MLM-3525(OP)

29th Annual Meeting of the INMM, Las Vegas, Nevada, 27-29 June 1988

"S" GLASS MANUFACTURING TECHNOLOGY TRANSFER

Dean A. Buckner
Monsanto Research Corporation
Mound
Miamisburg, Ohio

Howard L. McCollister
Sandia National Laboratories
Albuquerque, New Mexico

START TITLE PAGE

ABSTRACT

A glass-ceramic-to metal sealing technology patented by Sandia National Laboratories, Albuquerque (SNLA) was developed by MRC-Mound for use in the manufacture of weapon components. Successful implementation attracted increasingly widespread weapon use of this technology. "S-glass" manufacturing technology was transferred to commercial vendors to ensure that weapons production schedules would be met in the coming years. Such transfer also provided sources of this fledgling technology for the Department of Defense (DOD), aerospace and other commercial uses. The steps involved in the technology transfer are described, from the initial cooperative development work of Sandia and Mound scientists and technologists to the final phase of qualifying commercial vendors for component manufacture.

INTRODUCTION

Technology transfer has become formalized in recent years. A form of technology transfer has long existed within the DoE complex of integrated contractors. The development of "S" glass technology at Sandia National Laboratories resulted in the customary interagency technology transfer to the Mound production facility in order to accomplish a mission. That very important transfer is briefly alluded to in the following section. The major thrust of this paper is to describe the steps taken to transfer the manufacturing technology, as developed at Mound, to private industry. The program was specific in its scope, conceived by persons involved with a necessity and carried out for a self-serving purpose. Certainly the policies of that more formalized technology transfer philosophy were acknowledged, and those in the private sector stood to gain therefrom. The reader may gain insight from this case history.

Mound is operated by Monsanto Research Corporation for the U. S. Department of Energy under Contract No. DE-AC04-76-DP00053.

BACKGROUND

Electrical feedthroughs are required to carry current from a power source into apparatus isolated within a controlled environment. Numerous devices which include this feature are used in the general electronics industry, with specific adaptations for use in weapon systems. The feedthrough concept provides electrodes encased within an insulating material which separates them from one another and from any metal housing. The insulator is also a structural barrier providing environmental isolation.

Development work done at Sandia National Laboratories, Albuquerque resulted in the award of U.S. Patent No. 4,414,282 "Glass-Ceramic Seals to Inconel". The patent teaches that the particular glass composition known as "S" glass, will bond to high nickel alloys when molten, thus forming a strong, hermetic (gas tight) seal. Furthermore that a defined thermal treatment causes the glass to crystallize into a polycrystalline material, known to technologists as a glass-ceramic. The controlled crystallization produces a material with a thermal expansion which matches that of the metal, thus forming a durable glass-ceramic-to-metal seal. Feedthrough devices so made with proper metal alloys are exceptionally strong. The "S" glass-ceramic is twice as strong and three times tougher than glass. The material is also an excellent insulator, with dielectric breakdown strength measured at 3800 volts per mil. "S" glass technology is a vernacular abbreviation which is understood to describe the particular joining of certain metals to the "S" glass (glass-ceramic insulator).

Advantages are realized in the manufacturing of feedthrough devices when using "S" glass technology. An assembly of metal piece parts is quickly made on a holding fixture. The initial glass part needs be nothing more than a convenient piece of proper weight added to the top of the assembly. Multiple assemblies contained within an atmosphere-controlled furnace are automatically processed through a microprocessor-controlled thermal cycle. Upon melting at 1000°C, the glass flows into the metal housing, filling all space while affecting a chemical bond with the metal surfaces. The glass flows through even tiny openings, and complex geometries are achieved, while molding the electrodes firmly into place. Lower temperature heating steps cause the glass to crystallize and form the glass-ceramic material; the metal housing can be precipitation-hardened through ensuing heat treating steps. This whole process is completed in a single furnace cycle. Sealed parts are ready for machine finishing, metal cleanup and selective gold plating. The manufacturing process is cost-effective in that it is not labor intensive and yields as high as 95% are realized. Demonstrated function reliability exceeds .9998 indicating that only two components are expected to fail in 10,000 units tested.

