A more realistic view…



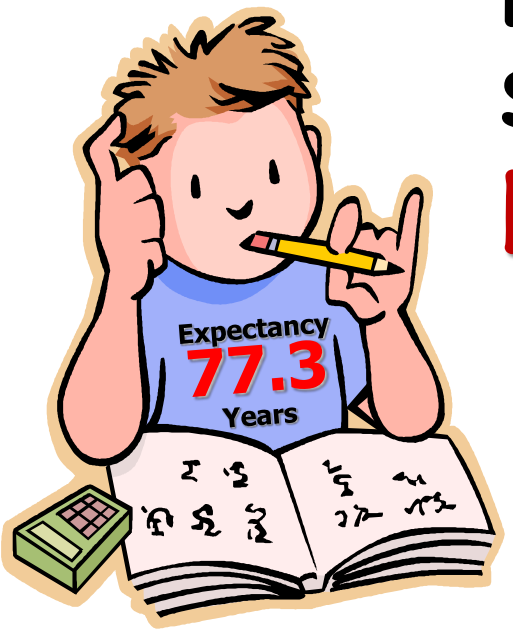
Age-related failures

An even more realistic view?

(I believe it is)

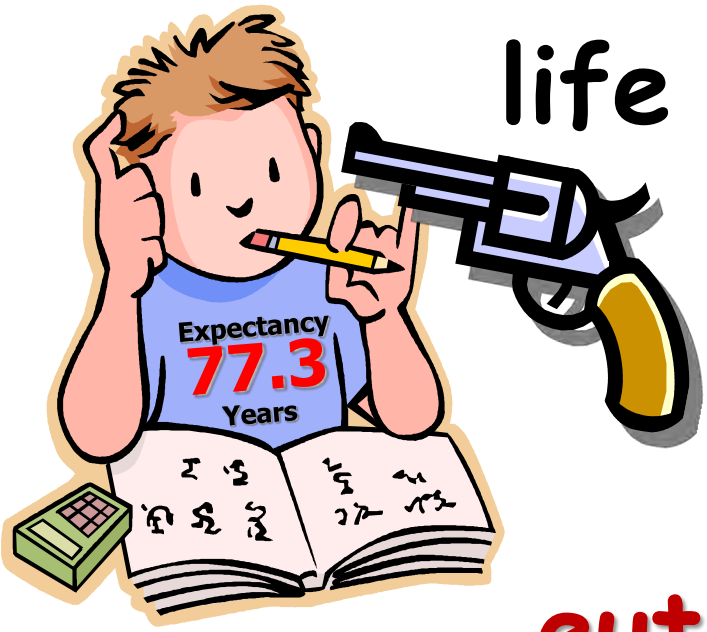


We should think about published TBO in the same way we think about **human life expectancy**



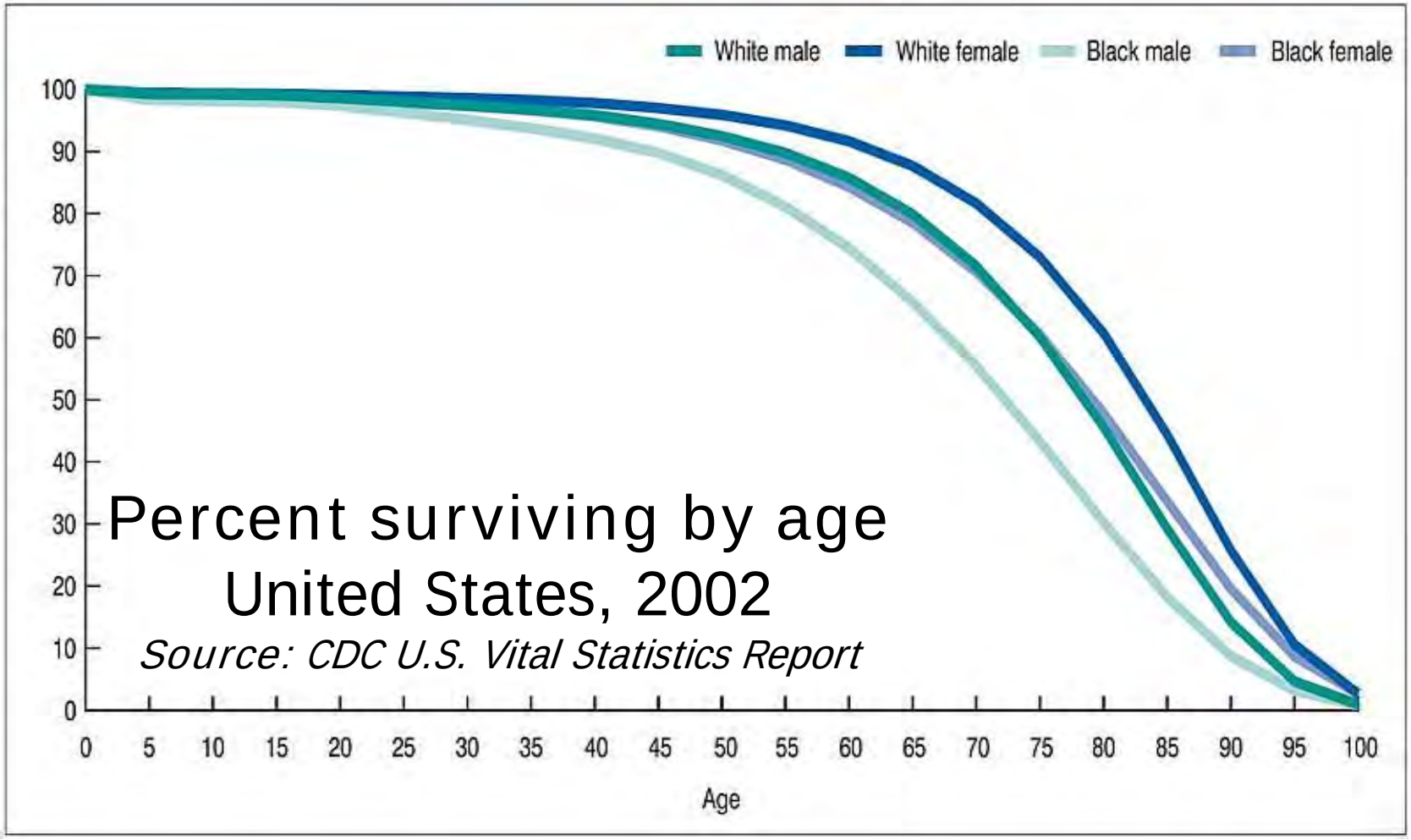
We should use TBO strictly for strategy, and never for tactics

We don't euthanize humans when they've reached their published life expectancy…

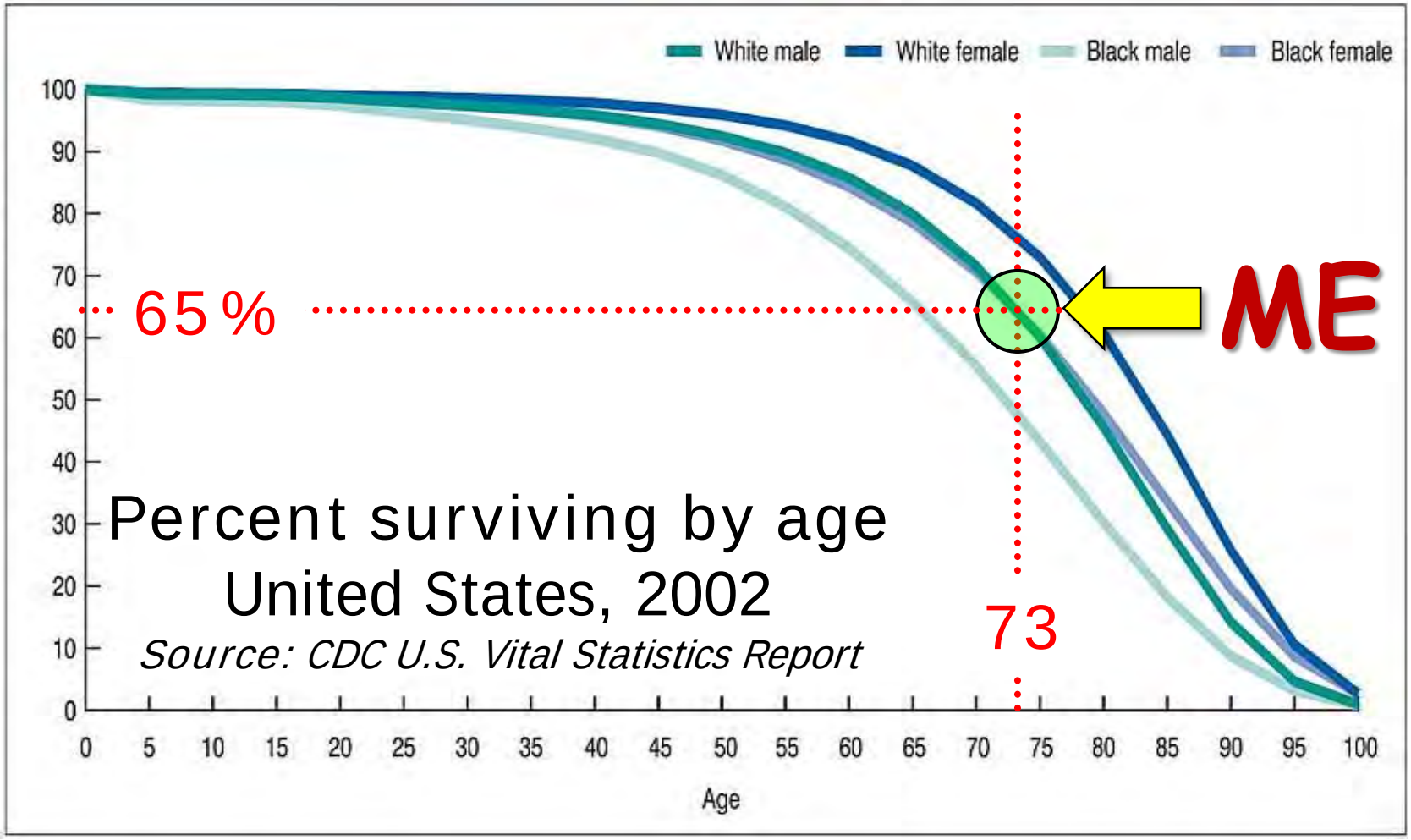


…and we shouldn't be euthanizing engines when they reach TBO, either!

