Gallery of goofs

This is the second in a continuing series that reports on errors of judgment made in the design and engineering of actual plastics parts and products.

In this report, Glenn L. Beall, president of Glenn Beall Plastics and former design editor of Plastics Design Forum *magazine, illustrates how one person's well-intended but uncommunicated solution to a small manufacturing difficulty created a significant loss in time and money. In the real world, Beall notes, changes are often made in the manufacturing process without the designer's knowledge; meticulous checking of the details of certain possible problems might have kept this one from happening.*

Many products, including those made of plastics, fail in the marketplace because of a well-intended but ill-advised action at some point in the product-development process. The following case history is a typical example of how concentration on the solution of one small difficulty created a much bigger problem.

In this case, the product was a simple test-tube heater that is used in diagnostic laboratories to hold reagents and tissue samples at a slightly elevated temperature (160F) for a specific time in order to accelerate a chemical reaction. An electric cartridge heater embedded in an aluminum block provides the heat. The test tubes containing the specimens are placed in holes bored into the aluminum block. The noncritical temperature is controlled by a simple surface-mounted thermostat.

The entire assembly is mounted on a steel plate, and the unit is housed in an injection-molded modified-PPO housing. The housing is a simple shell that provides the necessary aesthetics and ensures a suitable display area for the off/on switch, indicating lights and timer (Figure 1).

The housing was considered to be a simple problem, as it was virtually a no-load type of application. The PPO provided the necessary temperature resistance and the nonburning characteristics required for the application. Molded samples were tested and found to have sufficient impact strength to withstand being dropped or knocked off a laboratory bench. It was also determined that the modified-PPO housing material would provide the needed resistance to the chemicals most commonly used in the process, as well as common cleaning solutions

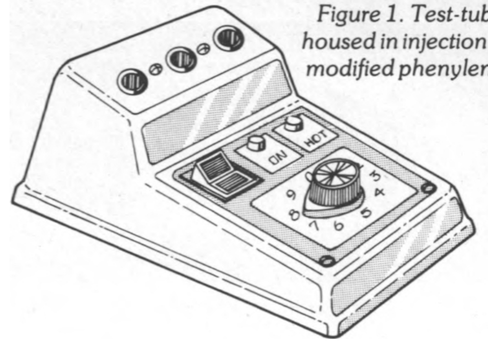

Figure 1. Test-tube heater housed in injection-molded modified phenylene oxide.

employed in this type of laboratory. Figure 2 shows the interrelationships of the various components.

The first lot of production units were produced and assembled with minimum difficulty. Sales volumes developed much as expected. Reports from the field indicated that the product was well received and that it performed as anticipated.

Shortly after the initial introduction of the product, users registered complaints about the housing's tendency to crack between the three test-tube heating wells. These failures did not prevent the unit from performing its intended function, but the cracks did destroy the nice appearance of the housing.

Investigation into the cause of the housing failures included considerations of material substitution and pigment compatibility. Molding procedures, especially weld lines around the holes, were also studied. The tolerances that govern the fitment between the heating wells that project through the housing and the housing itself were rechecked for a possible interference fit. The possibility of a stress failure caused by the differences in thermal expansion between the plastics and the aluminum heating block were also considered. None of these investigations revealed the source of the failures.

Unused units that had been assembled at the same time were withdrawn from stock and inspected. None of these units had cracked housings, an indication that the source of the problem had to be in the actual laboratory use of the product.

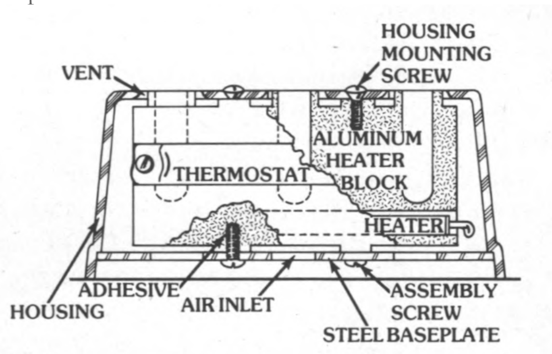

Figure 2. Schematic of test-tube-heater components.

Careful examination of the actual fracture surfaces seemed to indicate a stress-cracking pattern (Figure 3) characteristic of a chemical attack.

Premarket introduction testing had already suggested that the plastics was not adversely affected by common chemicals used in this diagnostic procedure.

