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IMPROVED MOLDING OF DAP ELECTRICAL COMPONENTS IN ALUMINUM HOUSINGS

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ABSTRACT

Diallyl phthalate (DAP) resin-based compounds with fiberglass reinforcements were used for the transfer molding of electrical components in aluminum housings. The gate size for this molding is less than 1 mm, and the end products, which are very small parts, must conform to stringent dimensional tolerances (typically ± 0.05mm). Parts must also exhibit physical properties that exceed the requirements specified by Mil-M-14G without compromising excellent electrical characteristics. In the past, processing had proceeded with only minor difficulties, but an alloy change instituted for the electrode material caused molding yields to plummet from 80 to 25%. Subsequent evaluations and process modifications not only remedied the impact of the alloy change but also increased yields to 96%.

DISCUSSION

In the electrical component shown in Figure 1 the aluminum housing contains two electrode assemblies which are molded in place with DAP. To assess the molding process as it had been performed in the past, the last 13 lots (approximately 2000 parts per lot) were evaluated. Several deficiencies were discovered. Difficulties were encountered in meeting the flushness and flatness requirements of the DAP plastic as it exited the insert in the electrode region (Figure 1, flagnote 1 area). Because the flushness was not adequately controlled during the molding process, aluminum needed to be trimmed from the top of the insert in a rework operation. The rework not only incurred additional costs and inspection, but also exposed the unit to metal shavings and often damaged the leading thread. This problem required an additional operation to chase the threads before the mating part could be assembled. It was believed that improving the molding procedures could eliminate these additional steps.

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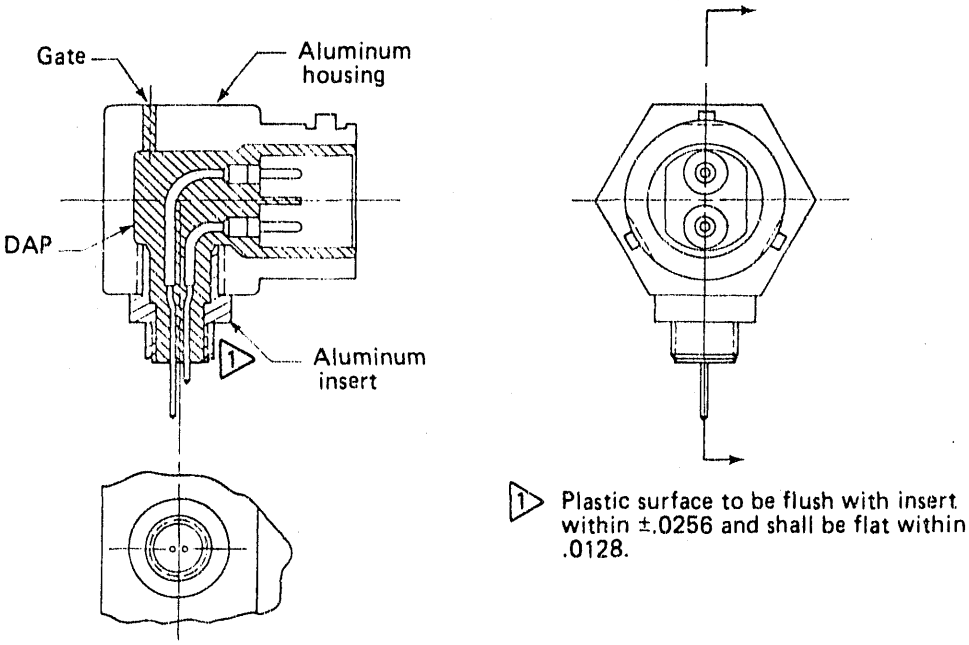

Figure 1 - Molded header.

In the first attempt to improve the molding process, vent notches were added to the insert to allow additional air to escape during molding (Figure 2). These notches were similar in configuration to the vent notches on the connector end of the housing. Under controlled conditions, 24 inserts were molded, 12 of which had the vent notches and 12 of which did not.

