Qualified Life

Not a Crock,
Definitely a Crack

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Chairman WG 2.1 Equipment Qualification (IEEE Std 323)

Definitions

- Service Life
  - The time period from initial operation to removal from service.
- Qualified Life (QL)
  - The period of time, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions.
- Design Life
  - The time period during which satisfactory performance can be expected for a specific set of service conditions.

Mild Environment

- Even Harsh Areas are Mild until
  - Design Basis Events
  - Excessive Environment
- Mild is not necessarily Benign
  - Agastat Relays
  - IN92-027 04/03/1992 Thermally Induced Accelerated Aging and Failure of ITE/Gould A.C. Relays Used in Safety-Related Applications

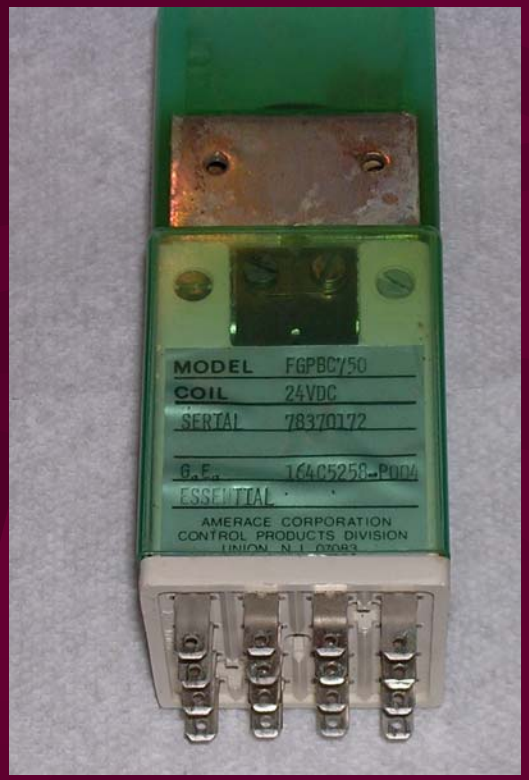
IN 84-020 03/21/1984 Service Life of Relays in Safety-Related Systems

- Agastat GP Series Relays
- These relay failures precluded the automatic operation of
  - Standby service water system valves,
  - Main steam isolation valves,
  - Components in the control room ventilation system,
  - Combustible gas control system,
  - Reactor core isolation cooling system,
  - Residual heat removal system, and
  - High pressure core spray system.

Additional Relay Failures

- IE BULLETIN NO. 84-02: FAILURES OF GENERAL ELECTRIC TYPE HFA RELAYS IN USE IN CLASS 1E SAFETY SYSTEMS
  - Lexan Bobbin
  - Failed to De-energize
- IN 82-13: FAILURES OF GENERAL ELECTRIC TYPE HFA RELAYS
  - Nylon Bobbin
  - Failed to De-energize
  - When Armature did move to the de-energized position
    - Melted insulation coated the Contacts

Root Cause Failure Analysis of Agastat Safety Related Relay



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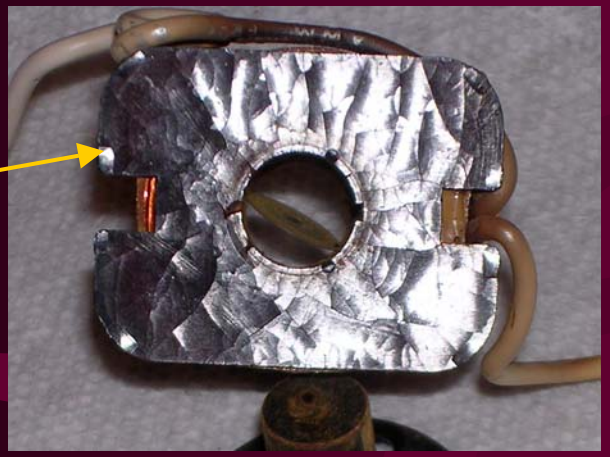
Root Cause – Bobbin
100% Loss of Tensile Strength

