

CURBING FUTURE PROBLEMS

Figure 2. This successful FMEA project reduced the RPN of a transformer's seven components from 540 to 188.

COMPONENT NAME AND FUNCTION: Bushing, supply high voltage

Failure mode	Failure effect	Severity	Failure causes	Failure cause	Failure causes	Failure cause	Occurrence	Current control detection/ prevention methods	Detection	RPN	Recommendations	Actions	Results			
													S	O	D	RPN
Short circuit	Equipment shutdown	4	Fault in insulation material	Water penetration or dirt	Inelastic gasket	Aging	1	Visual inspection and cleaning	6	24	Improve inspection and detectability	Use a proper condition-monitoring technique such as ultrasound to detect insulation faults	4	1	2	8
					Lack of maintenance		1		6	24			4	1	2	8
			Damage bushing	Sabotage stone, crash or careless handling		1	None	4	16	NA	NA	4	1	4	16	

COMPONENT NAME AND FUNCTION: Tank , enclose oil, protect active parts

Failure mode	Failure effect	Severity	Failure cause	Failure cause	Failure cause	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Results			
													S	O	D	RPN
Leakage	Equipment shutdown	4	Tank damage (rupture)	Material/ method	Inelastic gasket or corrosion	Aging	1	Visual inspection	5	20	Improve inspection and detectability	Use ultrasound analysis technique to detect arcing phenomena	4	1	1	4
						Insufficient maintenance	1		5	20			4	1	1	4
				Mechanical damage	High pressure due to gas generation	Arcing	1	None	10	40	NA	NA	4	1	1	4
					Careless handling		1		1	4			4	1	1	4

COMPONENT NAME AND FUNCTION: Core, carry magnetic flux

Failure mode	Failure effect	Severity	Failure cause	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Resulting RPN
Loss of efficiency (reduction of transformer efficiency)	Lower voltage, production disturbance	4	Mechanical failure	DC magnetization	1	Basic measurements and gauges monitoring on monthly basis	4	16	NA	NA	16
				Displacement of the core seal during construction (construction fault)	1		4	16	NA	NA	16

COMPONENT NAME AND FUNCTION: Winding, carry current

Failure mode	Failure effect	Severity	Failure cause	Failure cause	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Results			
												S	O	D	RPN
Short circuit	Equipment shutdown	4	Fault insulation	Generation of copper sulfide		1		8	32	Improve inspection and detectability	Use ultrasound analysis technique	4	1	2	8
				Hot spot	Low oil quality	1	Oil sampling	1	4	NA	NA	4	1	1	4
			Mechanical damage	Movement of transformer	Aging of cellulose	1	None	5	20	Improve inspection and detectability	Use ultrasound for early detection	4	1	2	8
				Transient overvoltage	Short circuit in the net	1		5	20			4	1	2	8
					Connection of transformer	1		5	20			4	1	2	8
				Lightning	1	5		20	4			1	2	8	
			Construction fault		1	5	20	4	1	2	8				

COMPONENT NAME AND FUNCTION: Oil, the oil serves as both cooling medium and part of the insulation system

Failure mode	Failure effect	Severity	Failure cause	Failure cause	Failure cause	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Results			
													S	O	D	RPN
Oil	Equipment shutdown	4	Short circuit in transformer	Particles in the oil	Overheated	Pump failure, dirty particles in the oil	2	Visual monitoring of gauges and oil sampling every three years	4	32	Increase the frequency of oil sampling to twice per year in the maintenance schedule	Sample oil every six months in the semiannual maintenance schedule	4	1	2	8
				Water in the oil	Overheated or aging											
			Overheated	Oil is not cooled	Oil circulation out of function, or air/water cooling is out of function	Fan/pump failure	2		4	32			4	1	2	8

COMPONENT NAME AND FUNCTION: Tap changers, regulate voltage (volt leveling)

Failure mode	Failure effect	Severity	Failure cause	Failure cause	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Results			
												S	O	D	RPN
Tap changes	Change of the voltage output	3	Can't change voltage level	Mechanical damage	Wear	2	Voltage measuring	6	36	Use a proper condition-monitoring technique to detect mechanical damages of the tap changers	Use infrared analysis to detect mechanical damages	4	1	2	8

COMPONENT NAME AND FUNCTION: Solid isolation in cellulose-based products such as pressboard and paper. Its function is to provide dielectric and mechanical isolation to the windings.

Failure Mode	Failure Effect	Severity	Failure cause	Sources of failure	Failure cause	Occurrence	Current controls	Detection	RPN	Recommendations	Actions	Results			
												S	O	D	RPN
Can't supply insulation	Equipment shutdown	4	Mechanical damage	Short circuit	Aging of cellulose	1	None	10	40	Improve inspection and detectability in the maintenance program	Use ultrasound to detect early isolation failures	4	1	2	8
				Movement of transformer				10	40			4	1	2	8
			Aging of cellulose	1	1	4		1	1	8					
			Hot spot	Low oil quality, or overload	1	10		40	Use a proper condition-monitoring technique to detect insulation faults early	Use ultrasound to detect isolation failures early	4	1	2	8	
			Generation of copper sulfide			1		10	40			4	1	2	8