

ENGINEERING PRACTICES STUDY 1161

TITLE: STUDY TO REVIEW USAGE OF ELECTROLESS NICKEL PHOSPHIDE IN
PACKAGE PLATING.

Project Number: 5961-2018-084

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STUDY PROJECT

FINAL REPORT

Study Conducted by DLA LAND AND MARITIME

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ATTACH 1

I. **OBJECTIVES:** DLA Land and Maritime-VAC has conducted an EP study to Review the use of electroless Nickel Phosphide in package plating. The purpose of this EP study was to obtain input from the military services, manufacturers, and user communities concerning the proposals to mitigate cracking found in some devices coated with electroless Nickel Phosphide.

II. **BACKGROUND:** Through a failure analysis a manufacturer has found that some devices that were seam welded with electroless Nickel Phosphide plated Kovar lids exhibit micro cracking near the seam weld zone. The micro cracking can lead to leaks after the device is exposed to MIL-STD-750, TM1041, salt atmosphere. The cracks allowed salts to deposit and corrode through the underlying Kovar material causing the leaks. Currently hermetic seal testing is not required directly following salt atmosphere in the conformance inspection of MIL-PRF-19500, the manufacturer performed it as an extra test as part of the failure analysis.

As a result of the findings, the manufacturer has added a layer of electrolytic Nickel between the Kovar base metal and the electroless Nickel Phosphide. Electroless nickel Phosphide that contains 10 +/-2% phosphorus is brittle and can crack during the seam weld process. The electrolytic nickel is more ductile than electroless Nickel Phosphide and will act as a barrier over the Kovar.

This could potentially affect all packages using an electroless Nickel Phosphide plating that has been seam welded.

Proposal: Based on the information provided from the manufacturer DLA has three potential changes to be considered to address this issue. One proposal is an additional Fine/Gross leak test to test for the potential cracking, and two proposals would add design rules to require or prohibit specific materials to prevent the cracking.

1. Add Fine/Gross leak testing to the following subgroups following Salt Atmosphere testing in MIL-PRF-19500:

Subgroup B1 (JAN/TX/TXV)

Subgroup B2 (JANS)

Subgroup C4

2. Add a design rule restriction in Appendix H requiring a layer (preferably Electrolytic Nickel) between Kovar and the immediate electroless Nickel Phosphide layer if applicable for seam welded lids.

3. Prohibit the direct application of electroless Nickel Phosphide over any corrosion-prone base metals for welded lids/packages.

Alternatively, a suggestion was made that too many additional variables exist in the manufacturing process that could potentially cause cracking and that the restriction of electroless Nickel Phosphide may not be the best solution for all manufacturers. So while a particular adjustment is needed / works for one manufacturer it might not be necessary and may even be detrimental to other manufacturers and require them to alter additional variables in their process. The seam seal process has many variables including, lid composition, lid thickness, plating layers, plating thickness, plating composition (phosphorus content), weld energy, weld repetition rate, electrode angle, electrode pressure, electrode material, native oxide, corner radius, over travel, etc.

III. **RESULTS:** Comments were received regarding the proposals to mitigate cracking near the seam weld zone of electroless Nickel Phosphide plated Kovar lids and are shown in **Attachment 1** herein. Resulting coordinated comments will provide a basis to determine which proposal is the preferred method to mitigate cracking for the affected devices or if the solution is manufacturer specific.

IV. **CONCLUSIONS:** Based on the comments received, DLA will consider adding a Fine/Gross leak test after salt atmosphere as this is also a requirement in MIL-PRF-38534. Further feedback will be requested to verify this additional test will not produce false failures. There will be no immediate proposals to add design rules regarding Electrolytic Nickel or to prohibit electroless Nickel Phosphide (Proposals 2 and 3 above) because of the large amount of variables in the manufacturer's designs and welding processes.

V. **RECOMMENDATIONS:** DLA Land and Maritime recommends that a follow up request be sent out to qualified manufacturers to test their designs through hermeticity after salt atmosphere to help determine if the test is appropriate and the test frequency. If added to MIL-PRF-19500, frequency was discussed as possibly Group B or keep as Group C once a design is proven.

Attachment 1 (Original questions with responses from 3 manufacturers and 1 user.)

1) Which (MIL-PRF-19500) device packages, currently manufactured, utilize electroless Nickel Phosphide plating?

MFR A: Currently the only military product we utilize seam weld on is in the SMD.5 (U3) package; and no electroless nickel utilized.

MFR B: ----

MFR C: We use this plating on our TO-25X and DO-X packages

USER A: What was the (nominal) phosphorus content of this bath? There are very different P contents, as low as 6% and as high as 15%. No surprise if these react differently in the welding process. Maybe, the answers will reveal a pattern. Then, one could just declare an upper limit on P concentration. But make sure it is told, if it's % by weight or at %.

a. If electroless Nickel Phosphide was utilized, have you had any qualification, conformance inspection, or customer concerns regarding corrosion of the base metal due to a breach of the electroless Nickel Phosphide plating?

MFR A: Not applicable for our operation per above answer. In a general sense though none of our manufacturing engineers had run into issues with electroless nickel on seam welded devices.

MFR B: We supply few SCD parts which use Kovar lids with electroless Nickel Phosphide per SCD (i.e. TO-254)

MFR C: No, we have had no reported concerns or evidence regarding corrosion of the base metal

b. If there was a breach of the electroless Nickel Phosphide plating was it attributed to a process control issue, or just the nature of the electroless Nickel Phosphide plating?

MFR A: Not applicable for our operation per above answer.

MFR B: No breach of electroless Nickel Phosphide plating has ever been reported, we have been supplying these parts for more than 10 years.

MFR C: N/A

2) Out of the three proposals;

(1) Fine/Gross leak testing.

(2) Requiring an intermediate layer (preferably Electrolytic Nickel) between Kovar and the immediate electroless Nickel Phosphide layer on devices with seam welded lids.

(3) Prohibit the direct application of electroless Nickel Phosphide over any corrosion-prone base metals for welded lids/packages.

a. Are there any disadvantages in the proposed additions or prohibitions?

MFR A:

1) Adding fine/gross leak testing should not pose any disadvantages.

2) Requiring that an electrolytic nickel layer be mandatory between the Kovar material and electroless Ni could change the melting temperature and sealing schedule required to achieve a hermetic seal and may be detrimental to some manufacturers processes.

3) While this prohibition would not directly affect us as none of our seam welded devices utilized electroless nickel we feel this is a drastic step given the limited nature of the problem observed. Of the three proposals we would consider the addition of hermetic seal after salt atmosphere as the preferable option.

MFR B: No

MFR C: For the fine/gross leak proposal: due to the nature of the salt atmosphere test and possible changes in the surface sorption, there is the likelihood of false failures at leak test. For the plating change proposals: Requiring an intermediate layer or prohibiting the use of electroless nickel phosphide would mean changes to our long-established, stable and successful process and plating scheme; this presents unknown risks to the possibility of future failure modes.

Attachment 1 (Original questions with responses from 3 manufacturers and 1 user.) - Continued

- b. Would there be any negative technical impact to the manufacturing processes that would be required?

MFR A:

- 1) There would be no negative technical impacts related to proposal 1.
- 2) Both proposals 2) and 3) could quite possibly entail negative technical results on the affected manufacturers as there are a large number of variable related to welding. We feel there is not enough information to justify either proposals.
- 3) Same as 2) above.

MFR B: No

MFR C: All designs and processes would need to be redeveloped, and again with unknown risks. We request more data on the issue, the evidence that true root cause was determined, and that the proposed addition of an electrolytic nickel layer eliminates the root cause, before taking further action.