Sandia designers utilized the novel technology to create components of exceptional strength and reliability. These were headers used to contain explosive events in ignitors, detonators and actuators. Such finished explosive products are fabricated for the DoE Weapons Complex by the Mound Plant, or by subcontractors responsible to Mound. Feasibility demonstrated by Sandia work resulted in a program to fully develop the new headers into viable components for weapon use.

effort

Accordingly, a joint effort occurred to affect interagency technology transfer between Sandia and Mound. A two year R&D and testing period ensued wherein details of design, "S" glass compositional specifics, and process parameters were derived and specified. A great deal of scientific understanding was evolved by Sandia. Mound concentrated upon productionization methodologies. A notable achievement was the acquisition of a qualified source of the "S" glass. By working with a commercial supplier, large quantities of the specified homogenous "S" glass were produced in custom-made glass castings.

The program resulted in production of two "S" glass headers plus significant development of several more slated for production, and demonstrations that more components of varying geometries were equally feasible. The successful track record attracted growing interest in the novel feedthrough product such that steps to assure a continual supply were necessary. In parallel with Mound's upgrade of manufacturing capacity, a major program was initiated to transfer the manufacturing technology to private industry to enable contract manufacturing of headers by those suppliers that became qualified for this procurement.

PROGRAM DESCRIPTION

Prior to any action, the concept of the proposed manufacturing technology transfer was presented to top management in the DoE, Sandia and Mound organizations. This confirmed that no interests would be violated, indeed that such transfer would be in keeping with policies to procure services from the private sector. The avowed goal was to cultivate multiple competitive sources and obviate sole source procurement. The proposed vendors would be qualified to manufacture designated components in keeping with quality assurance and procurement requirements. Components designated for manufacture would be those proven to be manufacturable via Mound's development procedures.

A task force was formed from pertinent disciplines of: Procurement, Quality Assurance, Product Management, Process Engineering and Ceramic Development. This group formulated and carried out the manufacturing transfer program.

Prospective vendors from U.S. industry were sought on a selective basis. Limited resources caused a search for potential vendors from those firms that had experience in similar manufacturing and had become known to have more than casual interest in the new technology. Three such sources were used, i.e., those firms that had obtained license to the Sandia patent, those recorded as participants in the more general technology transfer program sponsored at Sandia, and those firms that had made conventional ceramic headers for Mound or Mound sub-contractors. Twenty-eight companies, thus identified, were notified of the program by mail, and requested to return short answers to a survey of questions designed to assess the suitability of their facilities to engage in the proposed activity. It was pointed out that a growing market existed within the DoE, and that knowledge of the new technology could apply to other markets for their own benefit.

From the responses, few companies were judged to be inappropriate for "S" glass seal manufacture and were so notified. Others declined further interest. Fourteen companies accepted an invitation to send representatives to Mound for a one-day seminar. A total of thirty people attended, representing companies with all levels of experience in contract dealings with an agency of the U.S. Government.

The business side of the seminar covered those aspects of procurement regulations and quality assurance requirements, such that the potential vendors would understand the nature of audits and compliance surveys attending possible future contracts. Technical presentations were given on the science and technology of "S" glass feedthrough sealing, and on the manufacturing process used at Mound. It was particularly useful to tour the pertinent production facilities. Attendees saw firsthand that production personnel operating realistic equipment were indeed producing real products. It was important that the products could be seen in their final quality forms in order to appreciate the potential that could be realized in their own facilities.

The seminar attendees were briefed on the future plans of the program. It was pointed out that the vendors would make a contribution by fabricating some units in order to demonstrate their own equipment and resources. Given two weeks for the attendees to report and the vendors to consider, a second letter was sent. Additional information was included to clarify questions that had arisen at the seminar. A response was requested as to whether the vendors wished to continue with the program and receive on-site visits by task force members. Nine companies responded positively.

The first team of Mound personnel represented Procurement, Quality Assurance and Ceramic Technology. The purpose of the visits was to survey each vendor's contract administration system, quality control capability, and to examine the fabrication equipment/production facility. Invariably, vendor personnel, not at the seminar, wanted source information. Mini-seminars were extemporaneously tailored to meet those inquiries. Discussions centered on the suitability of available equipment. As a result of this visit, one firm concluded that they could not technically perform and declined further participation in the program.

The remaining eight firms received drawings and process manuals detailing Mound's procedure to manufacture one selected header to meet the product specification. The header selected was fairly simple but required full processing to form the seal plus metal conditioning, and required finish machining of metal and glass along with selective gold plating. The component was in production at Mound, thus there was much experience in its fabrication and evaluation.