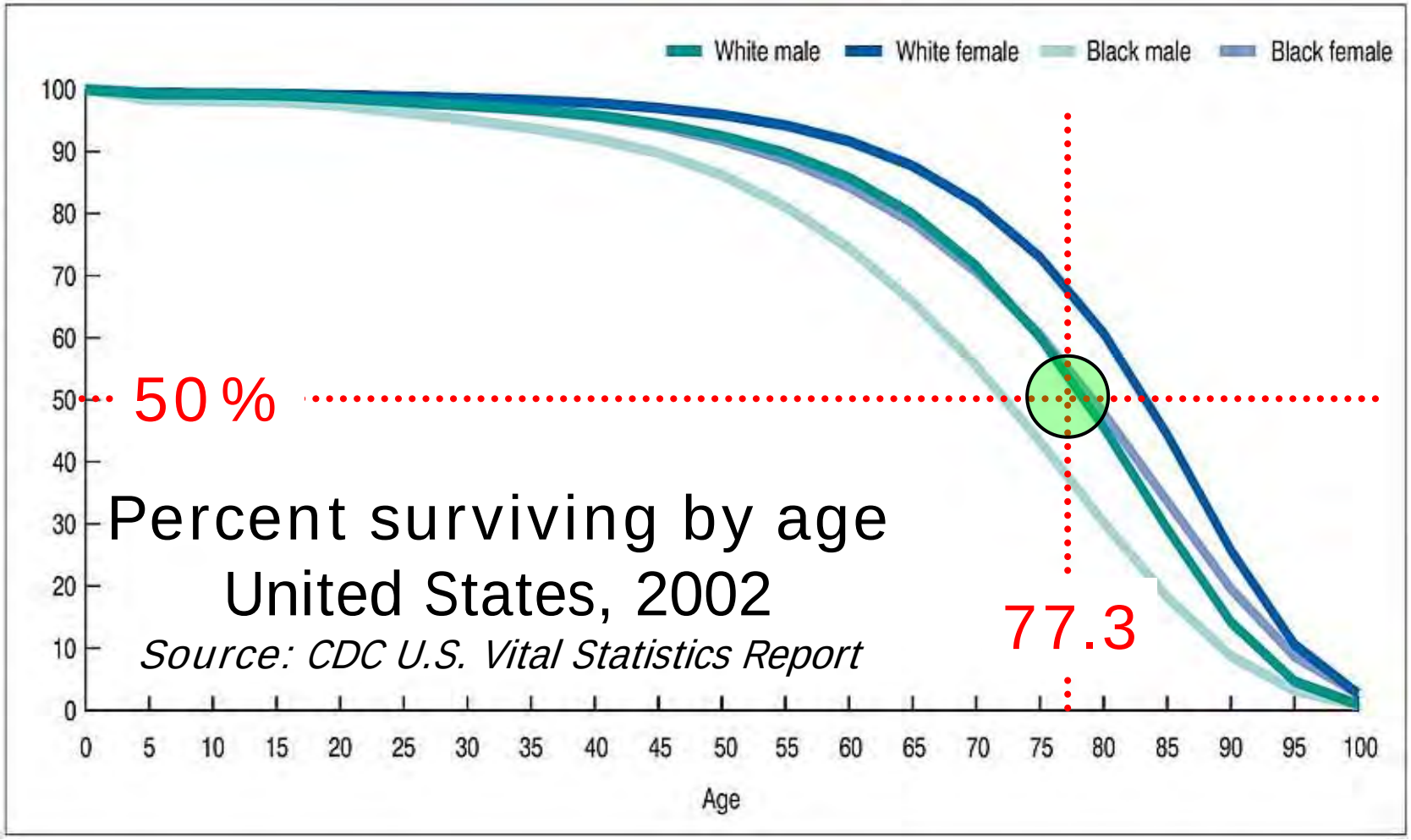
Human life expectancy



Human life expectancy



Human mean life expectancy



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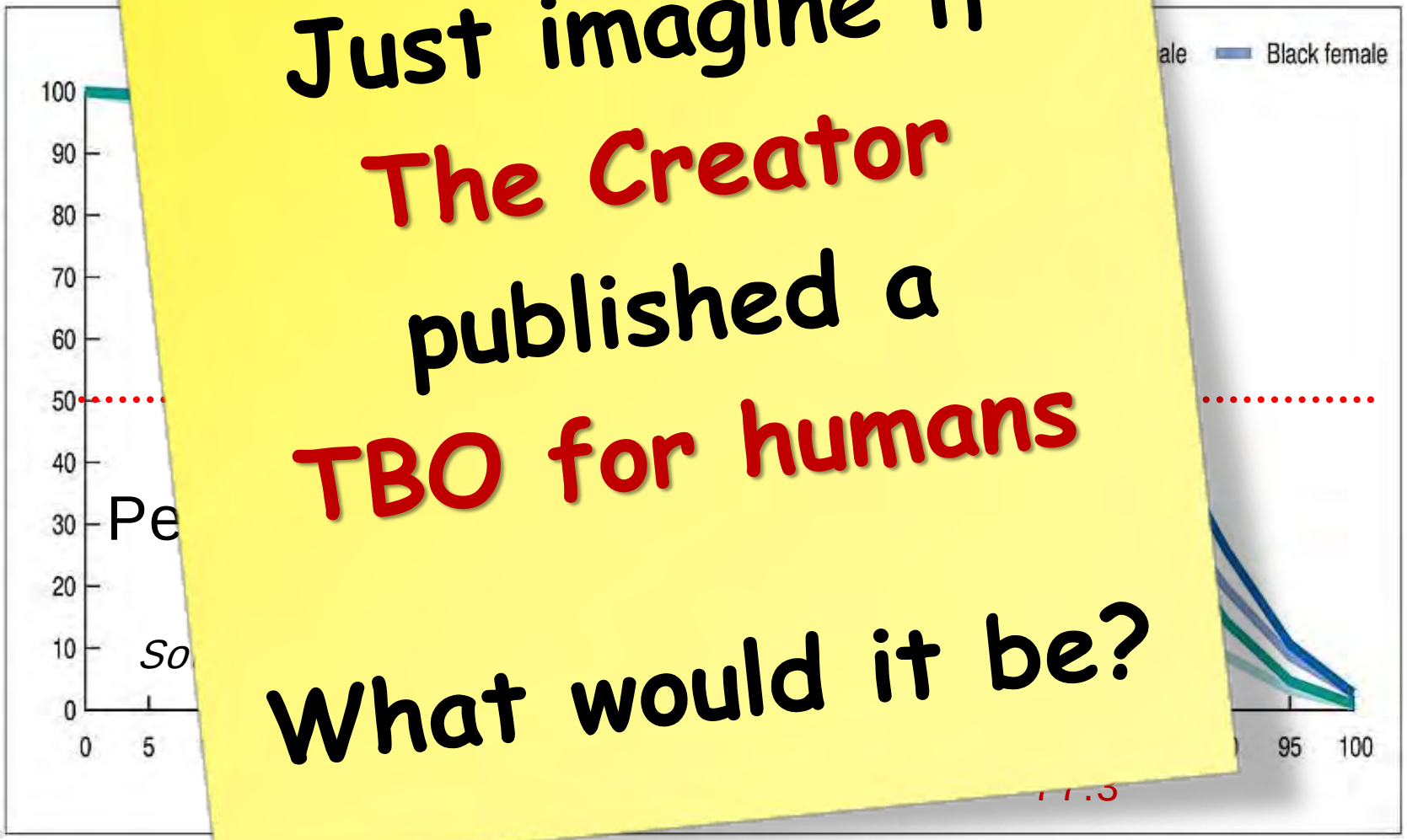


Just imagine if

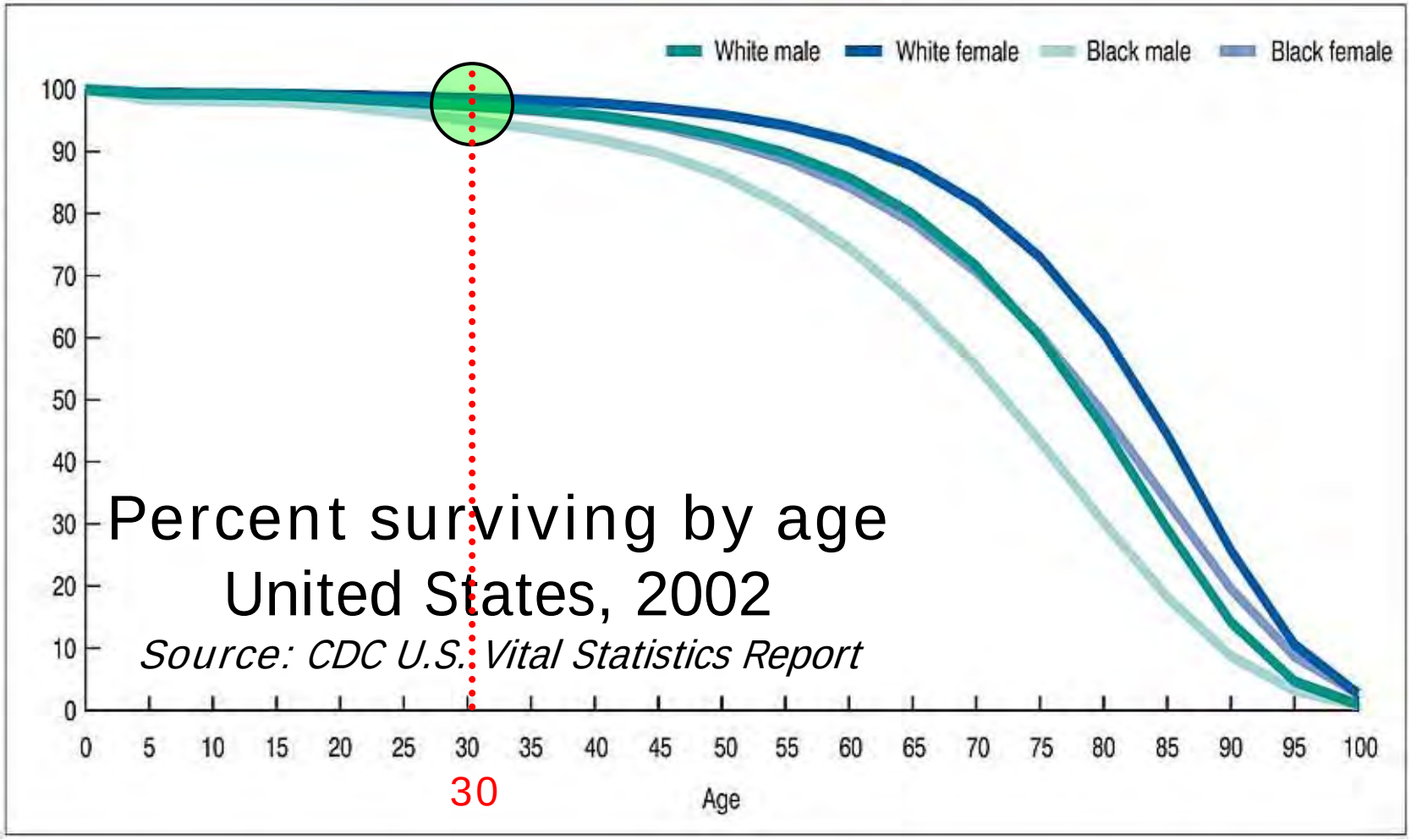
The Creator

published a

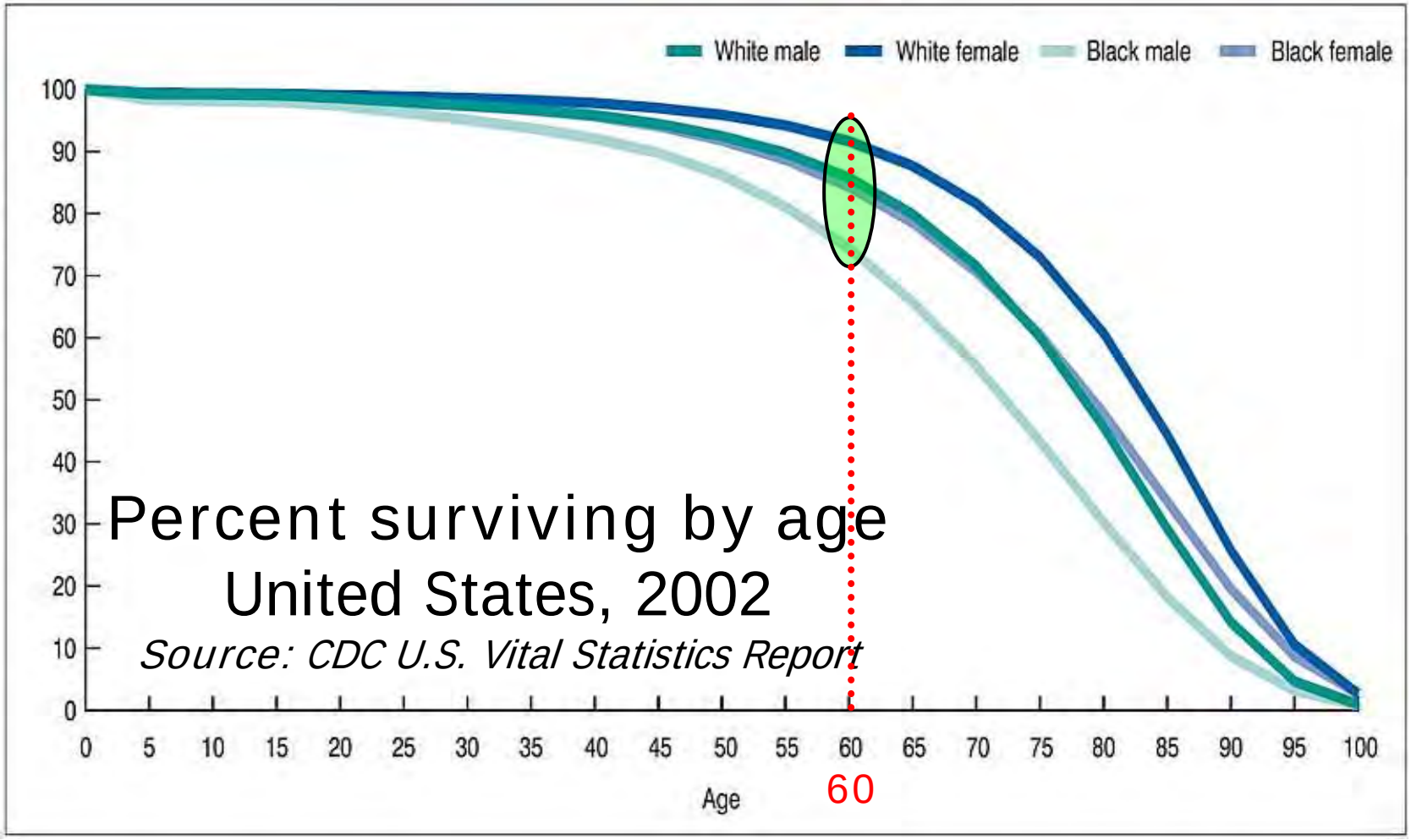
TBO for humans

What would it be?

