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"Excellence in Metallurgical Engineering"

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Case Study: Aluminum Fin Corrosion

By

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Subject

Examination of aluminum fins of a heat exchanger to determine the cause of deposits. White deposits were noticed on the aluminum fin material soon after the coil had been degreased. The degreaser solution was a spray-on automotive parts degreaser, and was not intended for heat exchanger applications. The investigation found that not only were the aluminum fins affected, but also the copper tubing. The aluminum fins and copper tubing were examined by visual examination, energy dispersive x-ray analysis, and metallographic examination.

Visual Examination

Figure 1 – Coil End

Figure 2 – White Deposits and Discolored Copper

Figures 1 and 2 show the end of the coil section with two rows of fins removed. Besides the white deposits on the fins, there was discoloration of the copper tubing associated with the contact area between the fin collar and the tubing.

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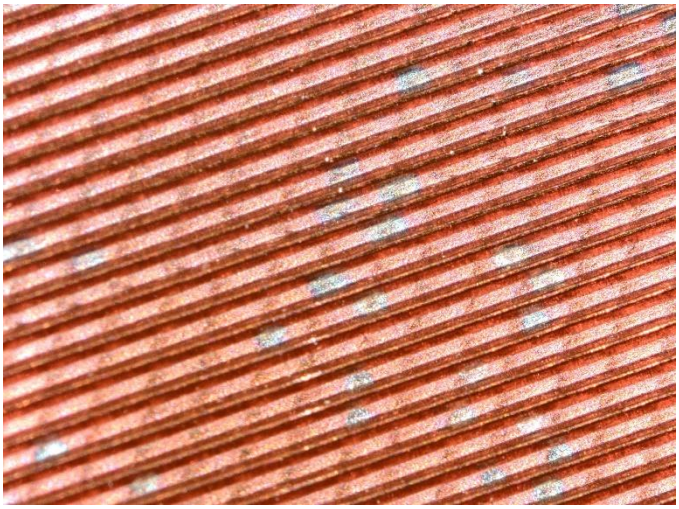

Figure 3 – Corrosion on Copper Tubing I.D.

In preparation for examination of the coil section, one of the tubes had been cut open, Figure 3. Indications of the beginnings of corrosion were found on the inside diameter of the tubing.

Energy Dispersive X-Ray Analysis

Figures 4 and 5 show the location of a white deposit on a fin. The location was near the collar associated with the installation hole in the fin material. Figure 6 shows the locations where the three analyses were done. Figures 7, 8, and 9 are the spectra for these locations. Table 1 gives the semi-quantitative analysis for these three locations.

