M. E. Williams and Associates, Inc.
"Excellence in Metallurgical Engineering"

12825 385th Avenue
Waseca, MN 56093

Case Study: Switch Contact Sticking

By

Merlin E. Williams, P.E.

Subject

Failure analysis of A101AS12VDC Switch to determine the cause of contact sticking during operation. The Switches were examined by visual examination, optical microscopic examination, scanning electron microscopic and EDS examination, hardness testing, and metallographic examination. A total of 9 switches were examined, but only three switches were completely tested. The results of only one switch are used in this case study.

Visual Examination

Figure 1 – Switch Package and Description

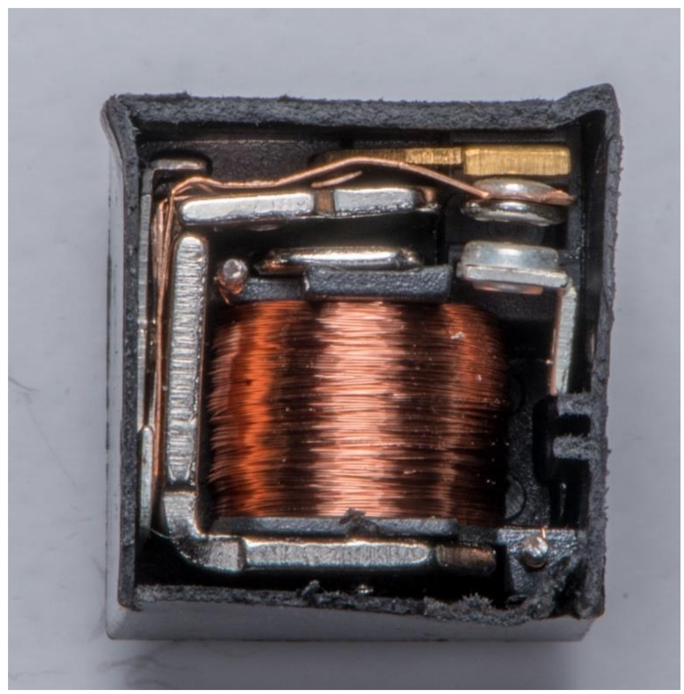
Figure 2 – Switch Cover Removed

Figure 1 shows the identification cover of a switch. Switches had a date code of 09Q in the lower left-hand corner.

Figure 2 shows the internal assembly of a switch. The contact spring was bent during the cover removal.

Phone (507) 835-2344 • FAX (507) 835-3412 • Twin Cities & Cell (612) 750-5578 • Toll Free (800) 854-6078
Email merlin@mewai.com – Web Site www.mewai.com

