Instrument Reliability

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What Is Reliability?

- **Definition:** The **probability** that an item can **perform its intended function** for a **specified interval** under **stated conditions**.
- **Characteristic:** A **probability of success** as measured by a **success/attempts ratio**.
- **Quality measurement:** Reliability measures **dynamic effects of time** both in-service and in-storage.
- **Time aspect:** Reliability is concerned with **the probability of future events** based on past observations.
- **Generally speaking:** Reliability measures capacity of equipment or processes to **operate without failure** when put into service. **Nothing last forever except in advertisements.**

Why Inspect?

- **Learn what you don't know by inspecting devices and processes.** You expect success. What eats your lunch are failures (unreliability).
- Good **personal safety practices** says daily inspect your PPE even though in worst case **you may get killed**.
- Good **process safety practices** says inspect pressure devices and control systems because worst case **failures can result in the loss of many lives**.
- Inspection is a simple principal: **Show me, don't tell me about compliance! Either you comply or you fail.**
- Two things prevail: the probability of failure and a cost consequence. Keep the **$Risk = POF*$consequence** within your spending limits for your span of control.

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Attribute Data [pass/fail]

- The opera is not over 'till the fat lady sings.
- Business is about money so **fix big $Risk first**!

Calibration Results (#Successes/#Inspected)			
Unit	# inspected	# failures	Reliability
A	121	0	100.00%
B	67	0	100.00%
C	58	0	100.00%
D	40	0	100.00%
E	22	0	100.00%
F	20	0	100.00%
G	208	2	99.04%
H	62	1	98.39%
I	53	1	98.11%
J	233	8	96.57%
K	290	11	96.21%
L	58	3	94.83%
M	47	3	93.62%
N	40	4	90.00%
O	120	14	88.33%
P	382	45	88.22%
Q	78	13	83.33%
R	42	11	73.81%
Total=	**1941**	**116**	**94.02%**

Calibration Results Converted To $Risk					
Unit	# inspected	# failures	Reliability	$ Consequence	$Risk
R	42	11	73.81%	$ 75,000	$19,643
Q	78	13	83.33%	$ 50,000	$ 8,333
P	382	45	88.22%	$ 30,000	$ 3,534
M	47	3	93.62%	$ 25,000	$ 1,596
L	58	3	94.83%	$ 14,000	$ 724
J	233	8	96.57%	$ 8,000	$ 275
K	290	11	96.21%	$ 6,000	$ 228
N	40	4	90.00%	$ 2,000	$ 200
O	120	14	88.33%	$ 1,700	$ 198
G	208	2	99.04%	$ 10,000	$ 96
I	53	1	98.11%	$ 3,000	$ 57
H	62	1	98.39%	$ 2,500	$ 40
A	121	0	100.00%	$ 1,000	Nil
B	67	0	100.00%	$ 1,000	Nil
C	58	0	100.00%	$ 1,000	Nil
D	40	0	100.00%	$ 1,000	Nil
E	22	0	100.00%	$ 1,000	Nil
F	20	0	100.00%	$ 1,000	Nil
Total=	**1941**	**116**	**94.02%**		$34,924

SRisk = (probability of failure)*$ Consequence

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Age To Failure Data

- **At least three criteria must exist for data***:
- The time origin must be unambiguously defined.
- Establish a scale for measuring passage of time.
- The meaning of failure must be entirely clear.
- Store your data, retrieve it, and make fact based (unemotional) engineering decisions.
- Know what stresses kill your system.
- Identify and record your modes of failure.
- Record your censored (suspended data).

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What Is Failure?

- **Failure is loss of function when you need it.**
- Stoppage to due malfunction.
- Components cease to function.
- Can't meet predetermined quality, quantity or cost expectations.
- An unexpected occurrence that interrupts routine operation of a system.
- Often failure is degradation--not a step function.
- **Use judgement in defining failures!!! Your failure may be my nuisance.**

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Censored (Suspended) Data

- **Censored data has these characteristics***:
- Units that have not failed by the failure mode in question.
- Units that may have failed by a different failure mode.
- Units that may not have failed at all (suspensions).
- Left suspensions means the age is less than earliest failure.
- Right suspension means the age is older than oldest failure.
- Censored data is important data for analysis.
- **Since you're reading these slides, it tells me you are alive and you represent suspended data for human ages to failure data!**

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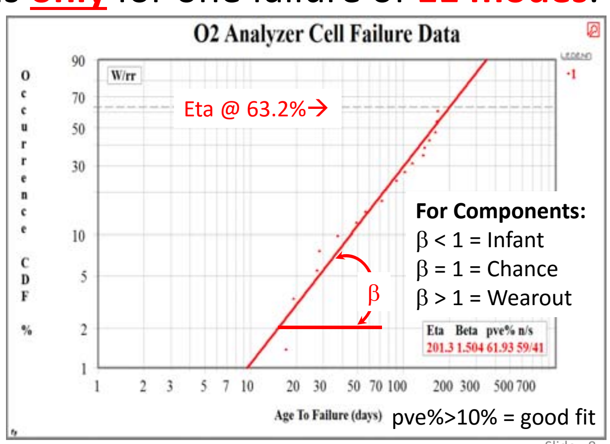
Oxygen Analyzer Failure Data*

- This oxygen analyzer has 11 failure modes.
- Data below is **only** for one failure of **11 modes**.