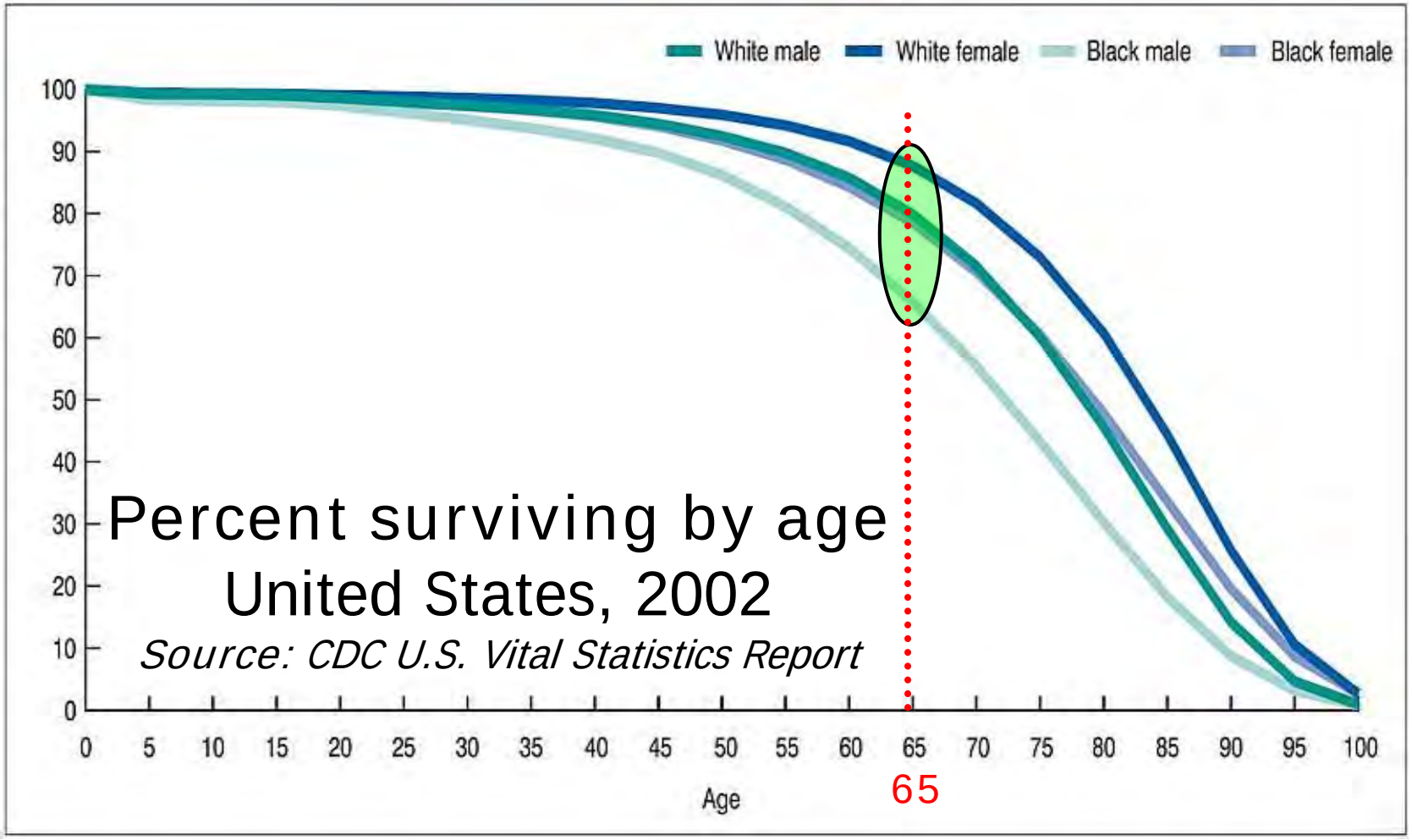
Sci-Fi TBO (Logan's Run)



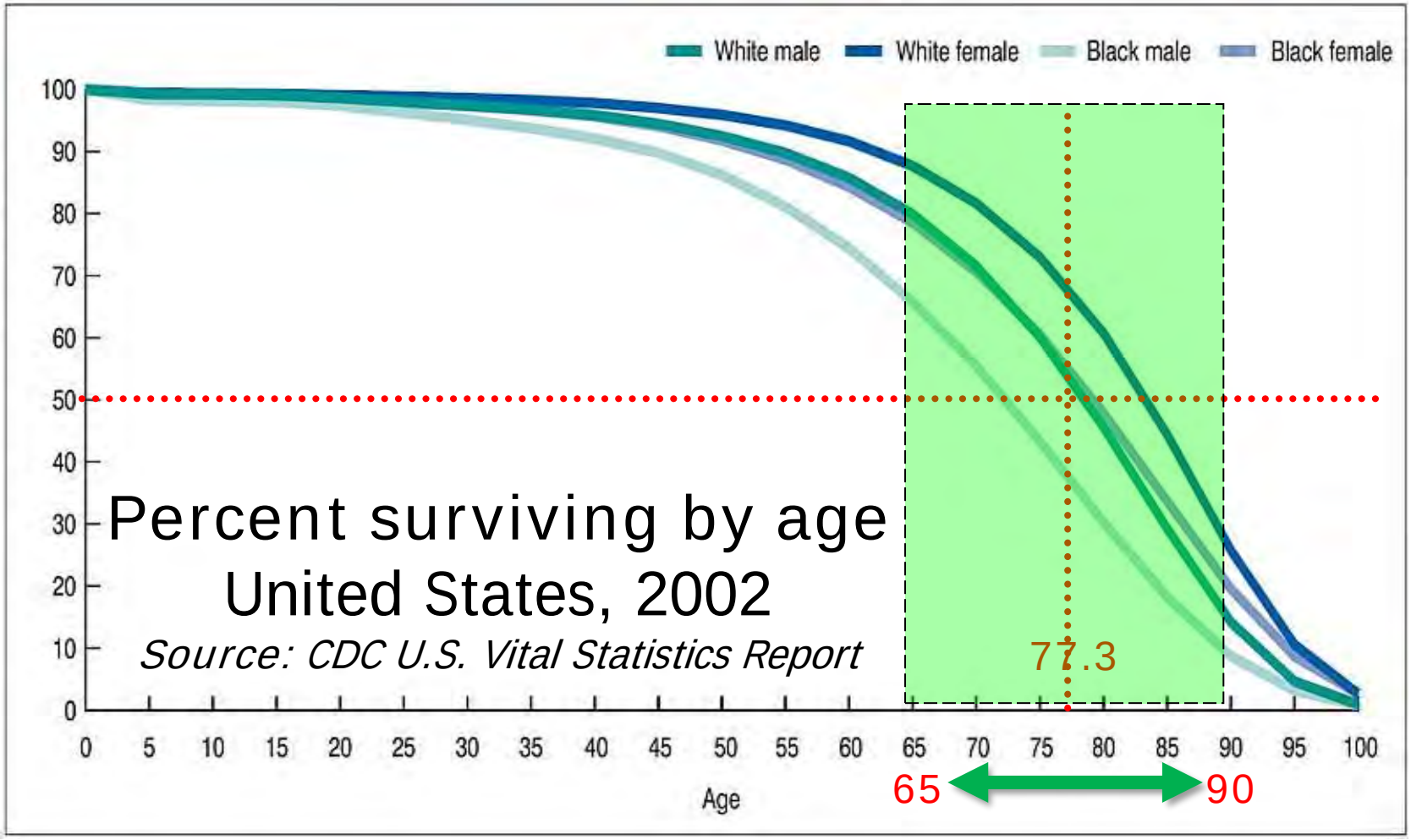
Airline Pilot TBO (before 2007)



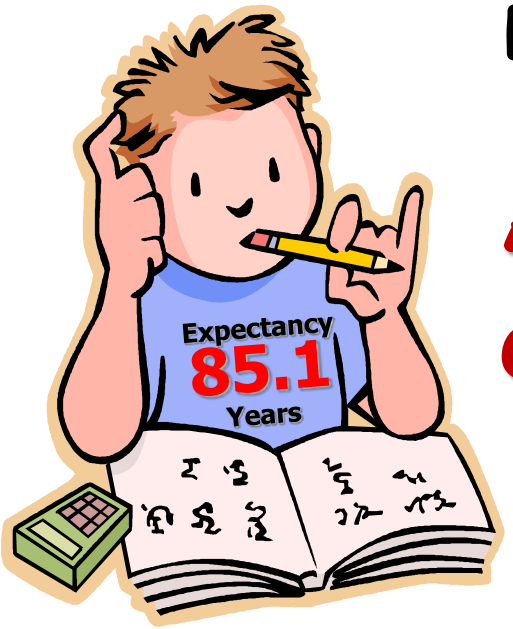
Airline Pilot TBO (after 2007)



"Normal" life expectancy



Also keep in mind that human life expectancy isn't a static figure:



As we get older, our life expectancy increases…

…and the same principle should apply to engines!

Age	All races		
	Total	Male	Female
0	77.3	74.5	79.9
1	76.8	74.1	79.4
5	72.9	70.2	75.4
10	67.9	65.3	70.5
15	63.0	60.3	65.5
20	58.2	55.6	60.7
25	53.5	51.0	55.8
30	48.7	46.3	51.0
35	44.0	41.6	46.1
40	39.3	37.0	41.4
45	34.8	32.6	36.7
50	30.3	28.3	32.2
55	26.1	24.1	27.7
60	22.0	20.2	23.5
65	18.2	16.6	19.5
70	14.7	13.2	15.8
75	11.5	10.3	12.4
80	8.8	7.8	9.4
85	6.5	5.7	6.9
90	4.8	4.2	5.0
95	3.6	3.2	3.7
100	2.7	2.5	2.8

Life expectancy AT BIRTH is about 77 years

Age	All races		
	Total	Male	Female
0	77.3	74.5	79.9
1	76.8	74.1	79.4
5	72.9	70.2	75.4
10	67.9	65.3	70.5
15	63.0	60.3	65.5
20	58.2	55.6	60.7
25	53.5	51.0	55.8
30	48.7	46.3	51.0
35	44.0	41.6	46.1
40	39.3	37.0	41.4
45	34.8	32.6	36.7
50	30.3	28.3	32.2
55	26.1	24.1	27.7
60	22.0	20.2	23.5
65	18.2	16.6	19.5
70	14.7	13.2	15.8
75	11.5	10.3	12.4
80	8.8	7.8	9.4
85	6.5	5.7	6.9
90	4.8	4.2	5.0
95	3.6	3.2	3.7
100	2.7	2.5	2.8

If you reach 77 you'll probably live to age 87

Age	All races		
	Total	Male	Female
0	77.3	74.5	79.9
1	76.8	74.1	79.4
5	72.9	70.2	75.4
10	67.9	65.3	70.5
15	63.0	60.3	65.5
20	58.2	55.6	60.7
25	53.5	51.0	55.8
30	48.7	46.3	51.0
35	44.0	41.6	46.1
40	39.3	37.0	41.4
45	34.8	32.6	36.7
50	30.3	28.3	32.2
55	26.1	24.1	27.7
60	22.0	20.2	23.5
65	18.2	16.6	19.5
70	14.7	13.2	15.8
75	11.5	10.3	12.4
80	8.8	7.8	9.4
85	6.5	5.7	6.9
90	4.8	4.2	5.0
95	3.6	3.2	3.7
100	2.7	2.5	2.8

If you reach 87 you'll probably live to age 92

If published "TBO at birth" for your Lycoming IO-360 is 2,000 hours, and it reaches 2,000 hours a still seems to be in good health, what is its remaining life expectancy?

