Lifetime tests for stationary contacts of tap-changers in transformers

Last results on functional life tests made at MR's test labs

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Functional Life Test
Fundamentals

Arrhenius equation:

for each 10°C temperature increase
the speed of chemical reactions is doubled

Acceleration factor target: 1.000 (roughly 2^{10})
(get from a 30 days test a life expectation of 30 years)

→ **Temperature difference between test and service must be 10 times 10K = 100K**

Estimated average oil-temperature of a transformer in service of 75°C leads to a contact super-temperature of around 100°C

→ **needed contact-super-temperature during testing is 200°C (100°C super-temp. in service plus 100K for the acceleration)**

Functional Life Test
(results presented in 2006)

“Bad” contact:

Basic measurement:

$I_1 = I_{rated} = 300$ A

$T_{oil} = 65$ °C

Measurement: $T_{s1} = 76.4$ °C

Accelerated test:

$I_2 = I_{test} = 1200$ A (= 4 times I_{rated})

$T_{oil} = 80$ °C

Measurement: $T_{s2} = 163.5$ °C

Acceleration factor: $2^{(163,5-76,4)/10} = t_{life}/\ t_{test} = 418.5$

“Good” contact :

Basic measurement:

$I_1 = I_{rated} = 300$ A

$T_{oil} = 65$° C

Measurement: $T_{s1} = 72,0$ °C

Accelerated test:

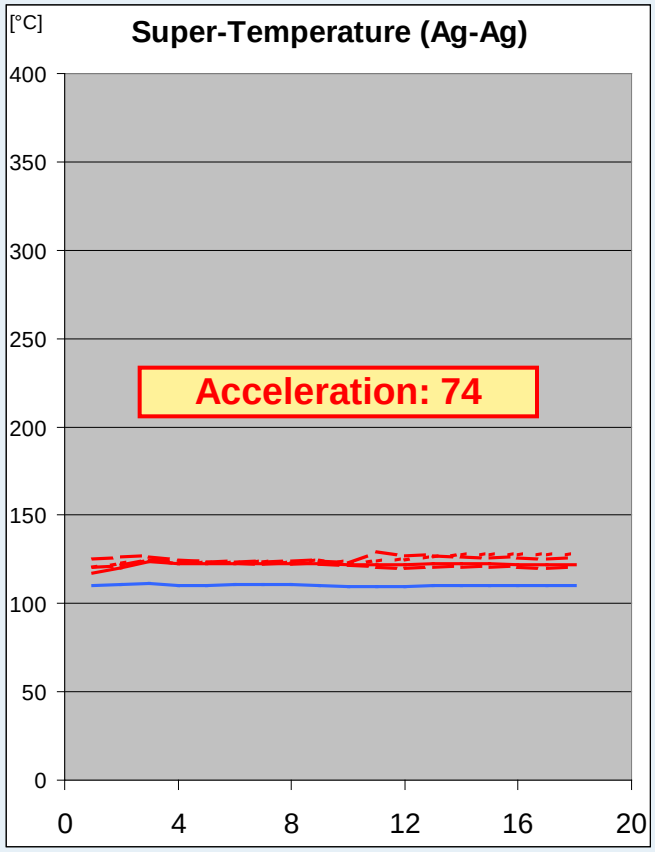
$I_2 = I_{test} = 1200$ A (= 4 times I_{rated})