Coil and Bobbin



Disintegrated Nylon Bobbin

Arrhenius Thermal Aging of Nylon Bobbin

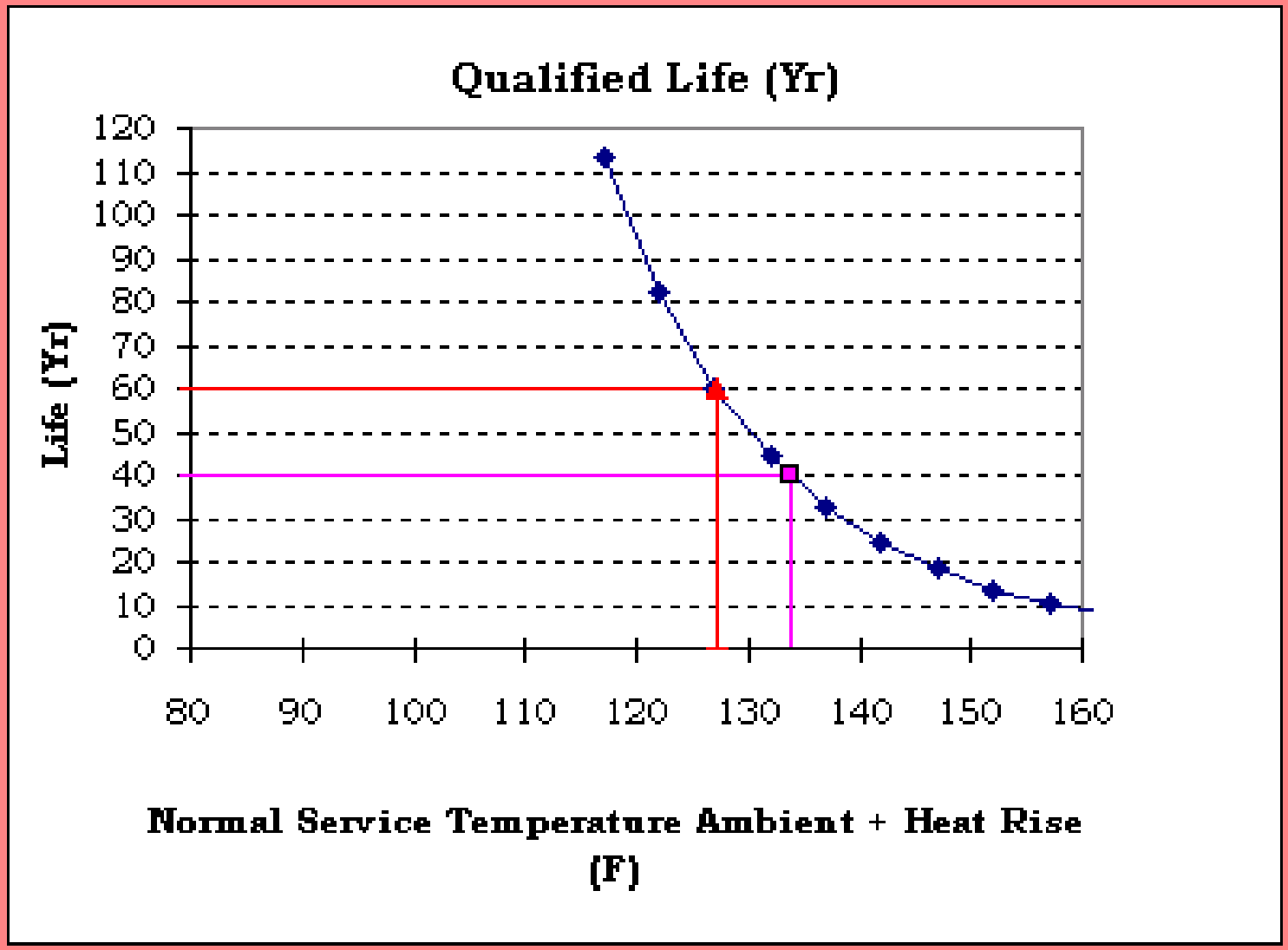
Mounts Horizontally
Loss of Bobbin,
Magnetic Wire interfered with plunger
Spring could not overcome resistance
Result: Fail safe mode (de-energized) did not de-energize

Applications Influence QL

- Radiation Environment
  - Dose Rate
  - Total Integrated Dose
- Operational Degradation
  - Number of Cycles
  - Loading / Severity
- Service Temperature
  - Ambient Temperature
  - Self Generated Heat Rise
  - Heat Rise from Adjacent Sources

	A	B	C	D	E
1		Formula:			
2		QL(=t2) = t1 * exp(-(Ea/kB) * (1/T1k-1/T2k))			
3		Where			
4		Ea		Activation Energy	
5		t1		Accelerated aging time at temperature T1 (hrs)	
6		T1c		Accelerated aging temperature (C)	
7		T1k		Calculated accelerated aging temperature (K)	
8		T2k		Calculated normal service temperature (K)	
9		kB		Boltzmann's constant = 8.617 E-5 (eV/K)	
10		T2f		Normal service temperature (F)	
11		t2=QL		Normal service time at T2 (Yrs)	
12	GLS QL Ht Rise Template Rev 1			Input Values	
13				here	
14	Act.Energy, Ea(eV)			1.02	
15	Aging Time, t1 (hr)			500.00	
16	Aging Temp,T1c (C)			130	
17	Normal Ambient Temp, Tnf(F)			122	
18	Heat Rise (F)			5.00	
19	Aging Temp, T1k(K)			403	
20			Qualified Life Calculation		
21	Ambient	Serv.Temp	Serv.Temp	QL(Yrs)	
22	Temp (F)	T2k (K)	T2f (F)	Ea= 1.02	
23	112	320.22	117.0	113.23	
24	117	323.00	122.0	82.40	
25	122	325.78	127.0	60.28	
26	127	328.56	132.0	44.34	
27	132	331.33	137.0	32.78	
28	137	334.11	142.0	24.36	
29	142	336.89	147.0	18.19	
30	147	339.67	152.0	13.64	
31	152	342.44	157.0	10.28	
32	157	345.22	162.0	7.79	
33	134	332.27	133.7	40.00	
34	127	328.59	127.1	60.00	
35	Notes: T2f = Ambient Temp in F + Heat Rise in F				
36	T2k = (5/9) * (Ambient Temp in F + Heat Rise in F -32)+273				

QL Template | Temp Distribution _ | Sheet3 | Sheet4 | Sheet5 | Sheet6 | Sheet7


Qualified Life (Yr)
Life (Yr)
120
110
100
90
80
70
60
50
40
30
20
10
0
80
90
100
110
120
130
140
150
160
Normal Service Temperature Ambient + Heat Rise (F)

Daughter Standards

- IEEE Std 650 Battery Chargers & Inverters
  - Qualified Life Required
  - Significant Heat Rise in Magnetics
  - Vendor Establishes QL
- Utility decides
  - Harsh/Mild
  - Use QL or not use QL

NPP Determines Applicable QL

- Harsh
  - Qualified Life based on Application
- Mild
  - QL Optional
  - Maintenance
  - Surveillance

Conclusions

- Aging Degradation Occurs in Real Time
- Real Materials Degrade
- “Fail Safe Functions” are not immune
- Application and Location Temperatures are significant factors
- Qualified Life will vary by application
- Definitions in IEEE 323™-2003 Unchanged