If published "TBO at birth" for your Lycoming IO-360 is 2,000 hours, and it reaches 2,000 hours a still seems to be in good health, what is its remaining life expectancy?

Lycoming says <u>zero</u>… Really?

How to use TBO

Appropriate use: strategic

- To plan reserve for overhaul
- To adjust appraised value

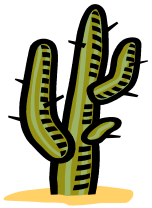
Inappropriate use: tactical

- Never "euthanize" an engine because it has reached some number of hours or years in service…that's crazy!
- Monitor engine health and overhaul strictly "on condition"

What makes our engines wear out?

Rust

Cold starts



Dry starts

Dirt

High CHTs

Rust is enemy #1

for piston aircraft engines

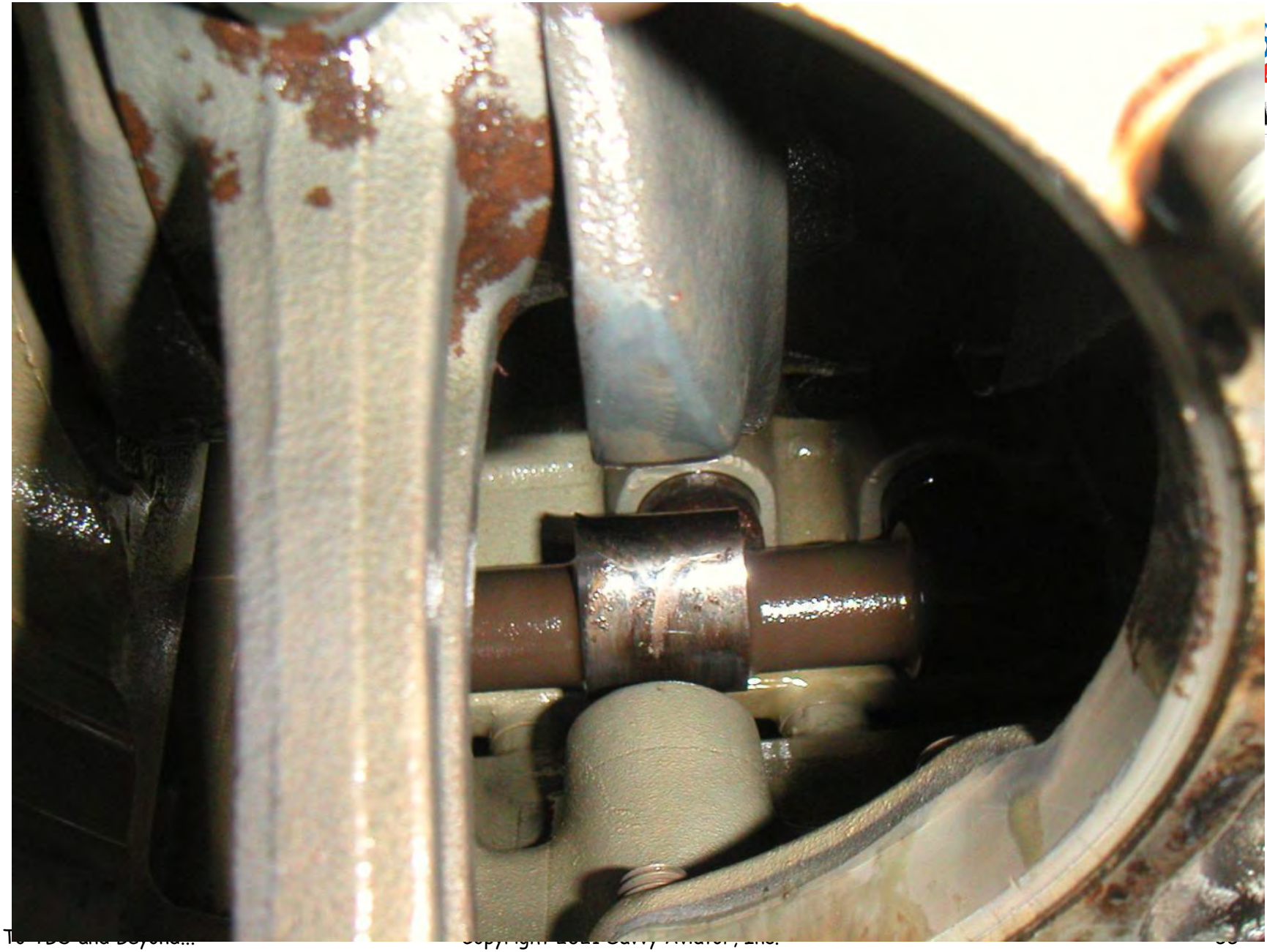
Rust is enemy #1

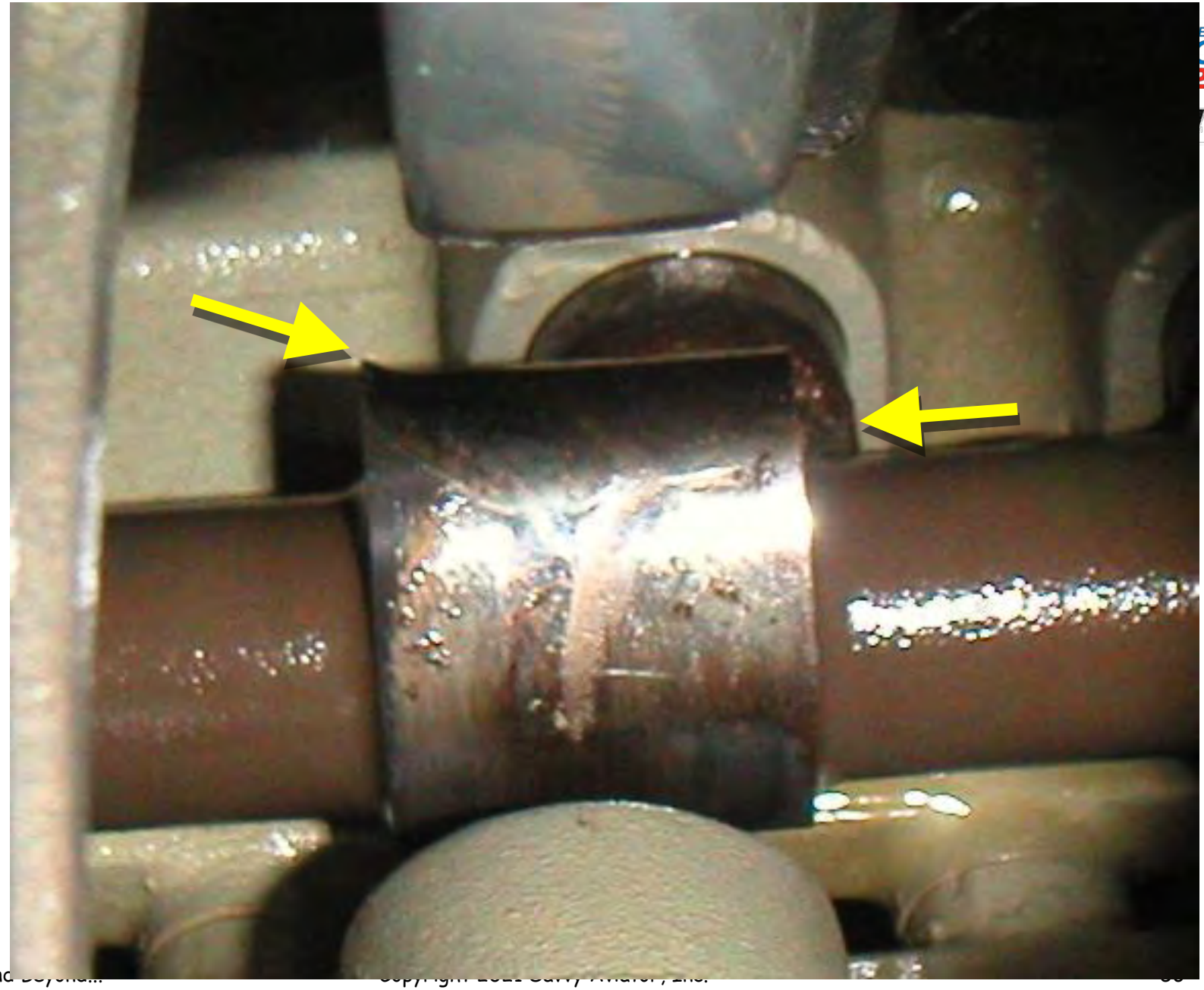
for piston aircraft engines

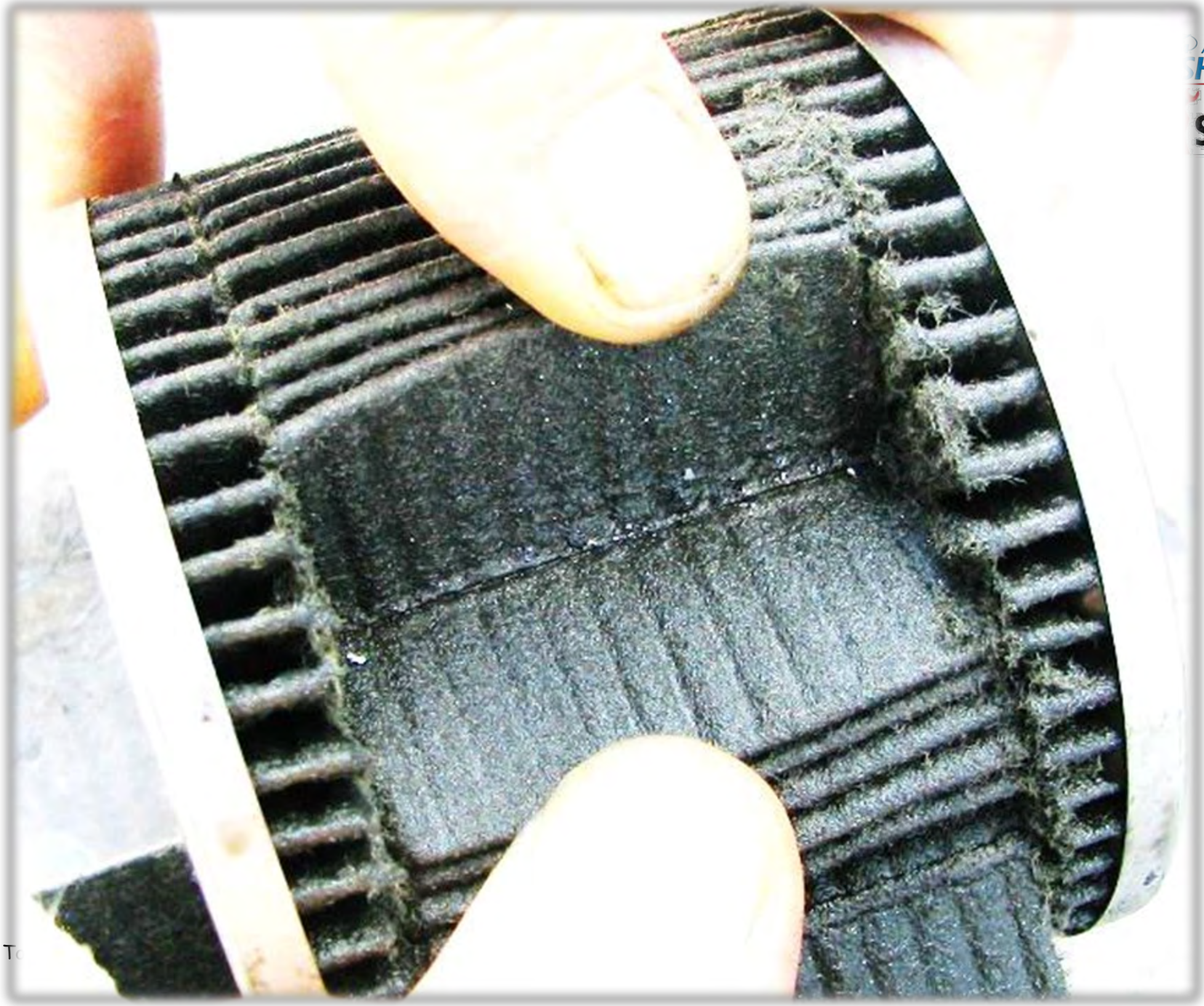
It's the #1 reason engines don't make TBO

