ACCELERATED LIFE TESTING OF UNIVERSAL REMOTE MODULAR CABINETS
Abstract

Accelerated Life testing (ALT) is performed to demonstrate the life of products by exposing sample units to stresses (temperature cycling, humidity) which exceed typical environmental conditions during the product lifetime. Based on the difference between test and expected conditions, an acceleration factor and accelerated life can be calculated. This paper will discuss how ALT was performed for the Universal Process Cabinet (UPC) and the Universal Safety Cabinet (USC), and provide the results with empirical estimate of the demonstrated life of the product. Feedback from various customers affirmed that the outdoor plant equipment had at least a 30-year lifetime. During the course of testing, the UPC and USC successfully exhibited more than 30 years of minimum accelerated life without any functional failures. Extensive visual inspection and functional testing were conducted at the completion of the test, and those observations were used to drive further product reliability improvements.
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Background
The UPC and USC are IPP66 rated cabinets housing redundant power supplies, IO modules and fiber optic extenders (FOE) eliminating the centralized marshalling cabinets. With the UPC and USC, as the cabinet components are preconfigured, the engineering effort is reduced in comparison to conventional cabinet customization and facilitates faster and more efficient plant startup. The home run cables are completely eliminated yielding lower project installation and execution costs.

Introduction
Unlike typical DCS system components which are located in indoor, climate-controlled rooms, the UPC and USC cabinets are outside and can be exposed to the elements. The electronics within the cabinets will be subject to temperature and humidity variations. While all UPC/USC cabinet (Figure 1 and 2) components are rated for, and have been tested to, the full range of the cabinet environmental specification, ALT provided a further practical demonstration of reliability in the face of long term exposure to varying climatic conditions.

Common reliability analysis models, such as MIL-217-F, typically show temperature and humidity as having a significant impact on the long-term reliability of electronics, up to an order of magnitude worse based on the expected conditions. However, these models are generally viewed as extremely conservative and do not provide an accurate representation of the expected life of the product; the value of these models is that they provide a common point of comparison and establish a minimal threshold. An empirical approach, such as ALT is needed to set a reasonable expectation for the reliability of electronic components of the UPC/USC products when subject to varying environmental conditions. By subjecting the cabinets to harsh temperature cycling and humidity, any failure modes present in the electronic components can be accelerated and years of effective life can be simulated within a few weeks of test time. Using the MIL-344A temperature cycling and Pecks Power Law (humidity acceleration models, a demonstrated life for test duration can be calculated.
Accelerated Life Test Setup
The ALT of the UPC/USC was performed by placing 3 units of the UPC backplate assemblies and 3 units of the USC backplate assemblies in 2 similar environmental test chambers capable of providing temperature and humidity condition to cover the full specified range of the product. The backplate assemblies were modified to fit within the chamber (Figure 3). The external cabinets were omitted to directly expose electronic components to the chamber condition. The redundant circulation fans were also omitted, as the chambers provide sufficient air circulation. The modified backplate assemblies were mounted to a wooden frame (figure 4) and positioned perpendicular to the chamber airflow (figure 5).

The UPC assemblies were connected to an external C300 server using a fiber daisy-chain connection, as shown in figure 6; similarly, the USC assemblies were connected to a Safety Manager located outside the chamber. Each input/output (I/O) channel was connected to the adjacent channel through a current mirror (figure 7) located outside the chamber. For each backplate, 19 channel pairs were configured as analog and 13 channel pairs were configured as digital, with each pair having one input and one output. The current mirrors allow for complementary I/O connections (i.e. DO ↔ DI, and AO ↔ AI) to be exercised in a loopback manner. Each output channel was configured to 10 mA.
The ALT chambers were programmed to cycle both temperature and humidity for the duration of the test. As shown in figures 8 and 9, the chambers' temperature controls were programmed to cool to ~40°C, then heat to 70°C. Humidity control was programmed to turn on when the measured temperature within the chamber reached ~10°C during the heating cycles, and turn off before the temperature reached zero during the cooling cycles to minimize condensation and frost. Due to the difference in the capability of the 2 chambers used, the ramp rates and cycle time of the test differed between the UPC and USC setups. As a result, the total test duration for the UPC ALT was increased to achieve the same demonstrated life. Temperatures within each chamber were measured using digital recording devices located at 3 locations within the chamber, and confirmed the uniform temperature and humidity distribution. (Figure 10)
Observations
The USC and UPC successfully passed the ALT conditions with the following summary test results:

- Both USC and UPC demonstrated over 30 years of accelerated life
- USC and UPC underwent 38 and 65 days of ALT stress conditions respectively
- All IO channels signals that were monitored continuously performed within the specified accuracy limits
- Visual inspection revealed typical signs of ageing which was consistent with accelerated stress conditions, but these did not translate to any functional or accuracy failures
  - Signs of corrosion as a result of exposure to liquid water/condensation were noticed
  - Presence of zinc oxide due to rapid cycling preventing the formation of a stable patina was observed

In the UPC, one DC terminal block screw and fuse was observed to be insufficiently torqued. This resulted in loss of power to the Fiber Optic Extender under hot and humid conditions. Factory procedures were revised to ensure proper torquing during assembly. Honeywell recommends checking all connections during field installation, as vibration during transport may also loosen some connections.

UPC power supplies were returned to the supplier and they passed the full manufacturing test process as well. All 3rd party electronics survived the test, with only one exception in which two power supply fans in the USC assemblies stopped functioning. This minor failure did not result in loss of power and redundancy was not compromised. As electromechanical components, fans are subject to different acceleration processes than electronic equipment. This favorably infers that the fans demonstrated a longer life than the calculated life for the overall system. Honeywell and the supplier of the power supplies carried out detailed analysis and the findings were provided to the fan supplier for product improvements.

Additional IOM Tests
Three redundant Universal I/O Modules, CC-PUIO31 were subjected to the Accelerated Life Test separately following the same stress cycle as the cabinets. All channels were monitored continuously and performed within the specified accuracy limits. The modules demonstrated an accelerated life of 28.4 years\(^1\) without any failures.

Conclusion
Honeywell Universal Process Cabinet and Universal Safety Cabinets demonstrated reliable operation under harsh temperature and humidity conditions performing the signal monitoring and control within specified accuracy limits. All assemblies showed normal signs of ageing as a result of the high temperature, high humidity conditions. Based on the accelerated life testing, the UPC cabinet and the USC cabinet each demonstrated continued operation within product specifications for over 30 years without any failures.

Within the planned testing time, the USC demonstrated 31.4 years accelerated life while the UPC demonstrated 32.4 years. Additional test times could have provided longer demonstrated lifetimes for the cabinets (see figure 11 below).

\(^1\)While the units were subjected to the same total stresses described in this document, the demonstrated accelerated life was shorter as a result of the shorter total test duration achieved by shorter temperature/humidity cycles.
Figure 11 – Demonstrated MTTF for UPC and USC

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