The second team visit from Mound personnel included process engineers, expert in all phases of the manufacturing detail. The purpose was to clarify drawings and processes with vendor personnel. An important aspect was to critique the vendor's fabrication plans and to counsel on the characteristics of the differing kinds of equipment that were available. Each vendor was given a quantity of piece parts drawn from Mound's production stock. It was important that known good piece parts be used lest the pedigree of those materials cloud the evaluation of the vendor's processing capability.

The vendors then set out to fabricate the prove-in units. In order to demonstrate approved capability, Mound required a total of fifty units processed from at least three separate furnace seal cycles. The vendors made their contributions by producing the seal fixturing, providing the labor and the shop facilities to fabricate the parts. During this period, Mound engineers were frequently consulted by phone and Mound performed first article evaluations of submitted specimens.

Upon receipt of the completed prove-in lots of headers, Mound performed a complete evaluation of the products. The choice of the prove-in header type, a Mound-manufactured item, was important in that evaluations were facilitated by the fact that all of the unique gages and test fixturing existed, plus experience therewith. All product was evaluated for dimensional and test performance attributes as done for Mound produced units. In addition, characteristics dependant upon process parameters were evaluated via techniques known from component development work. Each vendor was apprised of the evaluation results. Specific attributes failing to meet the product definition were indicated, with probable cause and corrective suggestions communicated.

Three vendors failed to produce prove-in lots. Lack of suitable equipment caused them to terminate their efforts. The five remaining vendors submitted finished lots; each showed a different degree of workmanship in the various categories. The discrepancies, as found in all of the vendor lots, were not fundamental to the process and could readily be corrected. For instance, dimensional control and surface finish were seen as minor faults derived from machining practice. Indeed all five vendors exhibited units that were perfectly functional. As a result, all five were designated as "approved" manufacturers of the "S" glass feedthrough products.

Ten months elapsed from the time of the seminar to the completion of the prove-in evaluations. Attaining the "approved" status of five vendors was a major milestone of the technology transfer program. These manufacturers had demonstrated their abilities to physically cope with the required technical phases to produce the end product. Coping means that while all of them produced the glass-ceramic seals, some found it necessary to subcontract the gold plating and/or some machining. It was considered probable that all five vendors could be self-sufficient in that commercial suppliers of the metal piece parts and the unique "S" glass had been established and used to supply Mound's needs. Therefore, these vendors could evoke their own make/buy decisions and carry out contract manufacturing using their own quality control procedures to furnish components to meet the product specifications.

IMPLEMENTATION

The next task is to firmly establish a number of approved vendors that will wholly perform as "S" glass component manufacturers to supply Mound's procurement needs of defined quality, quantity and scheduled deliveries. At this writing, each of the five approved vendors is engaged in contracts to fabricate specific "S" glass-ceramic headers. The headers are the first of two kinds, now being made at Mound, that have been chosen for contract manufacture. The present contracts are for small pilot lots that will be use-tested to ensure design performance. The vendors are required to perform the complete job, meet drawing requirements and provide evidence of compliance with process parameters. Those vendors meeting the contract requirements and whose product satisfies the use-test performance will be "qualified" to manufacture that specific component. Future component types for outside manufacture will probably be addressed in a more efficient fashion. Requests for quotes will go to all approved vendors, for a pilot lot plus a production lot. The successful awardee will first establish his status as being qualified to make that header via the pilot lot, then proceed to make the production lot. By judiciously applying procurement latitude as future situations warrant, it is planned that a small cadre of dependable vendors will be established.

It must be pointed out that it seems most desirable to have a small number of consistent and dependable vendors. Mound's technical staff is limited, and should not be impacted by a large demand to interface with outside suppliers. The vendors should realize benefits in that Mound's continuing experience may be transferred to improve the fabrication of Mound parts in their shops. In addition, diverse analytical resources are available at Mound to direct in the solving of production process problems.

SUMMARY AND CONCLUSION

Successful transfer of a novel technology was made to private industry. Following interagency technology transfer from Sandia National Laboratories to Mound, electrical feedthrough headers were developed for production. A program to establish contract vendors was conducted by a Mound task force. Selected potential vendors were apprised of the new technology and its market via a Mound-site seminar and by vendor-site personnel contacts. Interested vendors demonstrated their capabilities by fabricating units for evaluation by Mound. Five vendors were successfully approved for future contracting in that they were seen to meet the requirements for contract administration, quality control and technical ability. Current fabrications by these vendors will establish those qualified to manufacture designated components via competitive awards for production procurement.

A final fact worth noting is that through our communications, at least two of the selected vendors have already been engaged in making demonstration devices for receptive markets in the DoD and NASA.

TEXT STOPS HERE