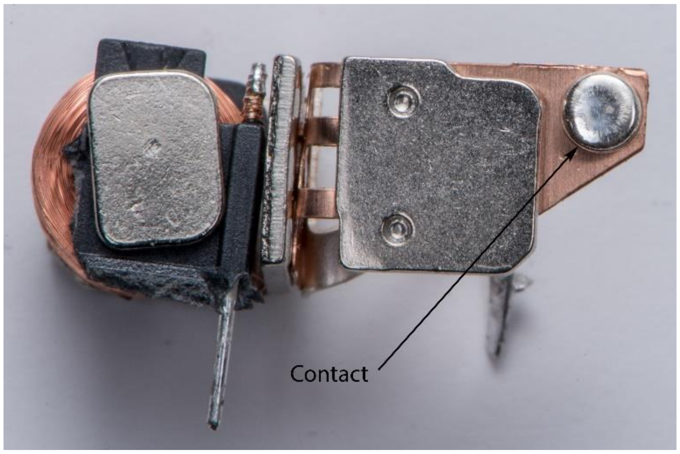

Figure 3 – Armature Contact

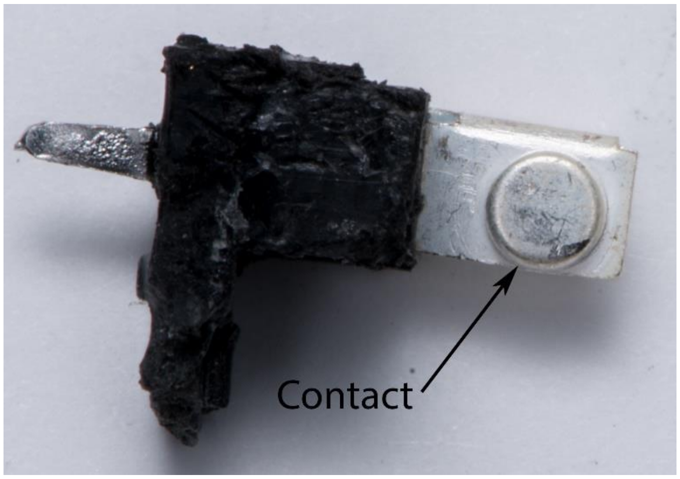

Figure 4 – Stator Contact

Figure 3 shows a switch coil and armature contact. Figure 4 shows the stator contact. The failure of the switch was caused by the bonding of the armature and stator contacts during use.

Optical Microscopic Examination

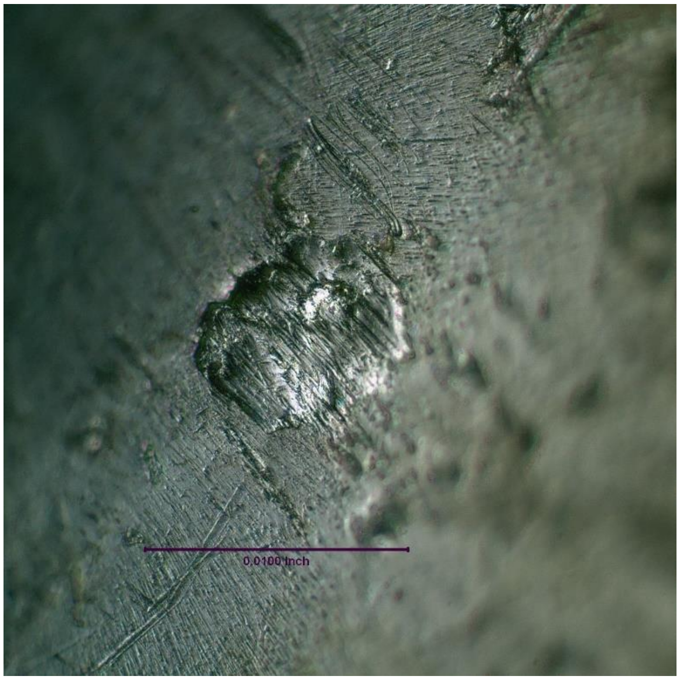

Figure 5 – 200X Contact Mark on Armature Contact of Switch

Figure 5 shows the contact point on the armature contact for the switch. Material from the stator contact was welded into the surface of this contact.