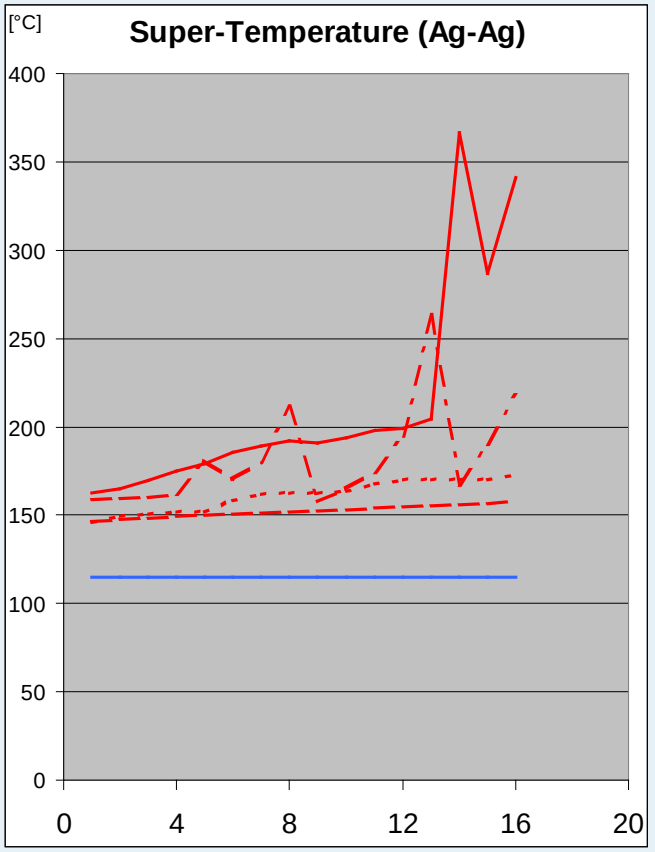
$T_{oil} = 80$ °C

Measurement: $T_{s2} = 117,5$ °C

Acceleration factor: $2^{(117,5-72,0)/10} = t_{life}/\ t_{test} = 23.4$

Functional Life Test
Contact: Ag-Ag





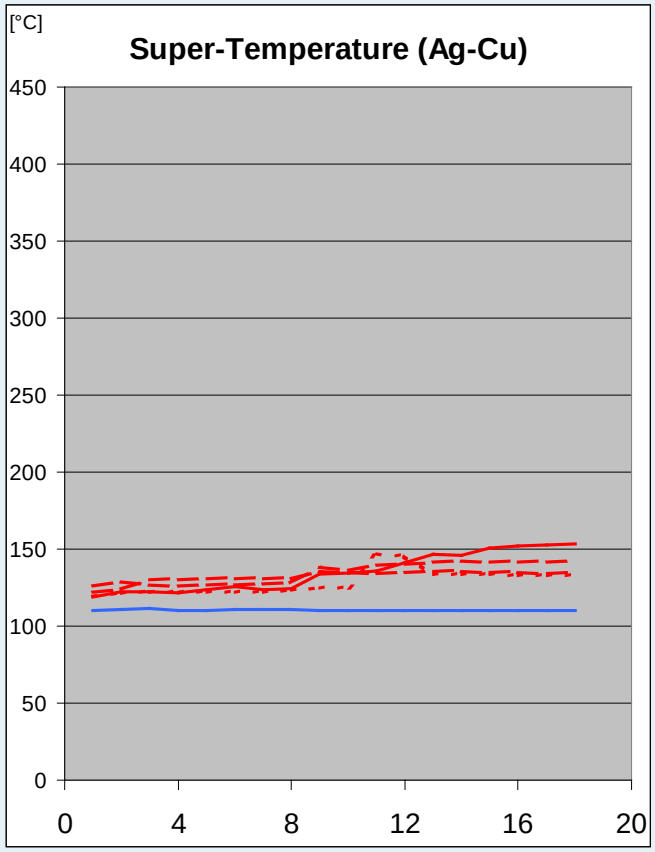
I_{test} = 600A = 2 times I_{rated}

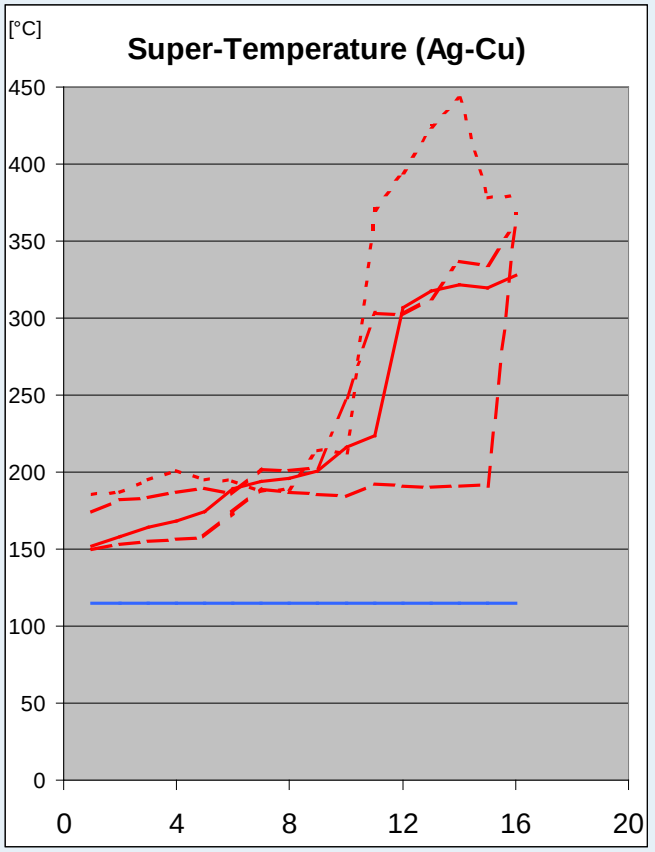
T_{oil} = 110°C

I_{test} = 1200A = 4 times I_{rated}

T_{oil} = 115°C

Functional Life Test
Contact: Ag-Cu





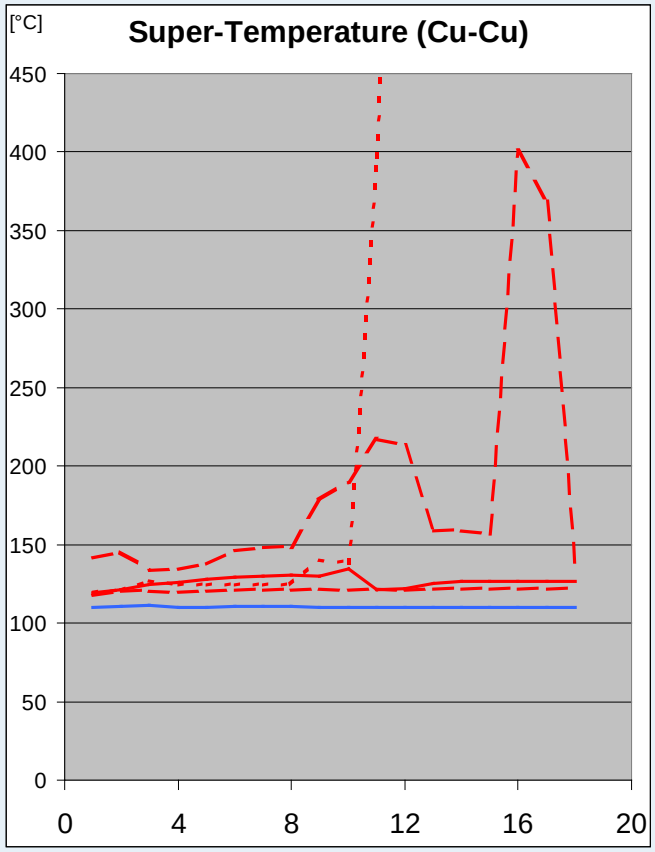
I_{test} = 600A = 2 times I_{rated}

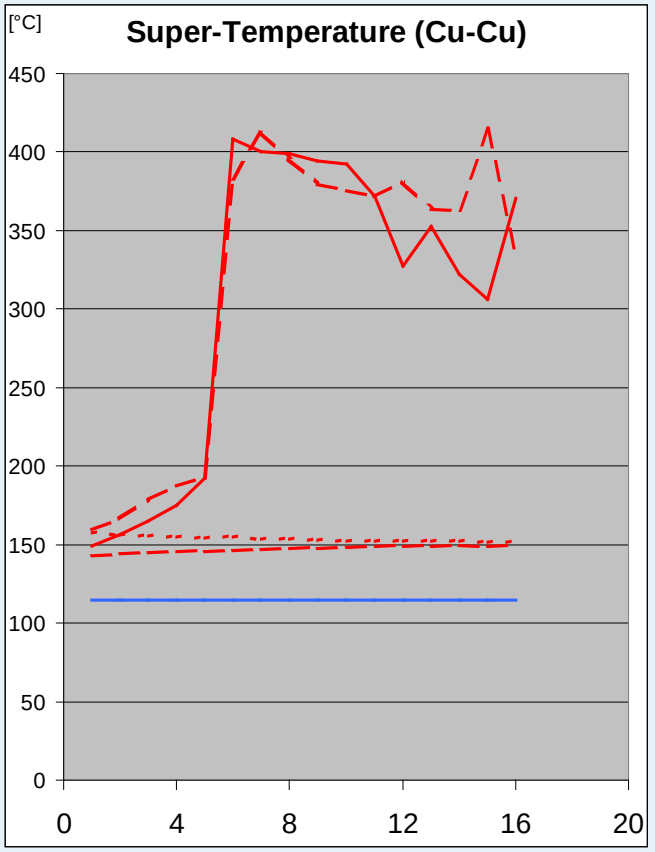
T_{oil} = 110°C

I_{test} = 1200A = 4 times I_{rated}

T_{oil} = 115°C

Functional Life Test
Contact: Cu-Cu





