Investigation of a Failed Circuit Breaker

Root Cause: Inappropriate Contact-tip Material

Background

A UK electrical Distribution Network Operator (DNO) experienced the disruptive failure of an oil-filled high voltage circuit breaker at a substation: an internal flashover occurred. The resulting restoration of supply and repairs required considerable effort and cost. Operating records showed that the breaker had tripped and re-closed two hours prior to failure, during a lightning storm in the area; this was verified using EA Technology's lightning location data. The breaker was over 50 years old - it was one of several similar units, well maintained and still giving otherwise good service.

Challenge

EA Technology was requested to investigate with the aims of determining the root cause of failure and any actions that could be taken to reduce the probability of future similar failures.

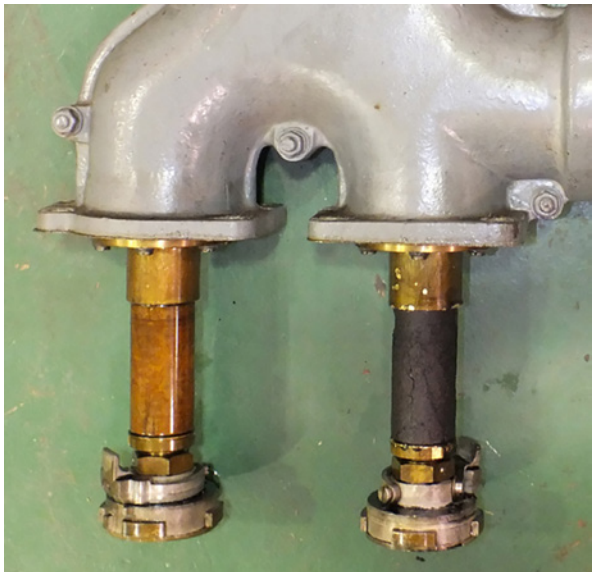
Approach

The process steps included:

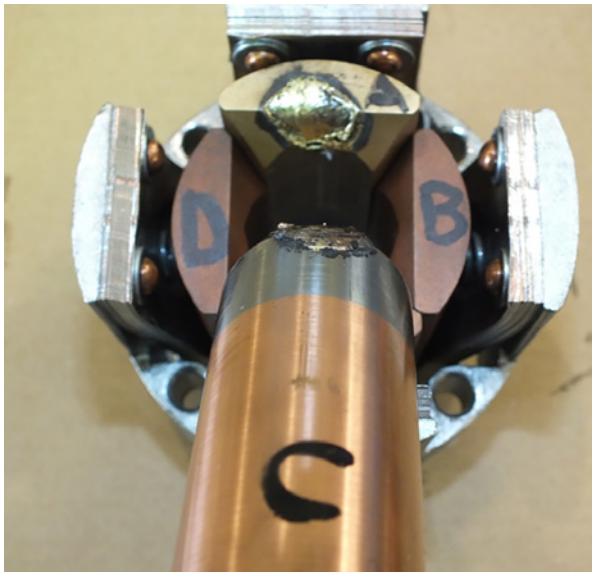
- Consideration of background information provided
- Initial examination of the circuit breaker truck in the substation and examination of the substation building condition
- Detailed laboratory examination of the circuit breaker truck
- Analysis of a sample of oil from the circuit breaker
- Optical microscopy and metallurgical examination of the contacts
- Scanning electron microscopy and elemental analysis of samples

Examination

The examination showed that a flashover had occurred between bushings in the breaker tank. The damage to the contacts was severe and of a similar nature on all six contacts. Various potential causes were considered: the cause of the poor performance of the contacts could have been due to breaking current beyond rated capacity or slow operation, but analysis of background information showed that these were unlikely and some other cause may have existed. Further investigation included microscopic examination, using visual and electron microscopes: an unexpected metal was found as spatter on some contacts during elemental analysis in the electron microscope.



Intact and arced bushings



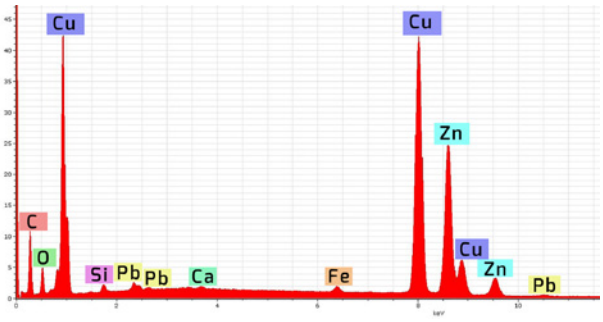
Arc contact and poker contact

Metallurgical examination of the material of the arc contact tips showed they were made of the same material as the spatter: the material is not commonly used where arc resistance is required. Analysis of the contacts from the failed circuit breaker and contacts known to be to the original manufacturer's specification showed that the failed contacts were made of material that was more prone to arcing damage than the material specified.