The correlation of the flushness and flatness readings by type, vented and nonvented, indicated no association between flushness and flatness. Therefore, independent comparisons of vent type for flushness and flatness measures were performed. The comparison for flushness and for flatness showed no difference between venteu and nonvented units. This indicated that adding vent notches did not improve the situation.

Since the behavior of the DAP plastic depends on the molding parameters, it was believed that the flushness and flatness requirements could be met by adjusting parameters. Before the mold parameter study was begun, a search for the parameters used throughout the history of the program was conducted to isolate changes and to determine their affect on the molding process. These data are contained in Table 1, and the changes to the parameters are displayed in Figures 3 through 6. The figures show that, while processing

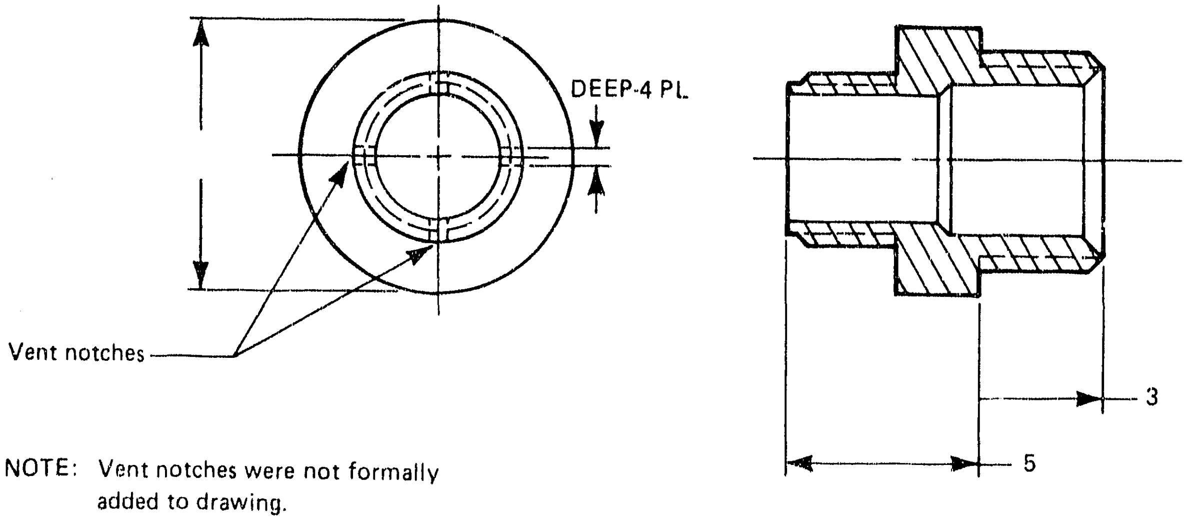

Figure 2 - Aluminum insert with vent notches.

Table 1 - MOLDING PARAMETER CHANGES

Change (Lot and Date)	Mold Temp. (°C)	Cure Time (min)	Open Cycle (s)	Feed Delay (s)	Plunger Heat (A)	Total Hold Time (s)	Hold Time Primary (s)	Ram Pressure Primary (kPa)	Hold Time Secondary (s)	Ram Pressure Secondary (kPa)
Lot 001A	160-170	3	1-1.5	1-2	0.40-0.42	28-32	9-12	3950-4740	18-20	19750-20540
Lot 001B	160-170	3	1-1.5	1-2	0.40-0.42	28-32	9-14*	3950-4740	14-19*	19750-20540
Lot 003	160-175*	3	1-1.5	1-2	0.40-0.42	28-35*	9-16*	3950-4740	14-19	19750-20540
Lot 006	160-175	3	1-1.5	1-2	0.40-0.42	28-35	9-16	3950-4740	14-19	12640-19750
Lot 007	160-175	3-4*	1-1.5	1-2	0.40-0.42	28-35	9-16	3950-4740	14-19	12640-19750
Lot 010	160-175	3-4	1-1.5	1-2	0.40-0.42	22-40*	8-20*	3555-4740	14-20*	11060-14220
Lot 011	160-175	3-4	1-1.5	1-2	0.40-0.42	22-45*	8-30*	5925-7230	14-20	11060-14220
Lot 013	160-175	3.5-4.5*	1-1.5	1-2	0.35-0.45*	20-60*	8-30	3160-7505	12-30*	7900-14220

*Denotes change.