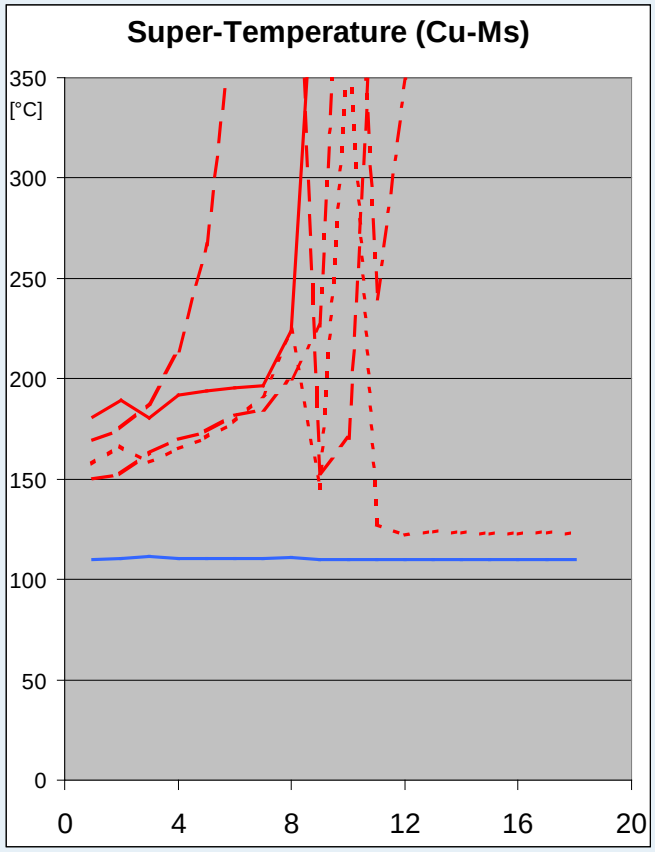
I_{test} = 600A = 2 times I_{rated}

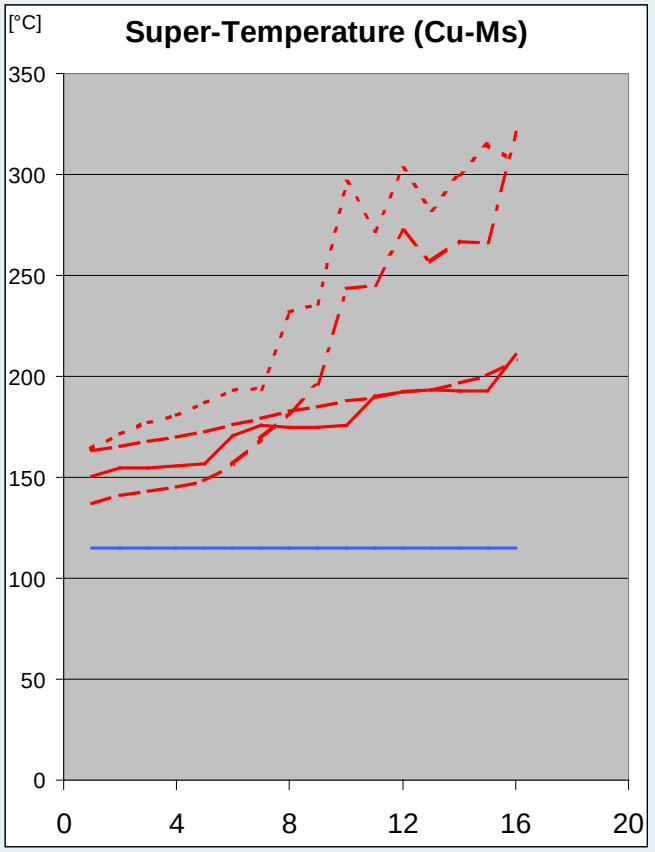
T_{oil} = 110°C

I_{test} = 1200A = 4 times I_{rated}

T_{oil} = 115°C

Functional Life Test
Contact: Cu-Ms





I_{test} = 600A = 2 times I_{rated}

T_{oil} = 110°C

I_{test} = 1200A = 4 times I_{rated}

T_{oil} = 115°C

Functional Life Test
Conclusion

1. The acceleration factor is only determined by the super-temperature difference in test and in service

   → If there is a very stable contact, the temperature difference is mainly determined by the oil temperature

2. When reaching a super-temperature of 150°C under oil

   → all investigated contact-combinations are showing a thermal runaway effect

3. When increasing the super-temperature over 150°C under oil to generate a higher acceleration

   → all investigated contact materials became “bad”

Functional Life Test
Conclusion

4. The thermal runaway of Ag-Cu-contacts below 150°C does not match with the excellent service experience of these material combination used in LTC contacts

5. The excellent service behaviour of Ag-Ag-contacts cannot be demonstrated with this test when generating a high acceleration

6. If contacts remain below 150°C in test (influenced by the test parameters) they can also show a “bad” behaviour in service (result from a former test series).