Primarily affects owner-flown fleet due to irregular usage

Damages steel parts like cylinders, cams and lifters







How to prevent rust

Live in ABQ, DEN, or PHX…

-OR-

Fly regularly (weekly/biweekly)

Hangar your aircraft

"Pickle" if not flying for >30 days

Choose **oil and additives** wisely

What oil to use?

I recommend single-weight oil…

- …if you don't fly at least weekly
- …if you're based in a humid or coastal climate
- …if your aircraft isn't hangared

In cold climates

where sub-freezing unpreheated cold starts are an issue, use a multiviscosity during cold-weather months of the year

I use and recommend **ASL CamGuard** for enhanced rust protection

I recommend AGAINST using synthetic or semi-synthetic oil

(e.g., Aeroshell 15W-50)
in any engine that
runs on 100LL

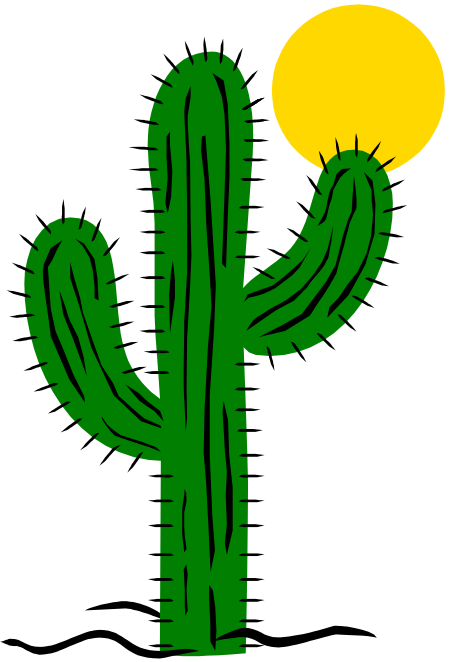
Especially for big engines
with small sump capacity
(8 quarts or less)

I recommend AGAINST using synthetic or semi-s oil (e.g., Aer in ar runs

Especi engines with sump capacity (8 quarts or less)

Check out my free 90-minute EAA webinar "All About Oil" at www.eaa.org/webinars

Dry starts are bad



Most engine wear occurs during the first 30 seconds after start

Mostly affects owner-flown fleet

Pre-oiler helps, but only a little

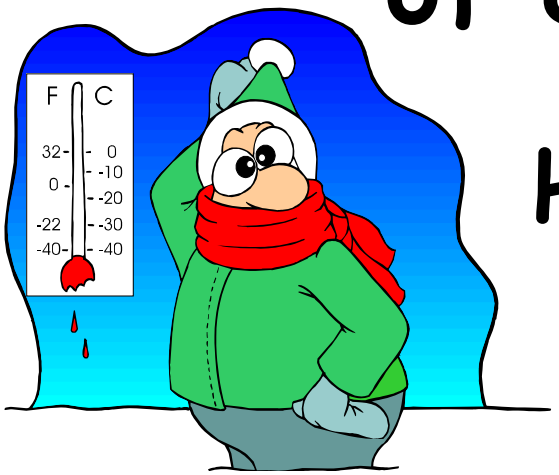
Cam and cylinders are splash-oiled

Think "cycles" … not "hours"

Don't start unless you're going to fly

Cold starts are bad

One cold start can cause more wear than 500 hours of cruise flight!



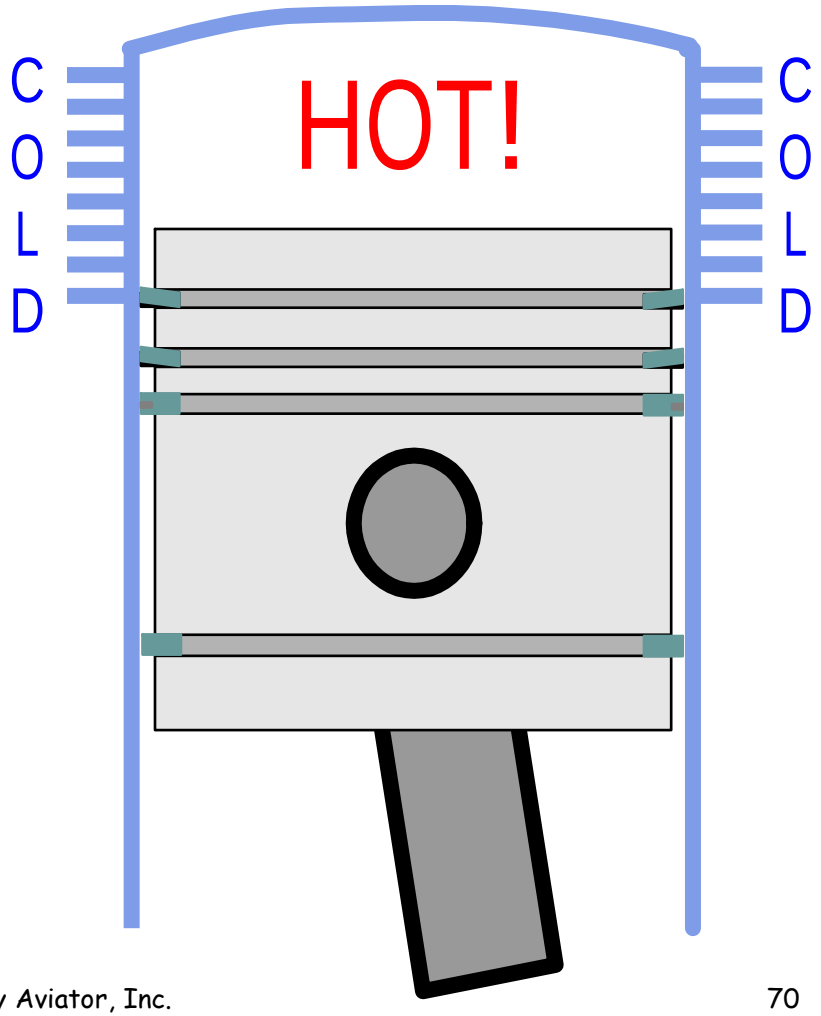
How cold is cold?

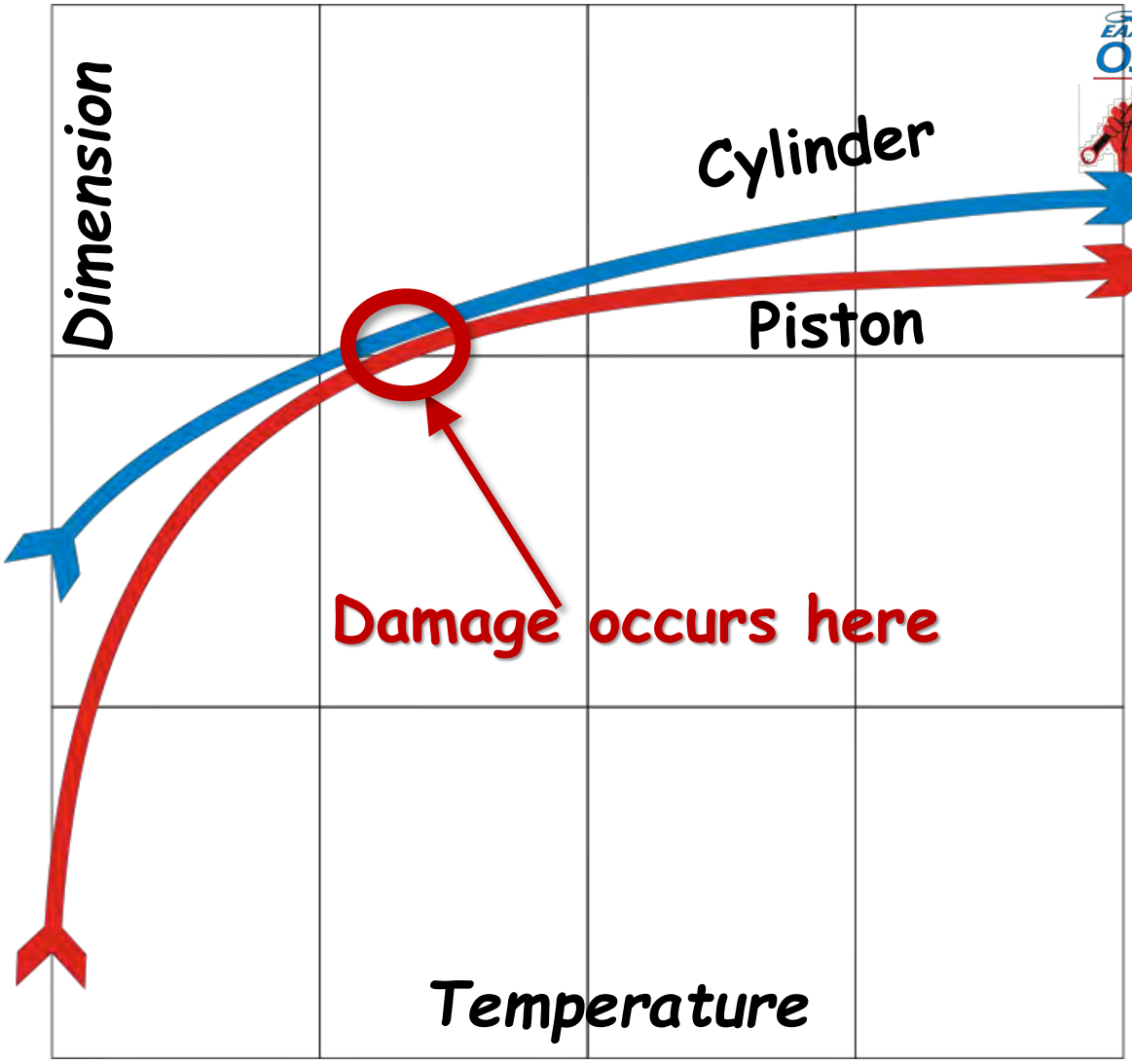
- < 32°F w/o preheat → misdemeanor
- < 20°F w/o preheat → felony

Oil pressure is <u>not</u> enough!