Case Study

Failure Process Deduced

The failure sequence started with the trip and reclose, which caused arc products from the contact tips to be deposited on the main current contact areas, leading to high resistance when the breaker was reclosed. This caused overheating, rapidly degrading the oil. The flashover was caused by the electrical weakness of the degraded carbon-bearing oil, probably exacerbated by arcing products generated as the contacts degraded further. The initial flashover was followed by full current power arcs, finally extinguished by the opening of other breakers.

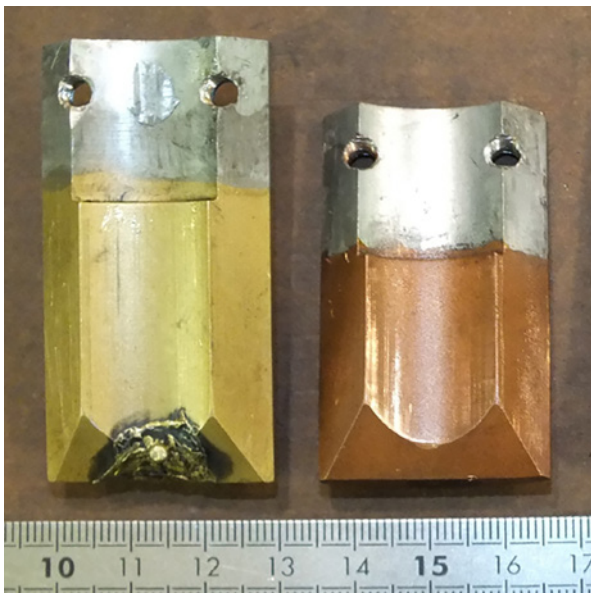


Elemental analysis of the contact tip material

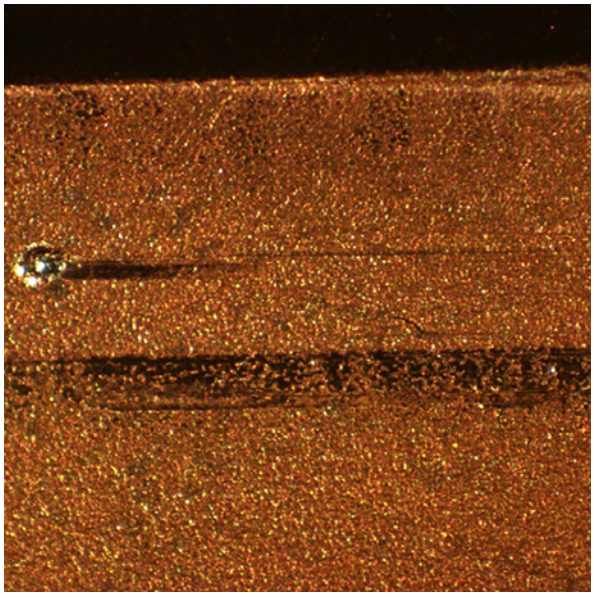
Client Benefits

The investigation of the incident allowed the client to target its asset management response onto contact clusters from the batch that included those examined; it also justified a technically improved approach to procuring spare contacts in future. Distribution network assets can economically remain in successful service beyond the manufacturer's intended lifetimes where appropriate maintenance and monitoring are applied. This investigation assisted the operator in preventing future incidents and contributing to cost-effective system management by justifying deferral of replacement.

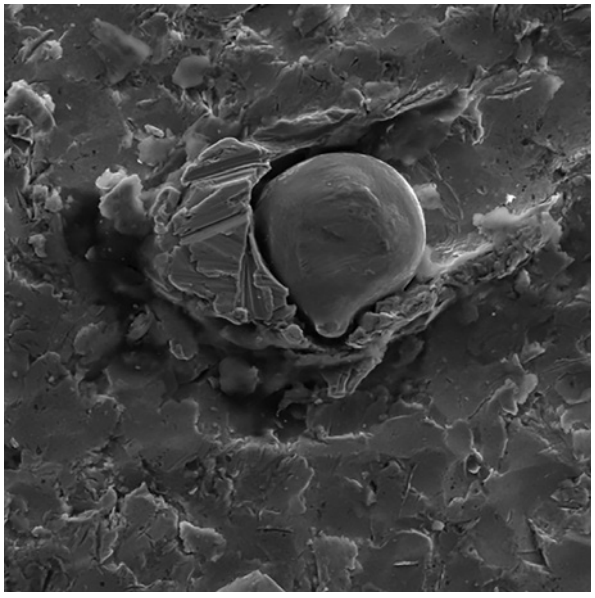
Damaged arc contact



Arc and main contacts



Globule of spatter (optical microscopy)



Globule of spatter (electron microscopy)

Global Footprint

EA Technology is an engineering and technology business that provides intelligent energy solutions for designers, installers, operators, and owners of power network assets.

Founded in 1966 we have over 50 years' experience in the industry and 5 regional offices around the world to support our global customer base.

We help clients to safeguard their networks. Advising them on strategy and implementation of a range of technology solutions to manage power assets, delivering maximum life and minimising cost

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Safer, Stronger, Smarter Networks

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