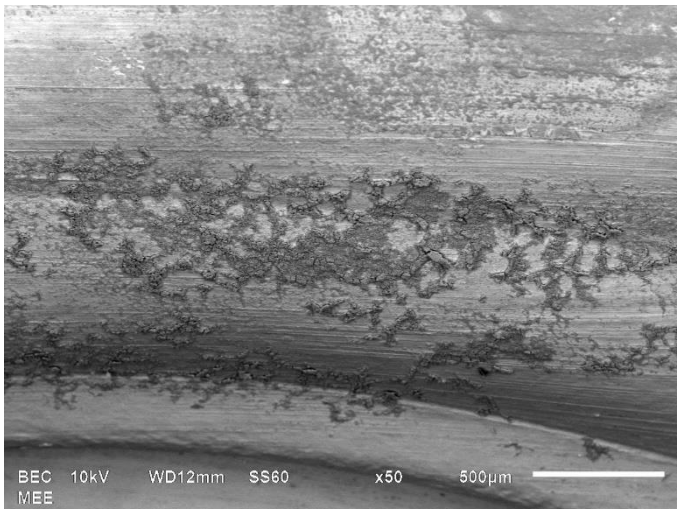

Figure 4 – 50X White Deposit on Fin

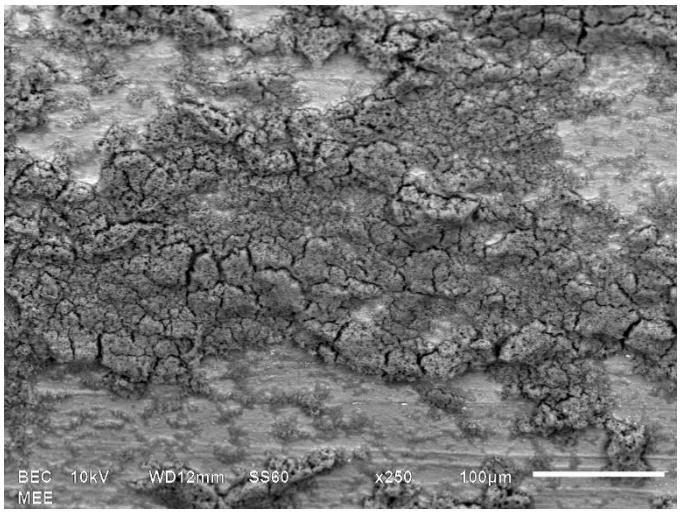

Figure 5 – 250X White Deposit on Fin

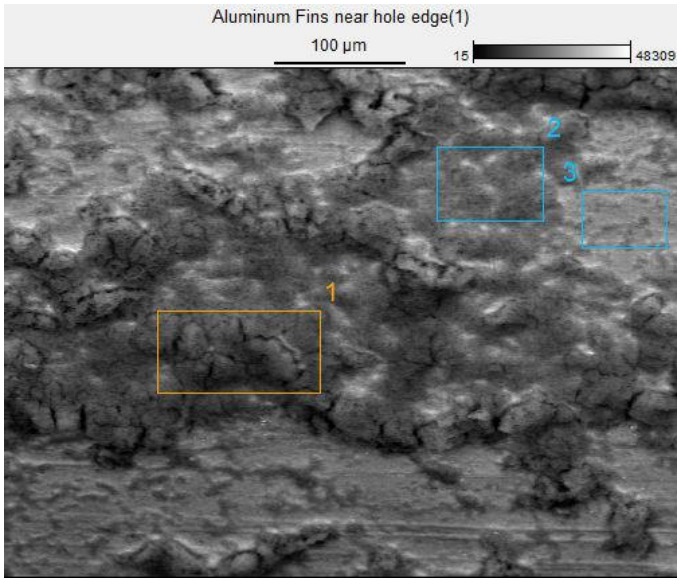

Figure 6 – 250X Analysis Locations

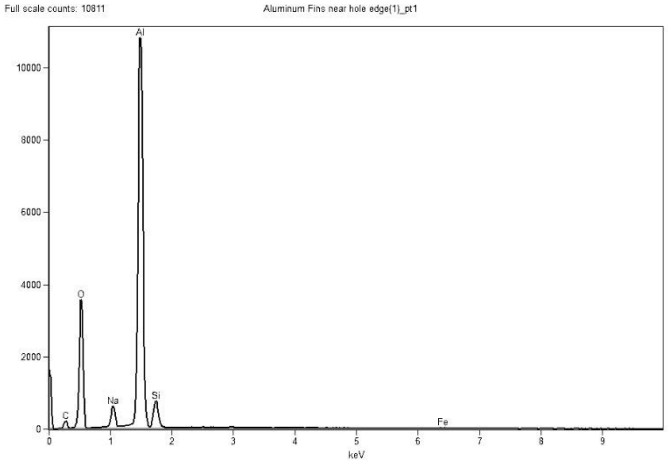

Figure 7 – Spectrum Location 1

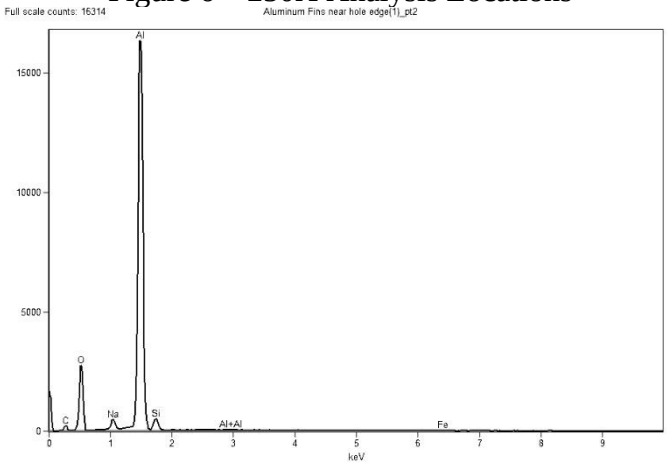

Figure 8 – Spectrum Location 2

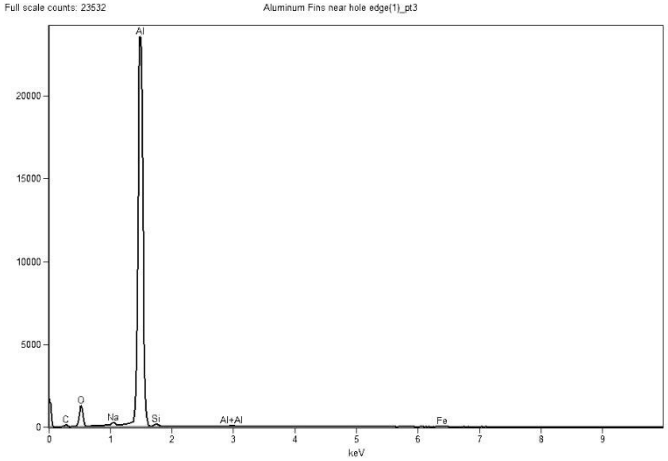

Figure 9 – Spectrum Location 3

Table 1
Corrosion Products on Aluminum Fin
(Percent by Weight)

Location	1	2	3
Carbon	5.20	5.20	4.30
Oxygen	42.40	33.10	18.00
Sodium	3.30	1.90	0.60
Aluminum	43.70	56.00	75.50
Silicon	5.10	3.10	0.80
Iron	0.40	0.70	0.80
Spectrum	Figure 7	Figure 8	Figure 9

The analysis showed the presence of sodium and silicon, indicating contamination of the fins by sodium metasilicate and sodium hydroxide from the parts degreaser. Sodium metasilicate and sodium hydroxide are very corrosive in aluminum and were major ingredients in the degreasing solution.