Scanning Electron Microscopic Examination

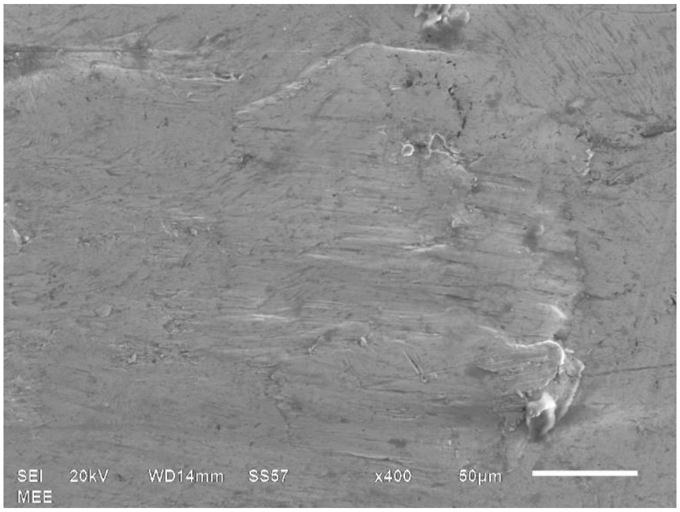

Figure 6 – 400X Armature Contact Point of Switch

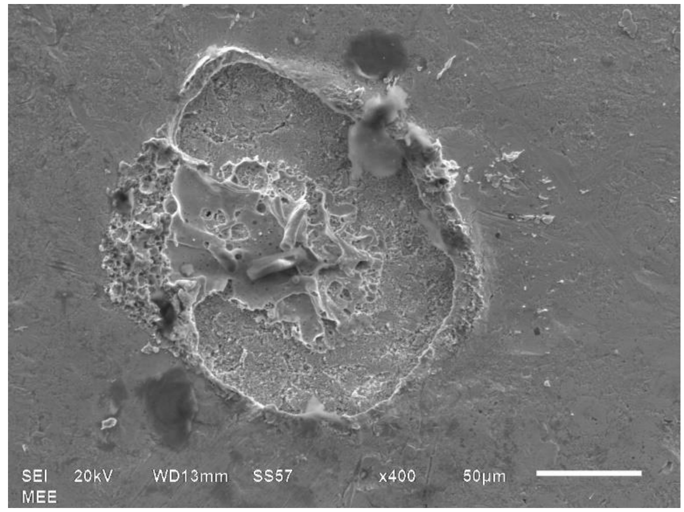

Figure 7 – 400X Stator Contact Point of Switch

Figures 6 and 7 show the armature and stator contact point of the switch. There was material imbedded in the surface of the armature contact, with the source of that material being the stator contact. The stator contact showed evidence of melting and material removal.

Figure 10 shows the microstructure for the stator contact point shown in Figure 7.

EDX and Semi-Quantitative Analysis

Table 1 shows the semi-quantitative analysis of the stator and armature contacts. The armature contact was a silver-tin oxide mixture, and the stator contact was silver.

Table 1
Analysis of Switch Contacts
(Percent by Weight)

Element	Stator	Armature
Carbon	1.00	0.60
Oxygen	0.50	1.30
Silver	98.50	92.50
Tin		5.60
Spectra	Figure 8	Figure 9

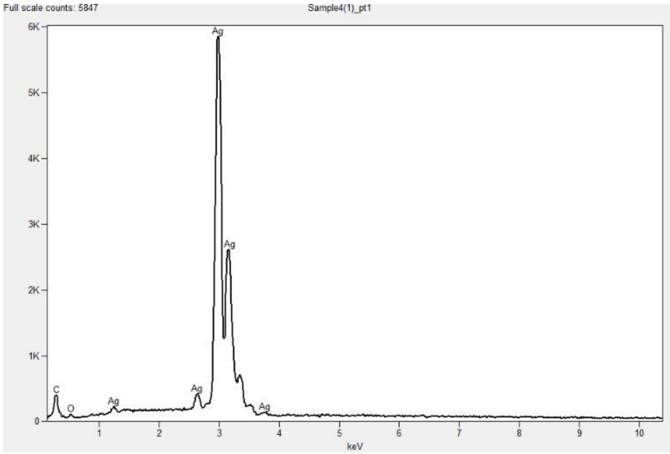

Figure 8 – Spectrum of Stator Contact of Switch

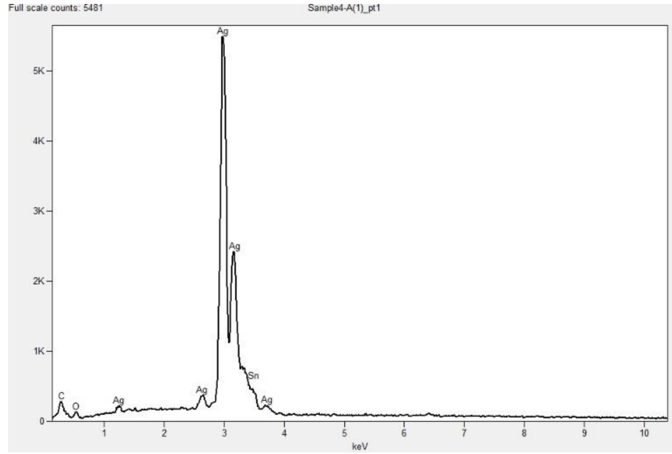

Figure 9 – Spectrum of Armature Contact of Switch

Hardness Test Data

Hardness testing was done according to ASTM E384, using a Vickers indenter and a 300 gram load. The results of the testing are given in Table 2.

Table 2
Hardness Test Data of Spring and Contact
(Vickers)

Location	Spring	Armature Contact
Vickers	259.00	123.00
STD DEV	5.97	1.52
MAX VALUE	263.00	125.00
MIN VALUE	250.00	121.00

The hardness testing shows that the armature contact was work hardened to about 125 Vickers Hardness, which will provide good wear resistance. The hardness of annealed silver-tin oxide is 70 Vickers Hardness.