The possibility of other chemicals being used in specific laboratories was considered and rejected since, by then, virtually all of the housings in use had failed. Attention was then directed to the assembly procedures.

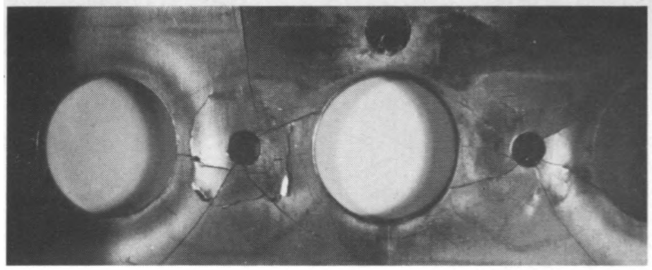

Figure 3. Stress-cracking pattern indicative of a chemical attack.

Detailed manufacturing procedures had been written, but a review of the component list did not reveal any item that could be suspected as a possible stress-cracking agent for PPO. The possibility of a residual machining fluid on the assembly screws or machined-aluminum heating block was also investigated with negative results. Heaters and thermostats were operated at the maximum temperature to determine whether or not they would disperse a volatile gas, but this did not prove to be the answer.

By this time, the product had been discontinued and the assembly line shut down. An actual inspection of the assembly line did reveal, however, a small can of adhesive of the type used to hold metal screws in place. This type of adhesive was not listed in the manufacturing instructions. A series of probing questions revealed that the adhesive had been added as an afterthought.

The logic in using the adhesive was good; however, the well-meaning person who applied it had not stopped to consider the possibility of an incompatibility between the adhesive and modified PPO. That was very understandable, as the adhesive itself never came into actual contact with the plastics housing, as can be seen in Figure 2.

The test-tube heater was designed to allow all of the components to be assembled on the metal baseplate. The plastics cover was not placed in position until after the unit was totally assembled and tested. The adhesive was added to the assembly screws on the baseplate in order to discourage anyone from inadvertently removing the baseplate instead of the plastics housing to service the unit.

Actual testing of full assemblies under normal usage conditions revealed that the adhesive dispersed a very small amount of volatile gas during the first few hours of operation. This gas followed the normal flow of cooling air through the assembly, which brought the volatile gas in contact with the inside surfaces of the plastics housing. These volatile gases only attacked the plastics housing in the two relatively high-stressed areas around the upper two flathead-screw holes that were used to attach the housing to the rest of the assembly. The two screw holes on the lower level were unaffected, since the volatile gas did not contact that area in the assembly.

A phone review with the adhesive supplier's technical people revealed that they were aware of some problems associated with chemical incompatibility and indicated specific adhesives having formulations that would be compatible with PPO.

Another phone call to the plastics material supplier confirmed the adhesive manufacturer's comments. It was interesting to note that the plastics material supplier's excellent product bulletin listed adhesives of this type as a possible stress-cracking agent.

In accordance with the material supplier's recommendations, a different adhesive was chosen and its use was written into the manufacturing specifications. After accelerated testing, the product was reintroduced. Those customers who had cracked housings were provided with replacements. Cracks in the test-tube heater housing are no longer a problem.

In summary, a simple addition to the manufacturing process was made in order to improve the product. Unfortunately, this well-intended action resulted in a significant loss in time and money.

The good end product could have been achieved and the problem avoided from the start if this change in the manufacturing procedures had been reviewed with the design engineer responsible for the plastics housing. He would certainly have been aware of the fact that many plastics materials can be attacked by many chemicals, including solvents and adhesives. A simple check of the plastics material supplier's literature would have confirmed the probability of this type of failure. A compatible adhesive could have been specified and the problem would have been avoided.

As in most endeavors, the secret to a successful product-design and development project is often meticulous attention to details. In this case, that would have meant checking the chemical compatibility of all of the materials that would or might have come into contact with the product. It is also obvious that the manufacturing specifications should not have been changed or added to without prior approval.

Designers must recognize, however, that in the real world, changes are often made in the manufacturing process without the manufacturer going back through the product-approval committee or specification-writing procedure. The "same" ABS from a lower-cost source or an "identical" soldering flux that is easier to use or the addition of an "insignificant" amount of lubricant to improve molding are all changes of the type that somehow or other are made without official approval. Designers investigating failures would be well advised to be skeptical of the glib phrase "We haven't changed anything," and should actually go and see for themselves.