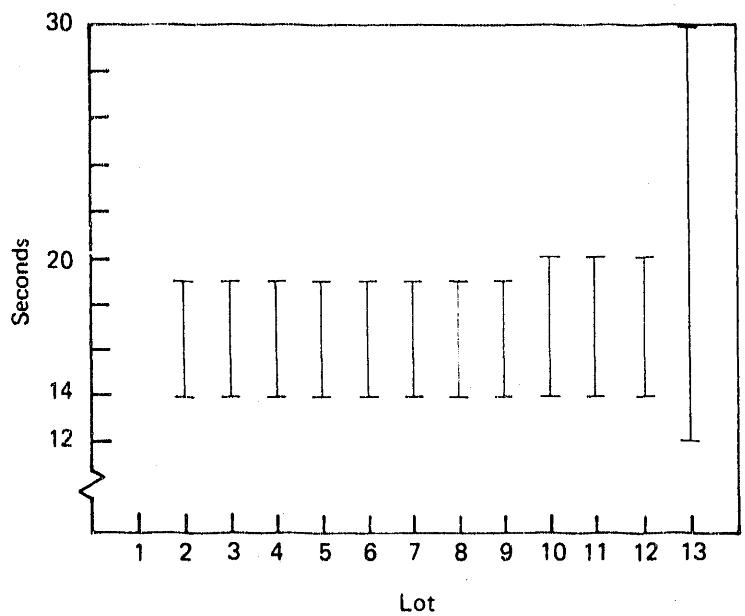

Figure 3 - Changes to secondary hold time, by lot.

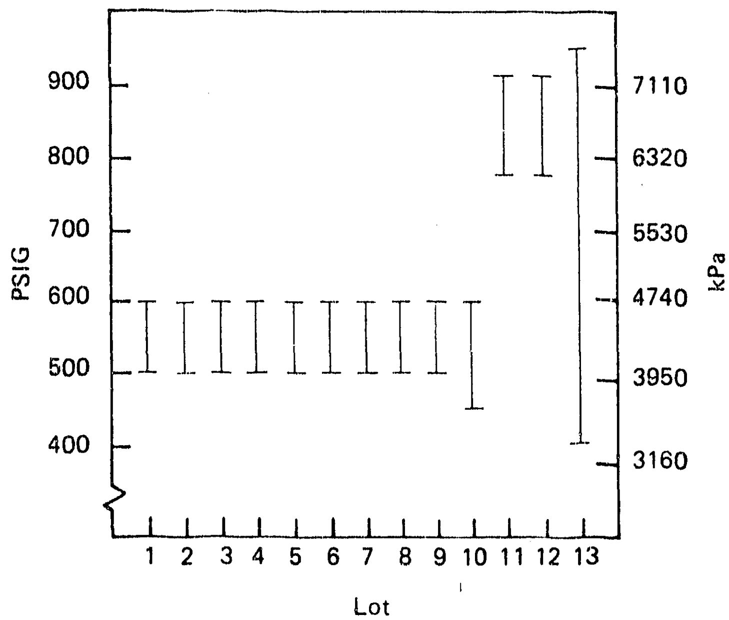

Figure 4 - Changes to primary ram pressure, by lot.

the final four lots, the tolerances of the critical molding parameters increased. An analysis of the lots revealed that yields were reduced. In addition, for lots 10 through 13, the insert trimming operation was performed on 100% of the headers molded. One stage of the plastic molding study focused, therefore, on parameters and tolerances during early fabrication of parts.

The new design presented an additional challenge. The internal wire structure requires a minimum spacing of 0.256 mm between the wires, as well as between the wires and the housing. This specification must be maintained. Because the new electrode material is softer than that used previously, it is more susceptible to movement, as the plastic is injected into the header at speeds in excess of 320 km/hr. When the electrode material was changed, the number of rejections caused by wire spacing increased dramatically, as verified by 100% radiographic inspection.