Aluminum piston expands twice as fast as steel cylinder…

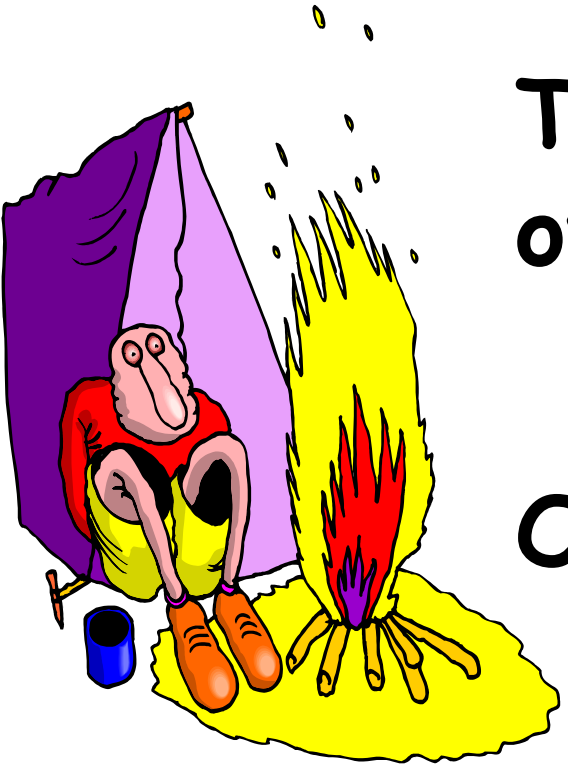
…and heats up a lot faster after a cold engine start.





COLD → → → HOT

If it's cold, preheat!



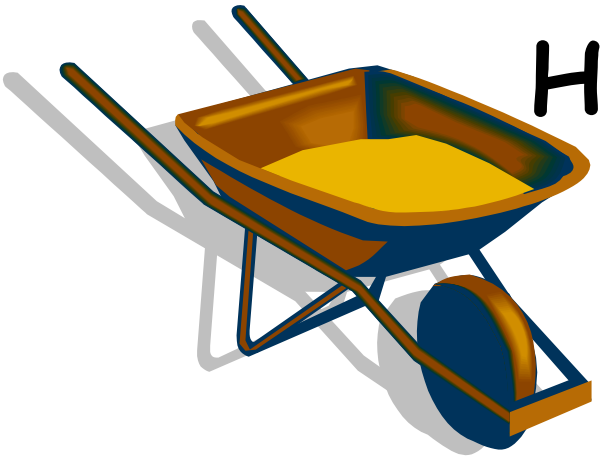
The best preheat method is overnight in a heated hangar

It's well worth the $50 IMHO

Other methods include

- Electric heater (Tanis, Reiff, etc.)
- Light bulbs and blankets
- Forced hot air
- Sleeping in late (my favorite)

Dirt is bad



Dirt+oil → grinding compound

How dirt gets in:

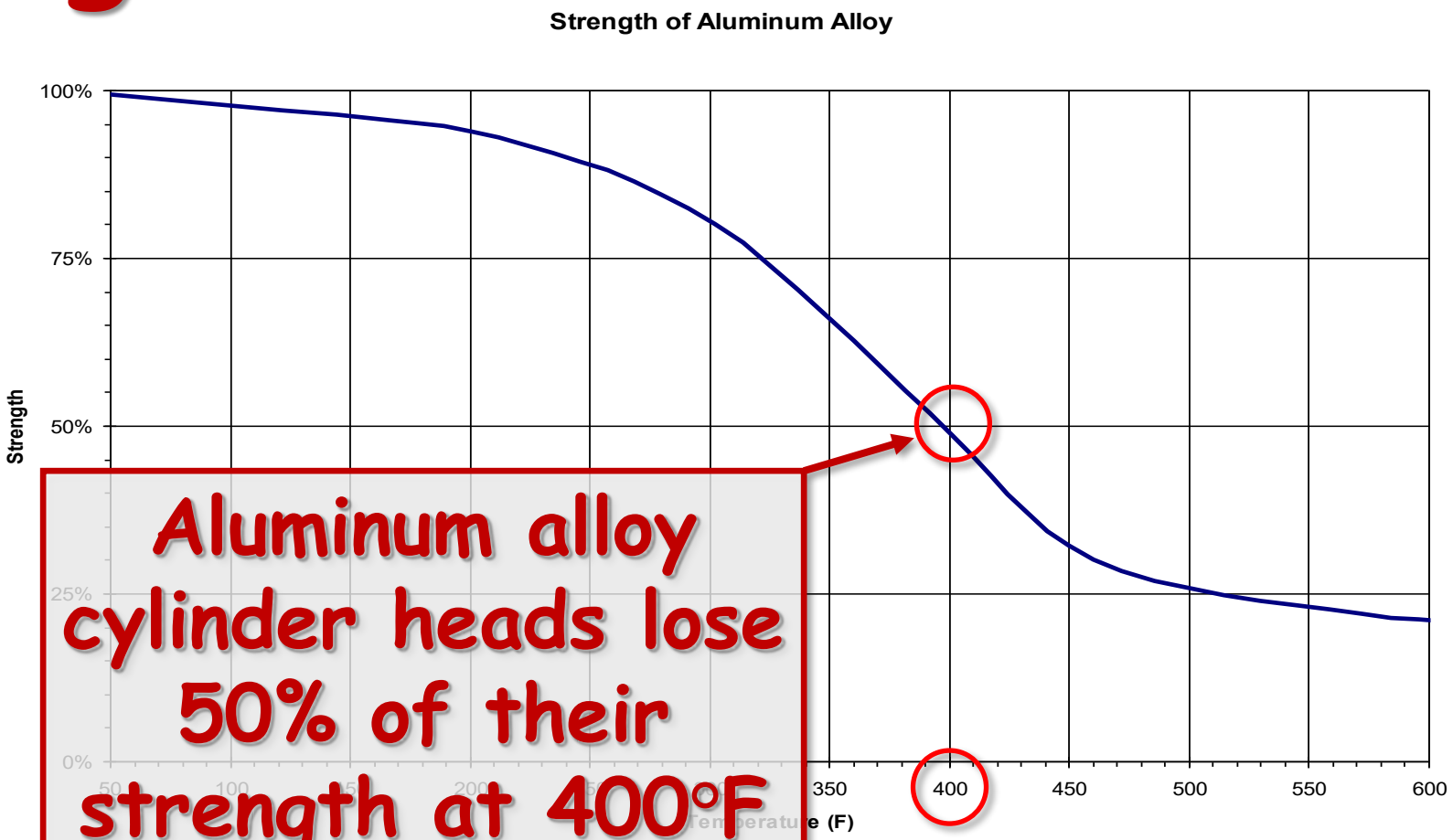
- Induction air filter
- Alternate air or carb heat door
- Induction system leaks

