MDC-III Feedthrough Status

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1 Introduction

Feedthrough production for MDC-III is progressing at Colorado State University. Prior to the start of production, much time was spent developing and testing prototypes for the new chamber. This note outlines the prototype work and the production of the new feedthroughs as of this date.

The new feedthroughs are essentially copies of the MDC-II feedthoughs, with a few minor design changes to facilitate easier molding. The major change from MDC-II was the decision to produce the feedthroughs from Celanex 3300-2. This material was successfully used in the production of the BaBar drift chamber feedthroughs by CSU.

The inserts for MDC-III will be molded from Celanex 3300-2 instead of being machined from Delrin, as for MDC-II. While there are no problems associated with the machined inserts, molding the inserts has the advantage of being able to produce a smaller diameter precision hole. In MDC-II there are 150 μm (sense and guard wires) and 250 μm (field wires) holes. With molded inserts, 100 μm holes will be produced for the sense wires.

2 Prototype Tests

During prototype development of the feedthrough prototypes, there was close interaction with the plastic manufacturer (Ticona), the molding company (Soft Touch), and the solder pin manufacturer (Medelec). Nearly all of these interactions were undertaken by CSU engineer Dave Warner, ensuring a smooth continuity in development and production. The prototype feedthroughs were subject to a series of tests designed to indicate the ability of the feedthroughs to perform as designed for the life of the new chamber.

2.1 Long-term High Voltage Tests

From our experience with MDC-II, the response of the feedthroughs to long-term application of high voltage was a particular concern. A sample of the first usable prototypes was assembled with solder pins in a 4 cm aluminum block and connected to a -4kV power supply on 30 January 1998. There are 42 feedthroughs in this test. The current draw of the

Figure 1: Current draw and ambient humidity during the -4kV high voltage test.

2.2 Mechanical Tests

To test the stability of the pin stop in the feedthroughs, several stress tests were done. In all of these tests, feedthroughs were assembled with solder pins. The feedthroughs were inserted vertically in aluminum plates with 18 ga copper wires attached to the solder pins. Weights were attached to the wires and the feedthroughs were observed for several weeks to look for signs of pin stop creep. One test was done at room temperature with three feedthroughs, each with 6 kg (the highest tension in the chamber will be 600 g on the thick field wires) attached to the wires. A second test was done at elevated temperature using 600 g and 1800 g. There was no observable creep in any of these tests.

2.3 Visual Inspection

During the prototyping phase a great deal of effort was put into the inspection of feedthroughs to identify problems with the molding process. Feedthroughs were destructively examined for voids and surface texture. Molding parameters (mold temperature, pressures, etc.) were monitored to ensure they were all within the recommended ranges for the plastic. Feedthroughs were measured, and this information was fed back to the mold maker and molder, who fine-tuned the mold cavities and molding parameters to produce feedthoughs within specifications. Only after satisfactory prototypes were produced was production started.

3 Production Tests

To ensure adaquate quality assurance and conrol during production, several tests are performed. There are both non-destructive tests (visual inspection, dimensional measurements, and short-term high-voltage tests) done on all feedthroughs and destructive tests (plastic integrity and visual inspection of cross-sections) using only a small sample of feedthroughs.

3.1 Dimensional Measurements

Feedthroughs are assembled with inserts and then the outer diameter of the feedthroughs, the inner diameters of the inserts, and the concentricity of the precision insert holes with the outer diameter of the feedthroughs are measured. A maximum of 50 μ is specified for the concentricity. Figure 2 shows the concentrities of a typical sample of feedthoughs, which peaks at about 25 μm. Any feedthrough over the maximum concentricity is discarded. Feedthroughs are also discarded if the outer diameter or inner diameter are out of tolerence. About 1% of the production feedthoughs are being discarded for being out of tolerence or otherwise failing a visual inspection.

3.2 Short-term High Voltage Tests

Every production feedthrough is placed on high voltage. A voltage of +4kV is applied to the solder pins, and the feedthroughs, in batches of 300, remain at this voltage overnight. Before being taken off high voltage, current draw and noise levels are measures. Typical currents for a batch range from -0.2 nA to 0.2 nA, consistent with zero for the equipment used. Typical noise rates for a batch, at a threshold of 500 μV, are 0.5 Hz with humidity-dependent excursions to 1 Hz. No feedthroughs have failed the high voltage test to date.

3.3 Plastic Integrity

When plastic is molded, the virgin material is melted and allowed to freeze inside a mold cavity. During this process, polymer chains are broken as the plastic is heated and then the plastic crystallizes as it cools. To ensure adequate ploymerization and crystallinity in the finished feedthroughs, samples of molded feedthroughs are sent to a commercial laboratory for analysis. Two standard tests are performed, differential scanning calorimetry (DSC) and melt index testing (MIT).

Figure 2: Concentricity measurements from a sample of the production feedthroughs.

The DSC measures crystallinity by measuring heat flow into and out of a sample (compared to a standard) as a function of temperature. Typical crystallinity values for processed Celanex 3300-2 range from 28% to 38%. Feedthroughs at beginning of production have a crystallinity of 35%, feedthroughs from the end of production have 30%, and inserts have 30%.

The MIT indicates polymerization by measuring the viscosity of the melted plastic. The result of the test is reported as the mass of material flowing through an orifice in a given time interval. For virgin Celanex 3300-2, this value ranges from 17 to 19 g/10 min. Most of the material used in the MDC-III feedthroughs was at the high end of this range. Processed material should have a MIT value less than twice the value for virgin material. Feedthroughs from the beginning of production are reported at 29.42 ± 1.2 g/10 min, feedthroughs from the end of production are reported at 25.5 ± 0.5 g/10 min, and inserts are reported at 26.8 ± 0.0 g/10 min.

Both these results indicate the plastic was handled properly during molding.

3.4 Visual Inspection

Samples of production feedthroughs were cut open to look for voids in the plastic and sinks on the inner surface. No significant voids or sinks have been found. Small voids in the pin stop ($\approx 50\mu$m) are found. These voids have been examined in prototype feedthroughs both before and after application of high voltage for an extended period. No changes in the voids are observed, indicating no degradation from electrical discharge. The extremely low noise rates in the high voltage tests also indicate no activity in these voids. Very small folds (a few micrns wide) are seen on the inner surfaces. These features also do not change with application of high voltage. No future problems are indicated.

4 Production Schedule

All feedthroughs, inserts, and solder pins are at CSU, where they are being cleaned, inspected, assembled, and tested. As of early June 1999, 4500 100 μm, 3500 150 μm, and 16k 250 μm feedthroughs had been completed. At the present rate of about 600 completed feedthroughs each day, the feedthroughs will be completed on schedule.

5 Conclusion

Feedthough production for MDC-III is about halfway done at CSU. The molded plastic has been tested and is within the manufacturer's specifications for processed material. Feedthroughs are throughly inspected and tested with a very low failure rate.