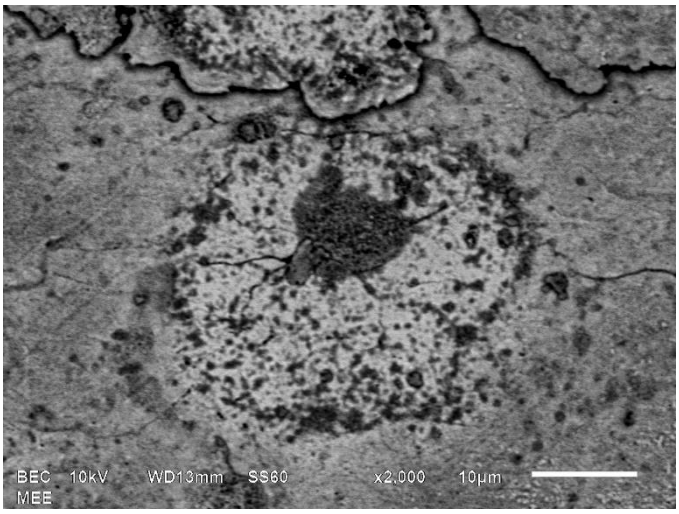

Figure 10 – 2000X Dark Spot in Copper Tube

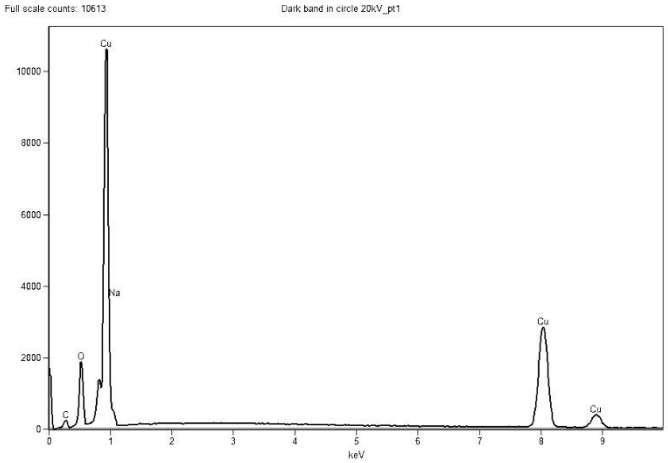

Figure 11 – Spectrum Location of Dark Spot in Copper Tube

Table 2
Dark Spot
(Percent by Weight)

Location	Dark Spot
Carbon	2.50
Oxygen	19.80
Sodium	6.60
Copper	71.10
Spectrum	Figure 11

Figure 10 shows a dark spot found on the inside diameter of the copper tubing. The presence of sodium in the Dark Spot, Table 2, indicated that the solution containing sodium hydroxide had been present on the inside diameter of the copper tubing. The copper oxide that formed was likely the result of highly alkaline conditions associated with the sodium hydroxide. Figure 10 also shows the beginning of intergranular corrosion of the copper tubing which resulted from being exposed to sodium hydroxide.

