VIP CLUB

A Legacy Project Document July 1, 2009

Parts Control

UNIVAC Minuteman III Program
AN/UYK-11 Computer System

Introduction

The Minuteman program at UNIVAC began in 1969. Initially, the program offices were in plant 1 on Shepherd Road in St. Paul, MN. The program was deemed of such significance and had such rigorous parts control requirements that component engineers from the central component engineering group in plant 2 were assigned to the program full time for the development and early production phases of the program. We had three expert component engineers: one for integrated circuits and hybrids, one for discrete semiconductors, and one for passive components/oscillator/connectors.

The Minuteman III system was to be designed so that our computer unit and associated memory unit had no electromechanical devices except card and chassis connectors. There were no on/off switches or indicators. There may have been a running time meter or fault indicator but this component was not critical to system function.

Parts Selection

TRW in California was the prime contractor for the system. UNIVAC was a subcontractor. There had been generations of the Minuteman missile prior to our involvement, so there were other subcontractors. These included Boeing, Autonetics, and Honeywell. Based on that past experience, TRW provided us with a "preferred parts list" containing previously used Boeing and Autonetics parts. We were to use those parts wherever possible. However, our design required use of the latest high technologies devices so hardly any of their preferred semiconductor devices could be used.

Some new technologies were considered "risky" and required special attention. One of the technologies was the new Schottky transistor-transistor-logic (TTL) semiconductor process. This technology was used in Schottky power diodes for the power supply and in the new 54Sxx logic families. I should mention that the power diodes were the hat shaped press-in style similar to automobile alternator rectifiers. We were amused at the creativeness of our power supply designers. Another component which pushed the state of the art was a 1 ufd ceramic 50V capacitor in a 0.3 x 0.3 x 0.1 inch case. We used a lot of these because they were the main local filter capacitor used near components on each printed circuit card.

Parts Screening

TRW had to train us in the philosophy of the Minuteman Parts Control Program. The first thing they asked us to do was to list all possible failure modes of the critical component types. Being the knowledgeable experts we were, we came up with a very thorough list. Unfortunately, the

next task we were given was to define how we were going to prevent use of any components which might fail due to any of these failure modes.

Use of military grade or even space rated components was not considered good enough and many had not yet been qualified for military systems usage. This led to the generation of a Univac Parts Control Plan which defined how were going to use regular mil-grade parts and make them good enough for use on the Minuteman program. Each component was to be subjected to an electrical and environmental screen followed by a powered burn-in. Military parts normally were subjected to a burn-in but this Minuteman burn-in needed to be special. Each part was uniquely serialized. Selected electrical parameters were measured and data was recorded both before and after screening. After the test, changes in value were calculated and recorded.

For each production lot, the measurements and deltas were statistically analyzed. We looked not so much at the amount of change but whether any units in the population did not meet the norm. So, if a parameter changed 10% from before to after on a good part, then all parts had better do that (provided that a 1,000 hour operating life test showed they were good). Initially, change limits were set at +/- 6 sigma from the norm. Any parts which showed changes outside that range were considered abnormal and were rejected. If a lot had too many "abnormal" parts, the entire lot was considered suspect and special actions had to be taken to see if the lot could be accepted. A second burn-in may have been imposed.

Data Analysis and Limit Settings

The parts and the individual variable and lot data were submitted to UNIVAC. We had written programs which would run on HP 1970-vintage calculators to combine data from multiple lots. The programs were saved on credit card style magnetic media which was fed thru a reader on the calculator.

We combined the data from several lots of the same part from the same manufacturer. Thus the size of the population grew and we became better aware of the characteristics of the part. After a year of data gathering on production parts, the accept/reject criteria was tightened to 3 sigma.

Computer Master Clock Oscillator

The master clock oscillator was an interesting part. It had very tight accuracy requirements. It was crystal controlled and the crystal was contained in an electrically heated insulated oven within the package. We had characterized the drift characteristics of the crystal over time. The initial frequency was set to one end of the tolerance band so that it would drift within the band over its expected life. This was the only oven-controlled oscillator used by UNIVAC Defense Systems.

Component Process Baselines

For most major/critical components, we baselined (listed the process documents and their revision) the manufacturers processes and limited which lines the Minuteman components could

be made. Manufacturers were required to tell us of all changes they made to the process and/or materials. We audited the suppliers at least annually to make sure they had not made any changes without telling us. All changes were reviewed by Univac for potential negative impact to product reliability.

Component Stress Derating

Another requirement was that all components had to be heavily electrically and thermally derated so as not to stress them too hard. There was a set of rules that had to be adhered to and we were required to justify and get permission from TRW for any application which violated the rules. As the design was being finalized, we had a couple of persons whose only job was to look at each and every component and determine what the design stress level was. The voltage, current, power, and temperature data was recorded for each and every application of every component. This data was reviewed by the customer. As you can imagine, this took a lot of paper.

These extra efforts also made the component costs rather high. Because of all the attention, paperwork, measuring, recording, serialization, reporting that went with each part, a normal $0.02 diode cost closer to $2.00. Costs of other component types increased dramatically as well.

Summary

It was through these efforts that the AN/UYK-11 computer achieved the high reliability of the Minuteman Program. The fielded systems provided the U.S. Air Force with a Mean Time Between Failure (MTBF) of over 25,000 hours. The launch control facility system computers were running 24 hours per day, seven days a week for over a two decades – yes that is about 3 years of continuous operation per site without a single failure. The reliability was designed in and built in. We, the defense engineers based in Eagan, have not had another program since which required such attention to reliability.

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