The hardness of the spring material used in the armature was about 260 Vickers Hardness, which indicates that the material was a beryllium copper alloy.

Metallographic Examination

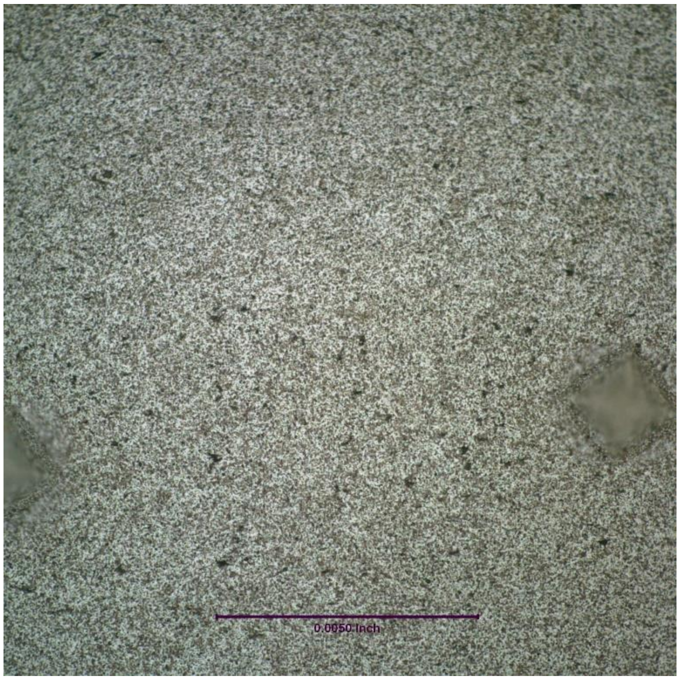

Figure 10 – 400X Microstructure of Stator Contact

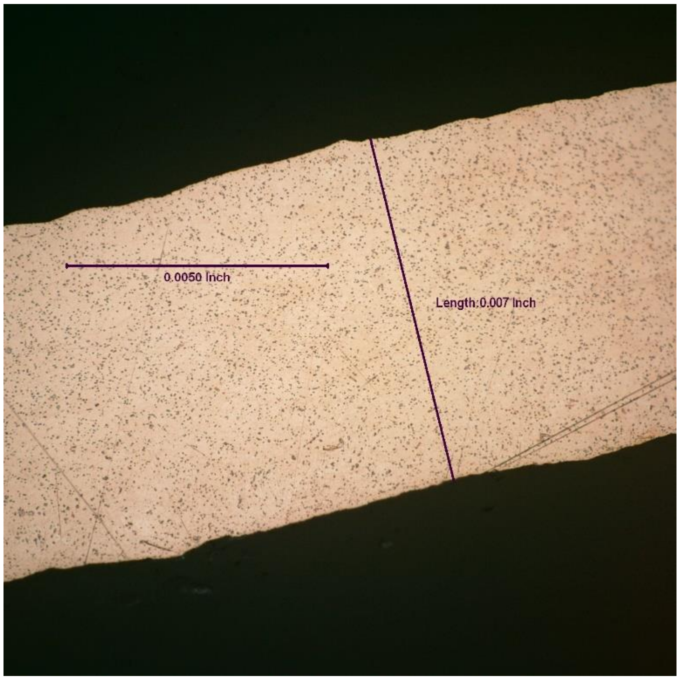

Figure 11 – 400X Microstructure of Amature Spring

Figure 10 shows the microstructure of the stator contact. The very fine, dark particles are tin-oxide, and the white areas are silver. The contact material is made by mixing silver and tin oxide powders and then sintering them.

Figure 11 shows the microstructure of the armature spring material. This is a typical microstructure of a heat treated beryllium-copper alloy. The thickness of the spring material was 0.007 inches, which results in a very weak spring. The force to move the contact is very low, meaning that any welding between the contact materials would prevent the switch contacts from opening.

Conclusions

1) The switch failed by arcing and welding of the contact materials. Silver contacts are subject to arcing and welding more so than silver-tin oxide contacts. The most probable cause of failure was the silver stator contacts.

2) The beryllium-copper spring material used in the armature was 0.007 inches thick, producing a very weak spring that would not open if any contact welding occurred. The weak spring was a contributing factor to the switch failure.