Metallographic Examination

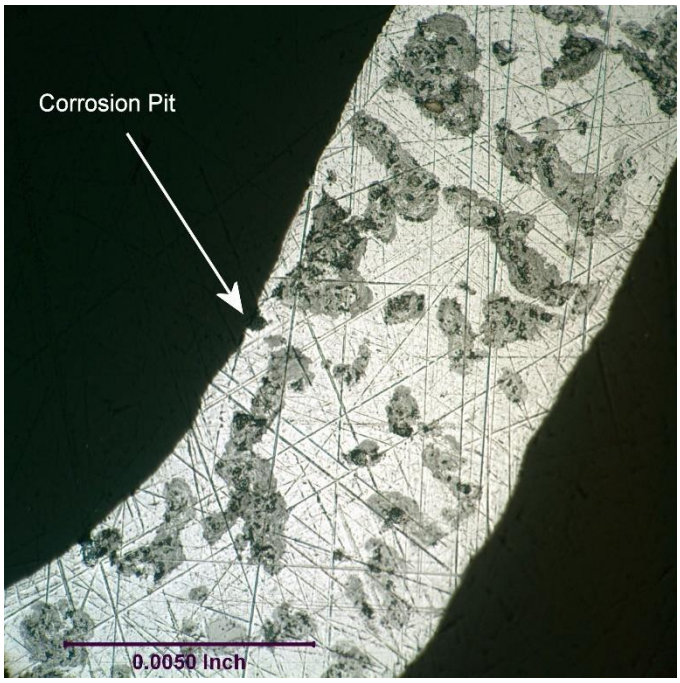

Figure 12 – 400X Corrosion Pit in Fin

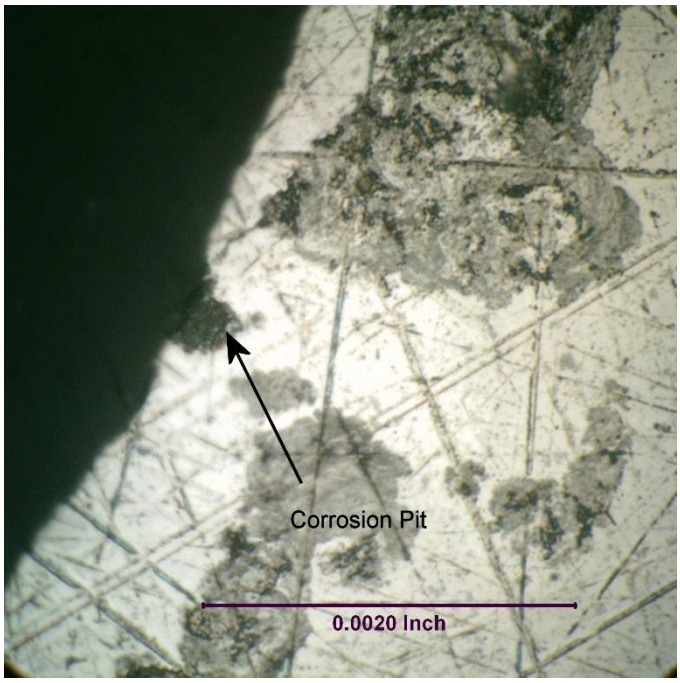

Figure 13 – 1500X Corrosion Pit in Fin

Figures 12 and 13 show a corrosion pit in the fin collar material near the tube. After the fins were cleaned with the degreaser, white deposits were noticed. This is again attributable to the sodium metasilicate and sodium hydroxide contained in the degreaser, which are both very corrosive to aluminum. These two materials will cause pitting and general corrosion of aluminum. This type of degreaser should not be used near or around any type of assembly containing aluminum or copper.

Conclusions

1. The white deposits on the aluminum fins were caused by corrosion resulting from contact with a degreaser containing alkaline chemicals, which are very corrosive to aluminum.

2. The cause of corrosion on the inside diameter of the copper tubing was contact with the alkaline chemical, sodium hydroxide.

Using Metallurgical Engineering to research this problem not only pinpointed the cause of the problem, but also indicated changes in production techniques that would eliminate the problem in future production.