This increase in rejections was believed to be related to the location of the gate where the plastic was injected into the housing (Figure 7). Since

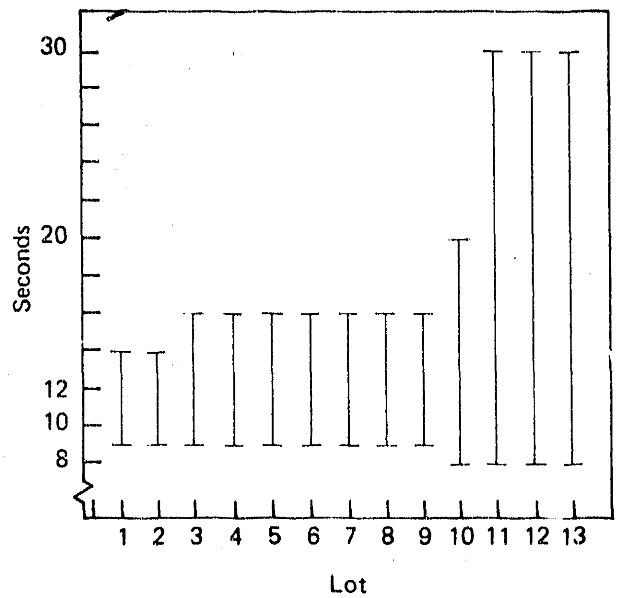

Figure 5 - Changes to primary hold time, by lot.

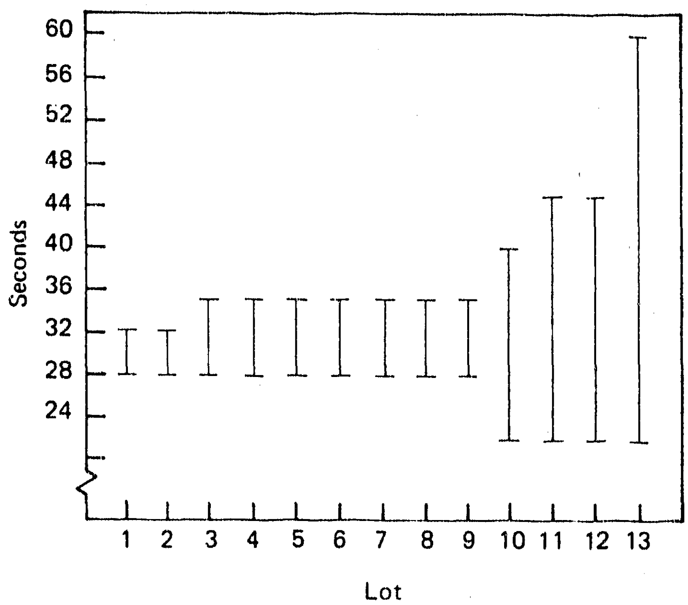

Figure 6 - Changes to total hold time, by lot.

the gate was located directly across from the wire's 90 degree bend, it was theorized that the plastic was striking the wires. When this occurred, the softer wires moved, causing rejects because of the minimum spacing requirement. To test this theory, the original gate was welded shut on several housings. Next, a smaller gate was drilled at a location that would allow the plastic to flow around the wires, thus minimizing the effect of the plastic impact. These housings were radiographically inspected and sectioned to ensure proper wire spacing and plastic flow (Figure 8). Favorable results were achieved with the new gate configuration and location. Therefore, the drawing was changed to reflect the new configuration (Figure 9).