Change oil & filter regularly

Do spectrographic oil analysis

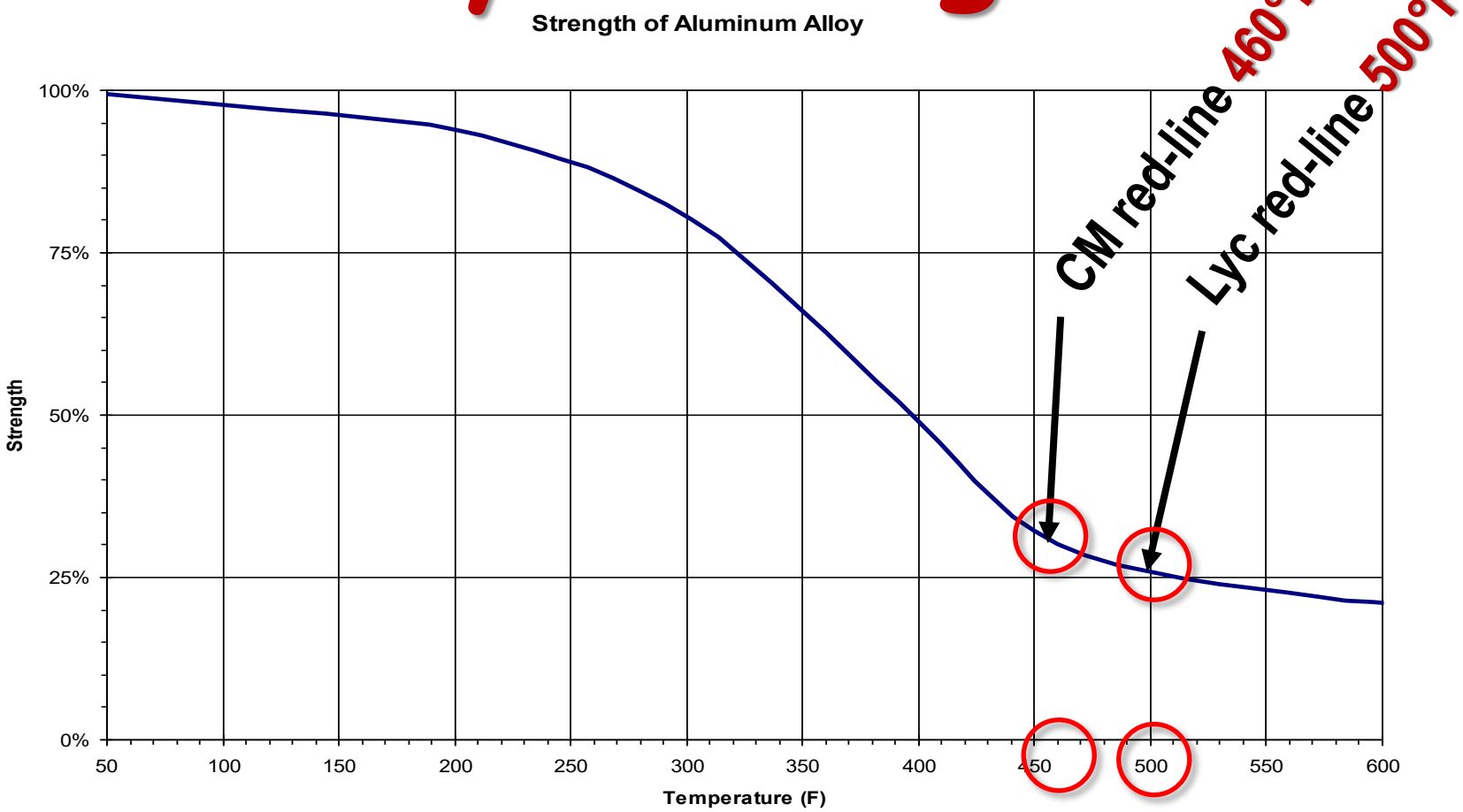
Dirt → elevated silicon

High CHT is bad

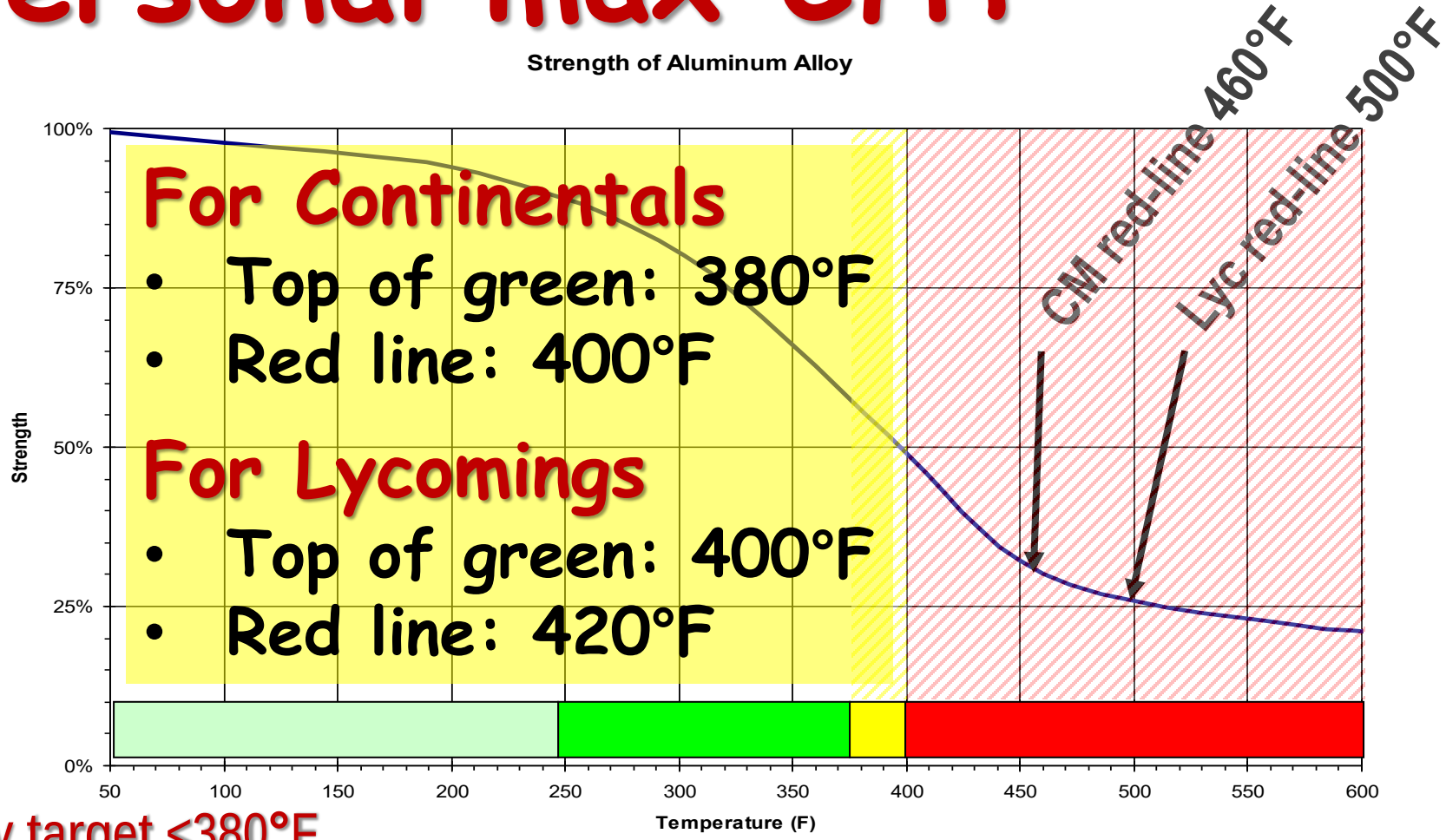


Aluminum alloy cylinder heads lose 50% of their strength at 400°F

CHT red-line is waaaay too high



Personal max CHT

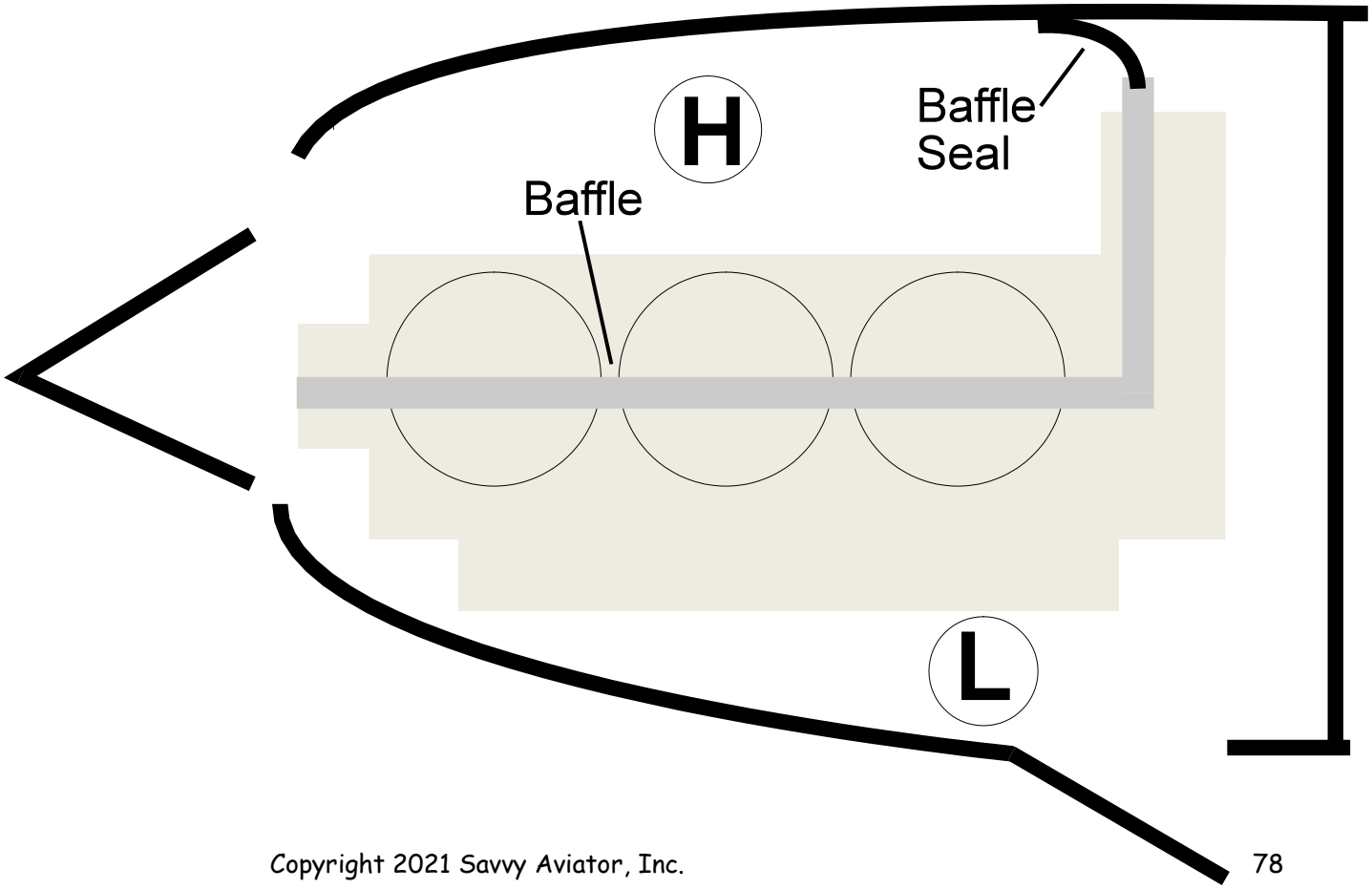


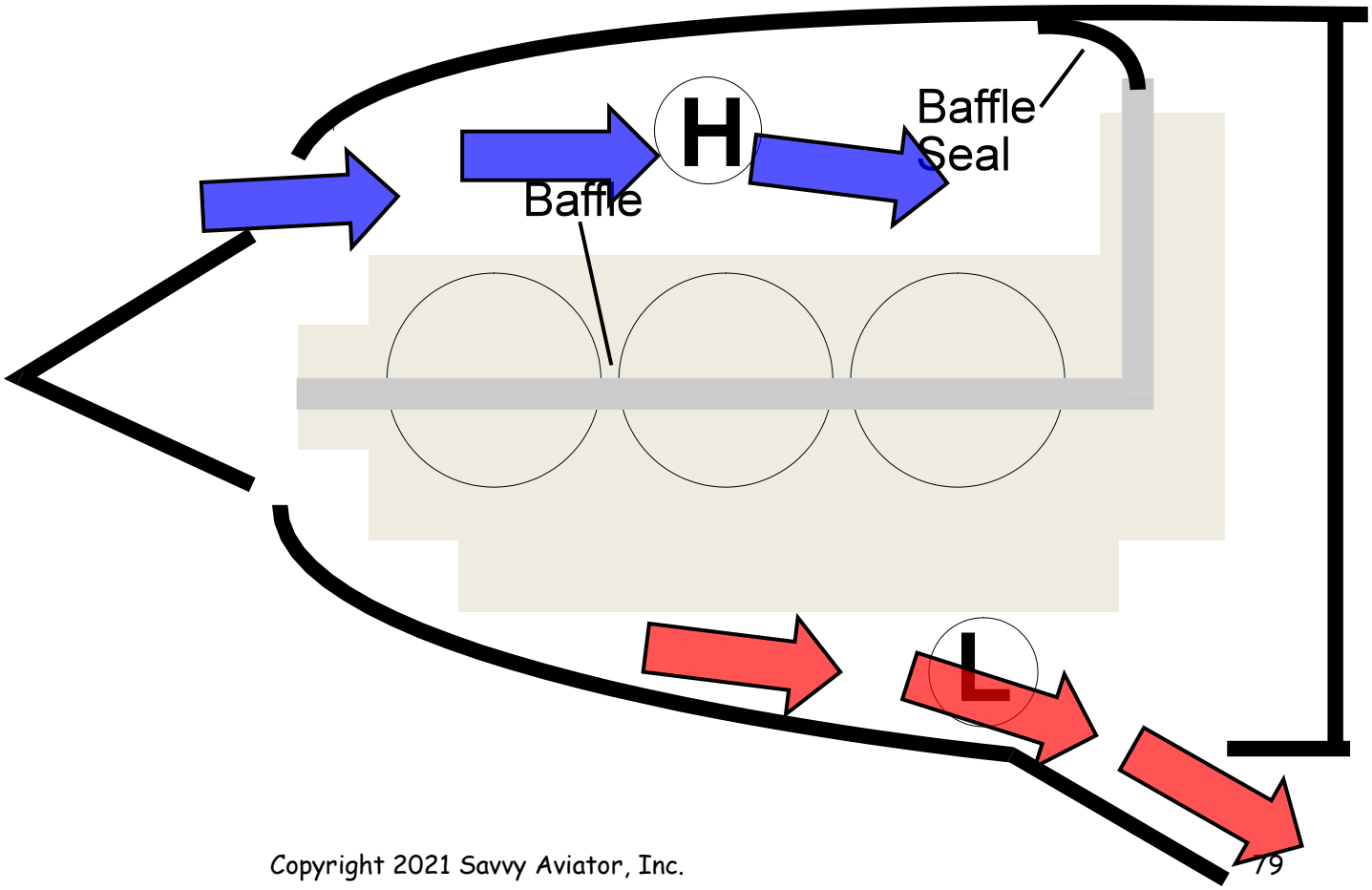
My target <380°F

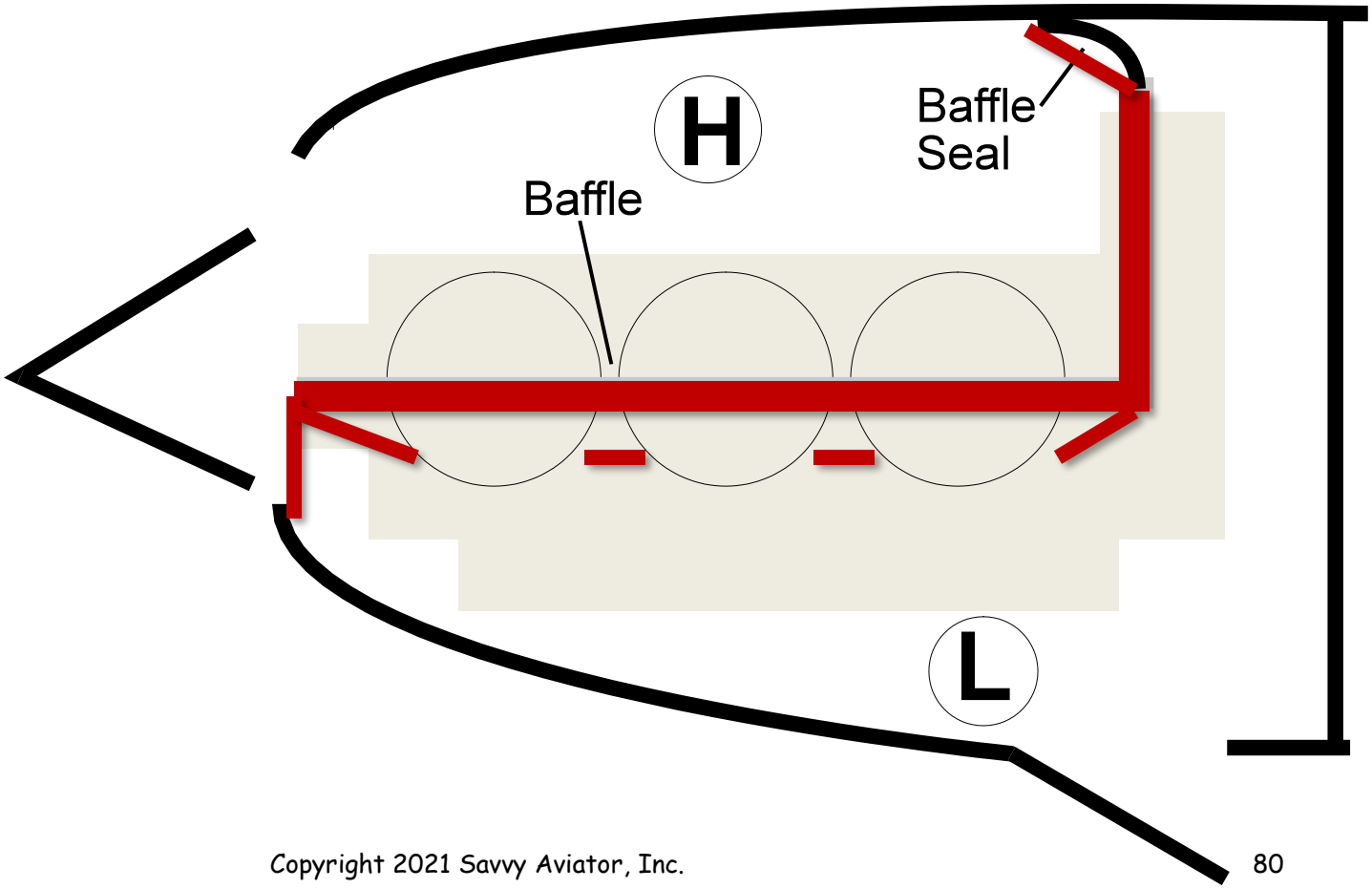
My red-line 400°F

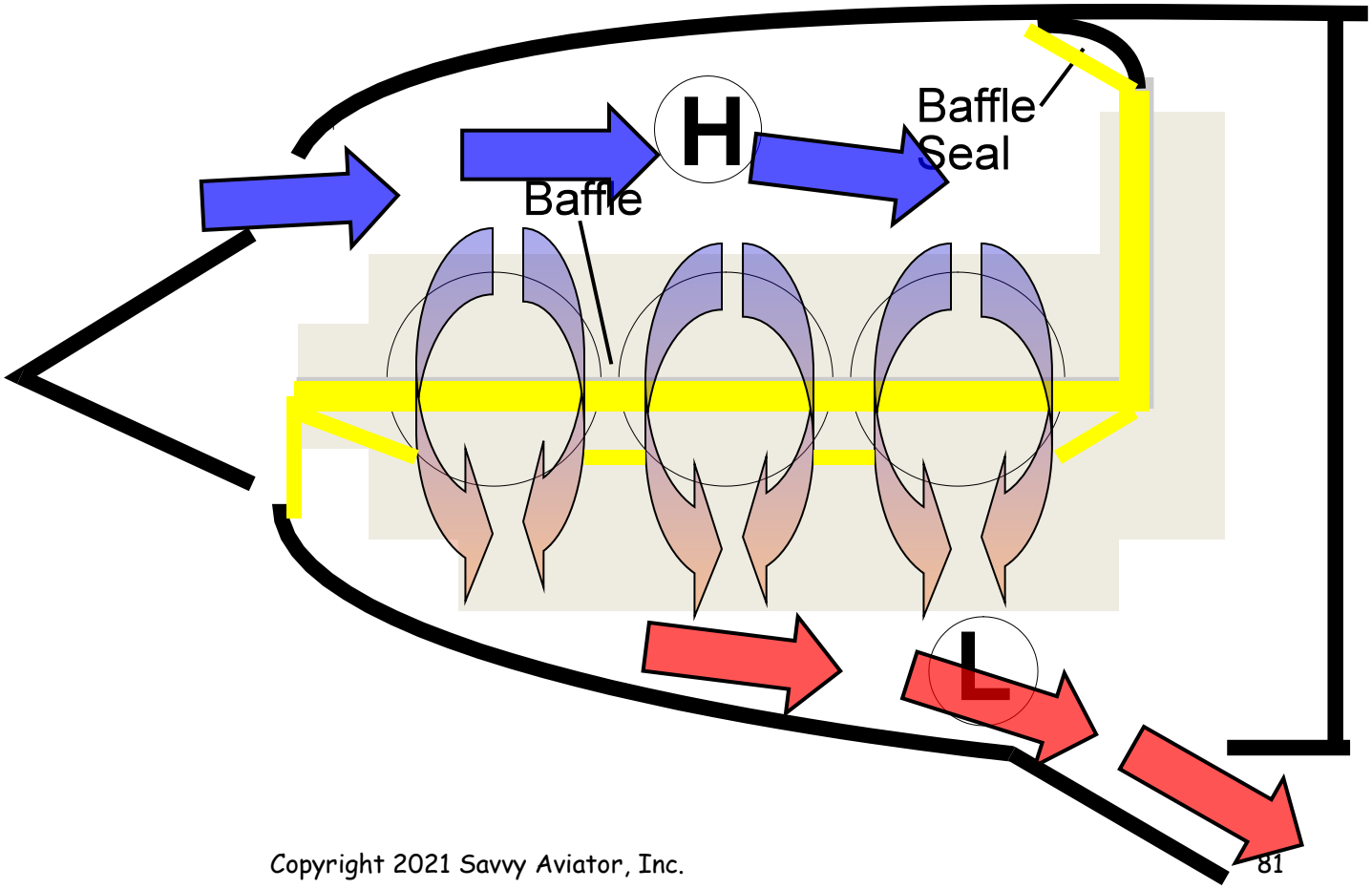
You cannot know your CHTs unless you have a multi-probe engine analyzer!

Engine cooling system

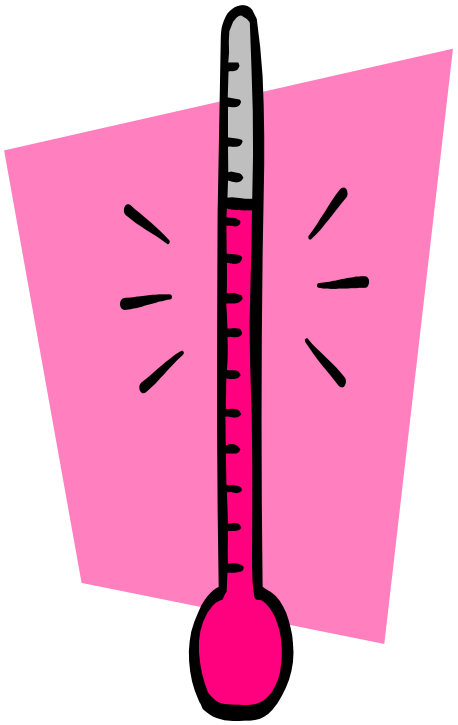








If CHT is too hot…



Open cowl flaps (if available)

Increase airspeed

Adjust mixture

- Hottest CHT occurs ≈ 40°F ROP
- If ROP, richen a lot
- If LOP, lean a little

Reduce power (if all else fails)

If CHT is too hot…

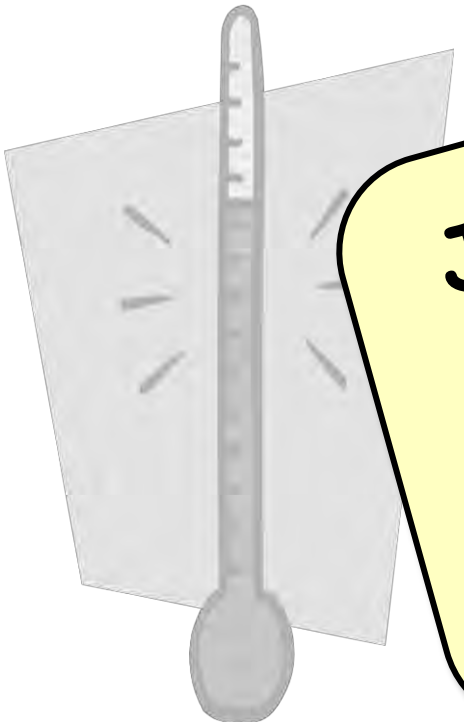
Open cowl flap… ble)

…F ROP

…a lot

…, lean a little

Reduce power (if all else fails)



Join me at 10:00 AM for

"Leaning the Right Way"

Summing up

TBO is not a magic number!

Engines wear from cycles, disuse and abuse … not hours or years

Engine failure is most likely when the engine is young, not old