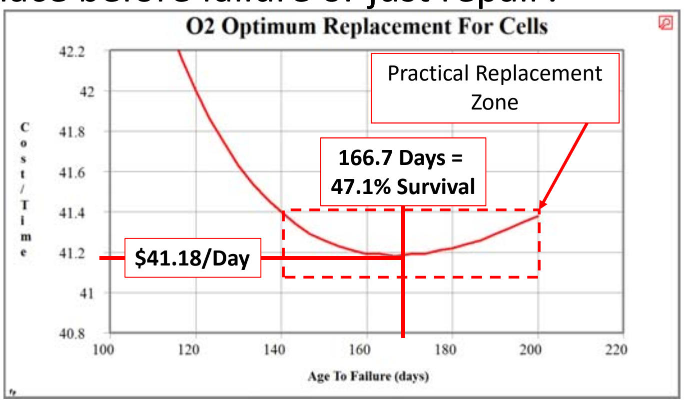
O_2 Analyzer Cell Failure Data (days)		
Suspension Data		Age To Failure
-180	-64	17
-179	-57	19
-173	-54	27
-172	-41	28
-172	-40	37
-164	-38	49
-164	-30	56
-162	-25	72
-155	-25	76
-151	-19	90
-143	-19	102
-119	-18	114
-108	-18	134
-97	-16	137
-94	-11	147
-75	-7	162
-73	-7	165
-72	-5	167
-69	-2	
-65	-1	
-65		



1/27/2016 *http://www.barringer1.com/pdf/Barringer-Analyzer-Reliability.pdf Slide - 8

Optimum Replacement For O_2 Cells?

- Planned replacement cost is $2,000.
- Unplanned (failed) replacement cost is $8,000
- Replace before failure or just repair?



Instrument Data Summary

- Two types of data: 1) **attribute**, 2) **age to failure**.
- **Age to failure data** provides much **more useful** information than attribute data.
- **Merge failure data** with **money issues for making business decisions** rather than emotional and/or ignorance decisions.
- Pharaoh said to the Israelites you can't make bricks without straw—gather your straw.
- **Barringer says you can't make wise decisions without considering failure data and money issues—go get your data and engineer the results!**

Bio

Paul Barringer is a reliability, manufacturing, and engineering consultant. His worldwide consulting practice involves, reliability consulting, and training with a variety of discrete and continuous process manufacturing companies and service industries. He is author of the training courses Reliability Engineering Principles , Process Reliability, and Life Cycle Cost. Barringer has more than fifty years of engineering and manufacturing experience in design, production, quality, maintenance, and reliability of technical products. His experience includes both technical and bottom-line aspects of operating a business with an understanding of how reliable products and processes contribute to financial business success.

Barringer has been:

- **Director of Manufacturing** and **Director of Engineering** in an ISO 9001 facility for highly specialized mechanical devices used as safety valves for containing pressures up to 20,000 psi during drilling of high pressure, high temperature oil and gas wells in sub-sea and land applications.
- **Director of Manufacturing**, **Director of Engineering**, and **Plant Manager** for domestic and international plants threading proprietary tubing and casing connections using specialized gaging systems for quality control of metal-to-metal seals on oil country tubular goods used down hole in deep, high pressure, oil and gas fields.
- **Operations Manager** in a multi-plant manufacturing operation for high-speed equipment used in textile machinery.
- **Manufacturing Manager** and **Plant Engineer** in nickel and cobalt based high alloy mills, foundries, machine shops, tube mills, and fabricating operations.
- **Development Engineer** for ultra high-speed centrifuges used in separating uranium isotopes and biological materials on a production basis.

Barringer is a Licensed Professional Engineer (Texas-51508). He is named as inventor in six USA Patents. Also he is a contributor to **The New Weibull Handbook**, a reliability text published by Dr. Robert B. Abernethy. His technical society membership include-

- 2010 Fellow, American Society of Mechanical Engineers,
- American Society for Quality
- Society of Manufacturing Engineers, and
- Society of Maintenance and Reliability Professionals.

Barringer's education includes a MS and Bachelor in Mechanical Engineering from North Carolina State University. Additionally he was a participant in Harvard University's three-week Manufacturing Strategy conference.

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