There were, however, over 4,000 housings with the original gate design in inventory. Even though the reduction in rejections would have offset the cost of scrapping these housings, part availability and the amount of money involved led to further analysis. An experiment was performed in which the original housings were reworked to include the new design gate. A slight adjustment was made to the mold body to allow the new gate to be used

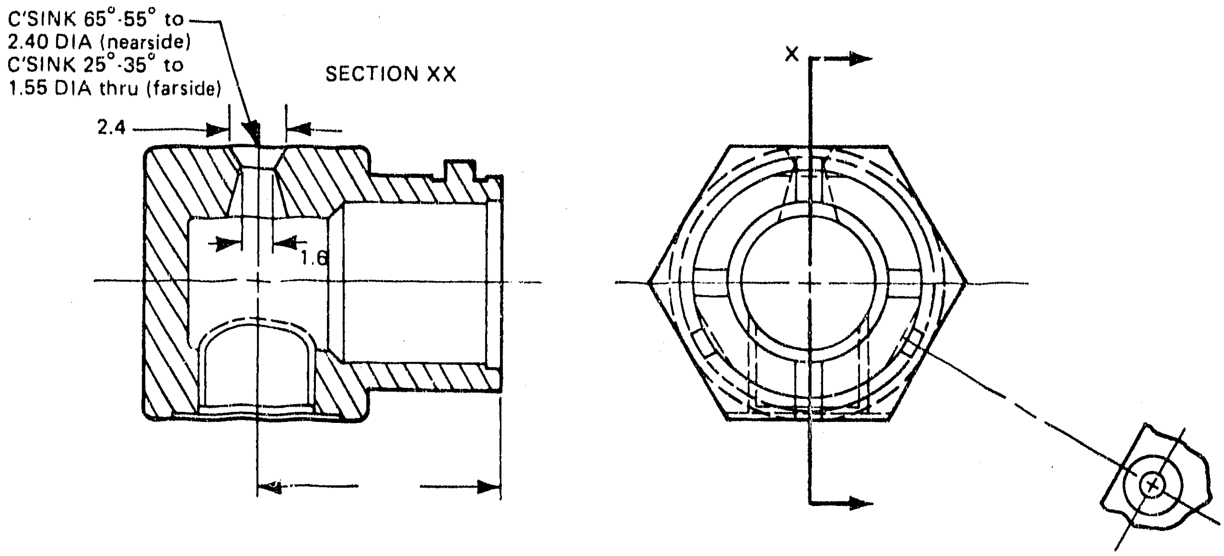

Figure 7 - Housing with original gate design.

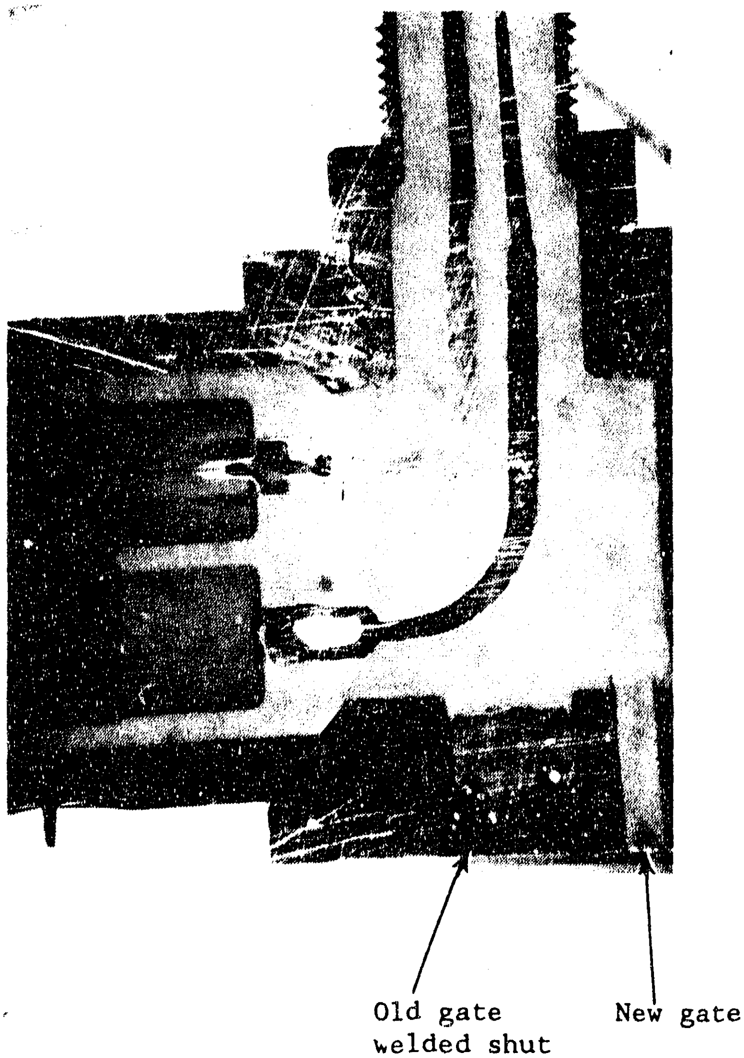

Figure 8 - Sectioned header showing the new gate. The original gate has been welded shut.