Overhaul strictly on-condition

Never overhaul just because of top-end problems

Summing up

Don't let your engine rust

- Fly regularly
- Hangar your aircraft if possible
- Choose oil/additives wisely

Avoid dry and cold starts

- Fly regularly
- Always preheat below freezing

Keep dirt out of your engine

Do regular oil analysis and watch for increased silicon

Summing up

Keep CHTs well-controlled

- For Continentals, never >400°F, preferably <380°F
- For Lycomings, never >420°F, preferably <400°F
- If hotter than 400°F/420°F, take action <u>immediately</u>

Mo 1000 #7	The EGT Myth
Mo 1300 #7	How Healthy Is Your Engine?
Tu 0830 #7	To TBO and Beyond…
Tu 1000 #7	Leaning The Right Way
Tu 1300 #7	Destroy Your Engine in 1 Minute
We 0830 #7	Cylinder Break-In: Do It Right
We 1130 #7	What Is Preventive Maintenance?
We 1430 #7	Cylinder Work: Risky Business
Fr 0830 #7	It's Baffling
Fr 1000 #7	Where Fuel Meets Air
Fr 1300 #7	Benefits of Running Oversquare
Sa 1000 #7	How Mags Work…and Fail
Sa 1300 #7	Predictive Maintenance

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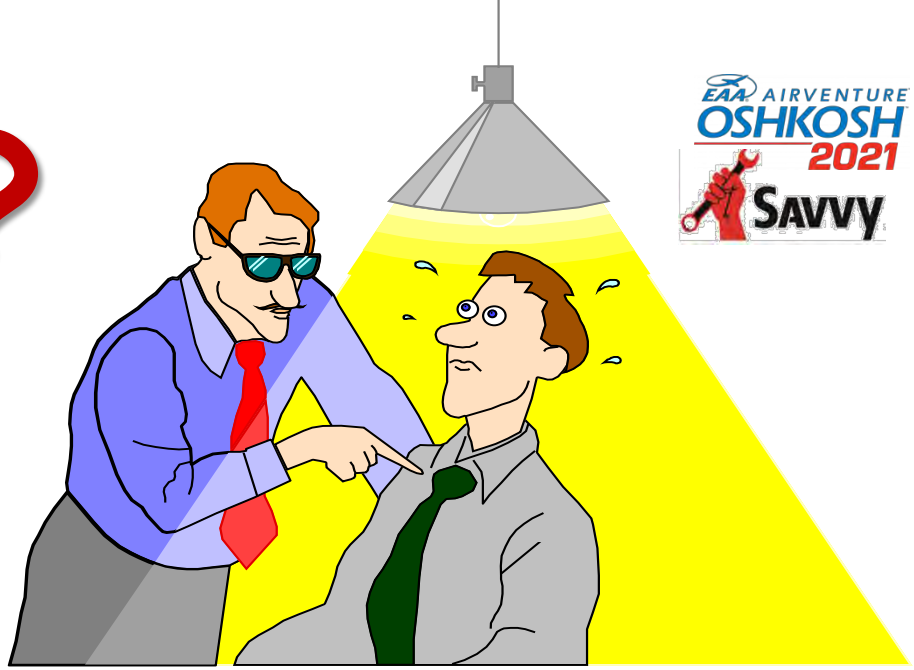
PLEASE POST YOUR REVIEWS!

Questions?



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