**Test Report**

**Spallation Neutron Source Project**
**MEBT Chopper Prototype Structure Outgassing Test**

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## Introduction

A prototype MEBT Chopper Structure assembly was tested in the Outgassing Measurement Test Stand, located at TA-53, Bldg. 365, Rm. 109A. The primary components of the prototype assembly consisted of a circuit board assembly bonded with epoxy to a machined aluminum base and enclosed by a formed sheet aluminum cover assembly. Two electrical connectors with mounting brackets were also in place during testing. The primary focus of the outgassing test was the gas load contribution from the non-metallic components of the prototype assembly in a high vacuum environment.

## Test Equipment

The Outgassing Measurement Test Stand consists of off-the-shelf high vacuum (HV) and ultra high vacuum (UHV) components. Standard vacuum industry practices were used for all cleaning and assembly procedures during the testing activities. The test stand pumping equipment consists of a Shimadzu TMP-403M magnetically levitated turbo-molecular drag pump backed by a VRC oil-free piston roughing pump. The approximate pumping speed of this equipment, as assembled, is 400 L/s (for nitrogen). The vacuum test chamber consists of a 24"L X 8" OD (w/ 10" conflats each end) stainless steel vacuum nipple mounted atop a 6"L X 6" OD (w/ 8" conflats each end) stainless steel vacuum nipple attached to the inlet of the turbo pump. The two vacuum nipples are joined via a zero-length reducing conflat flange and the top of the vessel is sealed with a 10" conflat adapter with three 2-3/4" conflat ports for attaching instruments. The instrumentation on the test chamber consists of a Granville-Phillips Model 370 Stabil-Ion gauge and a Leybold-Inficon Transpector 2 RGA. The ion gauge and RGA data is recorded by a PC running Labview software. Granville-Phillips ion gauges are individually calibrated at the factory and are shipped with a memory module containing the calibration. The memory module is then downloaded into the gauge controller and provides 3% accuracy.

The upper portion of the vacuum chamber (24"L X 8" OD nipple and attached hardware) was received new from the factory prior to the test. These were first cleaned with acetone, then cleaned again with ethyl alcohol. The vacuum vessel was assembled without the test sample for bakeout and baseline measurements. The vessel was then pumped down and heated to an average surface temperature of approximately 300°F for a period of four hours. After the test chamber assembly cooled for several hours, the steady state pressure was approximately $6\text{x}10^{-8}$ Torr.

The outgassing rate of the sample chamber alone (after bakeout) was $2.4\text{x}10^{-5}$ Torr-Liters/sec. The internal surface area of the vacuum vessel is approximately 8200 $cm^2$ for all surfaces above the inlet of the turbo pump. This corresponds to a surface outgassing rate of $2.9 \text{ x}10^{-9}$ Torr-Liters/sec-$cm^2$, which is within the range of published values for vacuum baked stainless steels.

**Preparation of the Test Sample**

As received for testing, the prototype MEBT Chopper Structure assembly was assumed to be highly contaminated due to previous handling of the sample and the presence of surface contaminants (i.e. discoloration, adhesive rubber feet, etc.). It was decided at this point that the formed sheet aluminum cover should not be included with the test sample during the outgassing test, the published values for surface outgassing of bare aluminum being readily available.

Ultrasonic cleaning of the sample was not considered to be an option due to the unknown porosity of the circuit board material (Rogers RT/duroid 6002) and the assumption that the epoxy (Emerson&Cumming ECCOBOND 45) bonding material would not withstand a high enough bakeout temperature to remove all of the moisture absorbed and/or adsorbed during the ultrasonic cleaning process.

Therefore, all accessible surfaces of the test sample were wiped down with acetone, then alcohol, in hopes of removing the majority of fingerprints, adhesive residue, machining oil residue, etc. The sample was then baked for sixteen hours at approximately 200°F to remove the solvents.

Prior to inserting the test sample into the vacuum chamber, the bolts were removed from the top of the chamber and the chamber was purged with nitrogen. The test sample was allowed to cool slightly and was then transferred directly from the oven to the vacuum chamber. The vacuum chamber was immediately resealed (using a new copper gasket) and purged with nitrogen before being pumped down.

## Test Results

The prototype MEBT Chopper Structure assembly (minus aluminum cover and rubber feet) was pumped under vacuum for three weeks. System pressure and RGA readings were logged continuously for the first five days of testing, at which point the system appeared to be nearing a steady-state condition. Thereafter, observations were made every other day.

During the first few hours of testing, the system pressure dropped precipitously from near atmospheric pressure down to $1x10^{-6}$ Torr, as would normally be expected. RGA scans indicated a normal distribution of atmospheric gases ($N_2$, $O_2$, $CO_2$, etc.), as well as the presence of water vapor and a myriad of hydrocarbons (both full and partial hydrocarbon chains). Water vapor was the largest single gas load contributor, the partial pressure being almost an order of magnitude larger than most of the other common gases.

After 24 hours had elapsed, the system pressure had decreased to $6x10^{-7}$ Torr. Water vapor was still the major gas load contributor, but the partial pressure disparity had decreased significantly when compared to the other atmospheric gases. However, the hydrocarbon partial pressures showed little decease from the previous days' readings.

After five days, the system appeared to be at or near steady-state pressure. The system pressure had decreased to $3x10^{-7}$ Torr, and was falling no more than $0.1x10^{-7}$ Torr per day at this point. The partial pressures of the atmospheric gases and water vapor had dropped an order of magnitude from the readings seen on the first day of testing. The hydrocarbon partial pressures had dropped significantly less and now contributed the majority of the gas load from the sample. The total outgassing rate from the test system with the test sample was $\sim 1.2x10^{-4}$ Torr-Liters/sec. Subtracting the outgassing rate of the empty chamber ($2.4x10^{-5}$ Torr-Liters/sec) gave an outgassing rate for the test sample alone of $\sim 1.0x10^{-4}$ Torr-Liters/sec.

At the time the test was terminated (day twenty-one), it appeared that the system pressure had leveled off to a nearly constant rate. The system pressure had decreased to $\sim 1.0x10^{-7}$ Torr, and was slowly fluctuating $\pm 0.1x10^{-7}$ Torr, depending on room temperature. **Assuming $1.0x10^{-7}$ Torr to be the total steady-state system pressure at room temperature, the steady-state outgassing rate for the test sample alone was $\sim 2.0x10^{-5}$ Torr-Liters/sec.** Because of the composite nature of the prototype MEBT Chopper Structure assembly and the questionable cleanliness of the test sample, it would be difficult to assign specific surface outgassing rates to individual components of the assembly.

## Conclusion

The steady-state outgassing rate for the test sample ($\sim 2.0x10^{-5}$ Torr-Liters/sec) is surprisingly low, given the questionable handling and cleaning of the sample prior to testing. If production units were rigorously cleaned (i.e. machining oil, fingerprints, adhesive residue, etc.) during the various fabrication steps, the steady-state outgassing rate might be lowered by as much as half the value measured on the test sample.

Note that in these discussions, the term outgassing rate is used as a generic term to mean the total gas evolved from the sample.  There is no way to determine in this measurement system if the gas source is from desorbed gases from the surface of the sample, diffused from the bulk material of the sample or from virtual leaks in the sample.