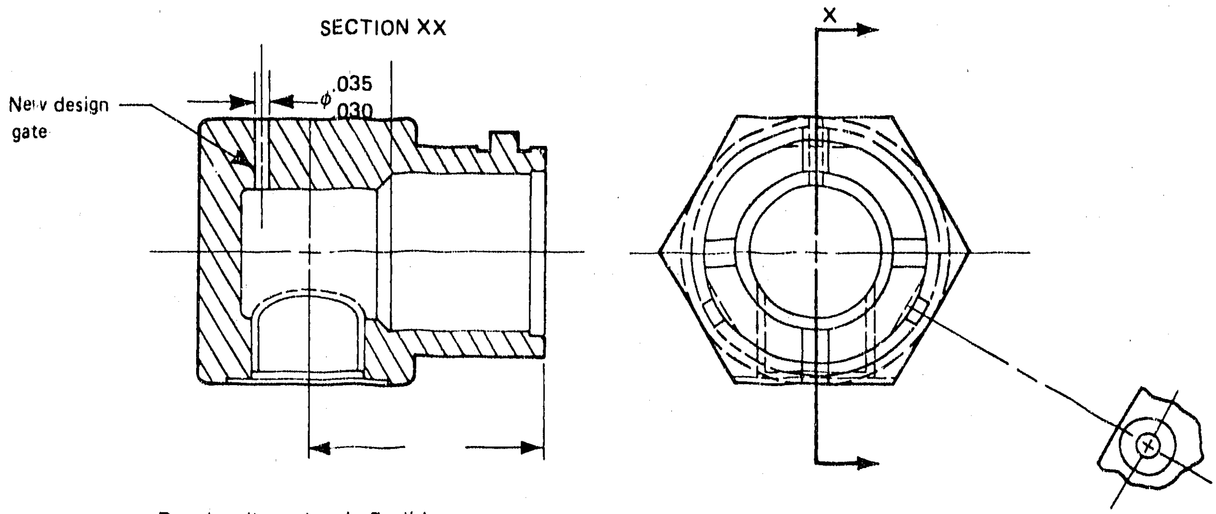

Figure 9 - Housing with redesigned gate.

during molding, and the original gate to be backfilled by the plastic. A test run was performed and molding results appeared promising. Parts were radiographically inspected to ensure compliance to wire spacing requirements; all were acceptable. Several parts were then sectioned to ensure wire integrity and to confirm that the plastic had backfilled the original gate. This experiment was also successful. Therefore, the 4,000 housings were reworked and used, resulting in a cost savings of $33,000.

With the wire spacing situation under control, emphasis was redirected to the molding parameter study. The flushness and flatness attributes were the areas targeted for improvement while not compromising the internal wire spacing. Parts were then molded under a controlled matrix study to determine the affects of mold parameters and to define their optimal levels. Part evaluation was judged by flushness and flatness, surface finish, and interior wire spacing.

The information from this molding study was used to define the parameters necessary to successfully mold the parts and eliminate the insert trimming operation and inspection previously performed due to flushness and flatness variability. The elimination of the insert trimming operation on inspection resulted in a savings of $14,700, and the combination effects of implementing new molding parameters and gate relocation improved yields and resulted in cost savings of $199,150.

CONCLUSION

Changing the electrode material of a molded header necessitated a design review of the part and a thorough process evaluation. These studies and subsequent experiments verified that design changes and process modifications could effect significant improvements in operational efficiency and yields. The positive affect on the processing time and improved yields resulted in cost savings of $246,850.

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