MetroCount Environmental Testing

Conducted for NYSDOT under the requirements of contract BA-081.

MetroCount Environmental Testing

Scope

This document describes the environmental testing conducted by MetroCount as part of the supply of ATR units complying with NYSDOT bid document BA-081 paragraph 2.3 Environment.

Test Requirements

Document NYSDOT BA-081 requires ATR units to be tested under simulation for 12 to 24 hours at 60°C and also at –10°C. Furthermore, units must be tested under simulation for 72 hours at "room temperature".

The rate of change of temperature is specifically limited to less than 18°C per hour.

The temperature error band is not specified in BA-081. For the cold test the external air temperature is maintained at –11°C ± 1°C ensuring that the temperature is always below –10°C. Similarly, the hot test is conducted at an air temperature of 60.5°C ± 0.5°C.

The nature of the simulation is not specified in BA-081.

MetroCount has interpreted the words "room temperature" to mean a normal uncontrolled indoor factory environment.

Documentation is to be provided with each batch of ATRs specifying the exact test conditions and external ambient environment.

Test Implementation

Simulation

Testing was conducted in batches of 120 units due to the large number of ATR units to be tested and the special requirement of continuous simulation. Two custom shelving units were constructed to hold 60 units each.

Pulse Generators

Air pulse simulation was provided by custom pulse generators. These devices were connected to a tuned manifold and pulsed the air-switches of six ATR units simultaneously.

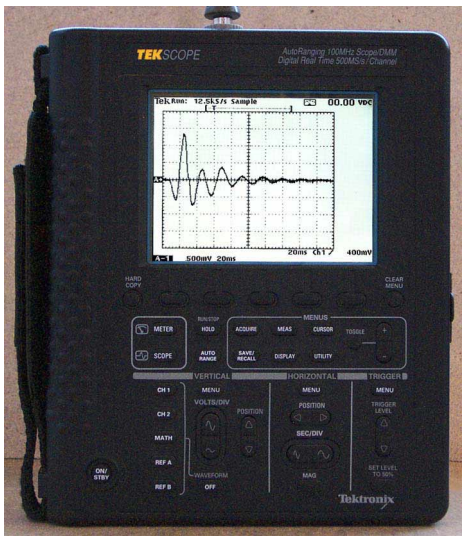
As it would be very difficult to bring 240 air hoses through the wall of an environmental chamber the pulse generators were placed in the testing environment. This required special care in the design of the pulse generators, so that their operation was not degraded by the internal conditions of temperature and humidity. Stable and calibrated output had to be maintained under the icing conditions of the cooling cycle, which ruled out any mechanical motion that relies on sliding or rotating parts.

The pulse generators are fired from a custom built driver circuit, using a microprocessor pattern generator with crystal controlled timing.

Custom pulse generator connected to tuned manifold, and driving circuitry.

The air pulse created by the pulse generators have the following characteristics:

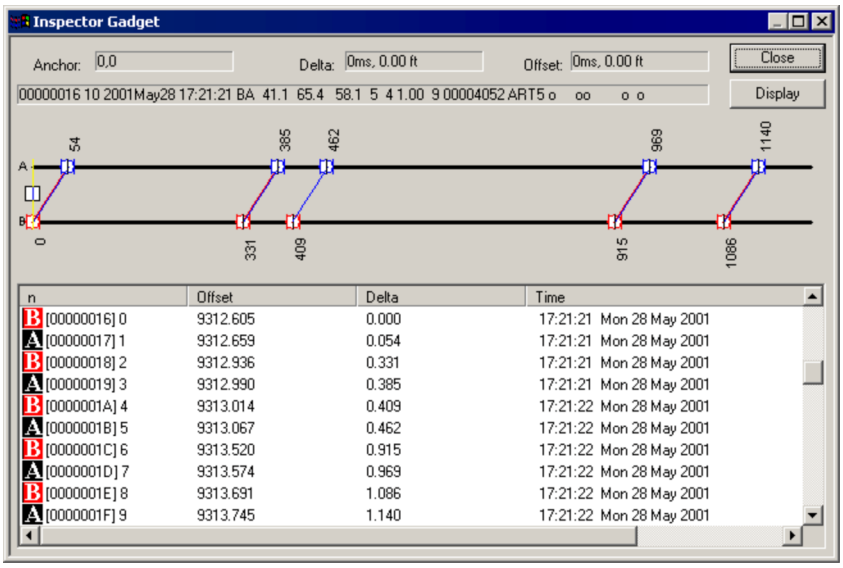
- The pulse is approximately one eighth of the amplitude of that seen from a passenger automobile crossing a standard length road hose. The marginal nature of this pulse will show any mismatch between the sensors and highlight noise or sensitivity changes with temperature.
- The pulse is a damped sinusoid with a gradual decay. This requires proper functioning of the self-adjusting characteristic of the air-switch amplifiers to remove the decaying peaks.
- The pulse has a much slower onset than a typical road tube pulse. This will tend to increase the effect of any timing changes that occur as a result of threshold and sensitivity changes.
- The pulses are delivered to both channels of the ATR simultaneously. Although this is not the normal mode of operation, it is the condition of maximum timing stress for a time stamping ATR.



Typical pulse characteristics.

Test Pattern

The pulse generators were used to generate a pattern modelling a real vehicle. The pattern chosen is a typical F9 truck, with a split tandem axle pair on the trailer, and travelling at about 40mph. This particular vehicle was selected as the spacing between no two pairs of axles is the same. This criteria clearly highlights dropped axle hits during the data analysis.

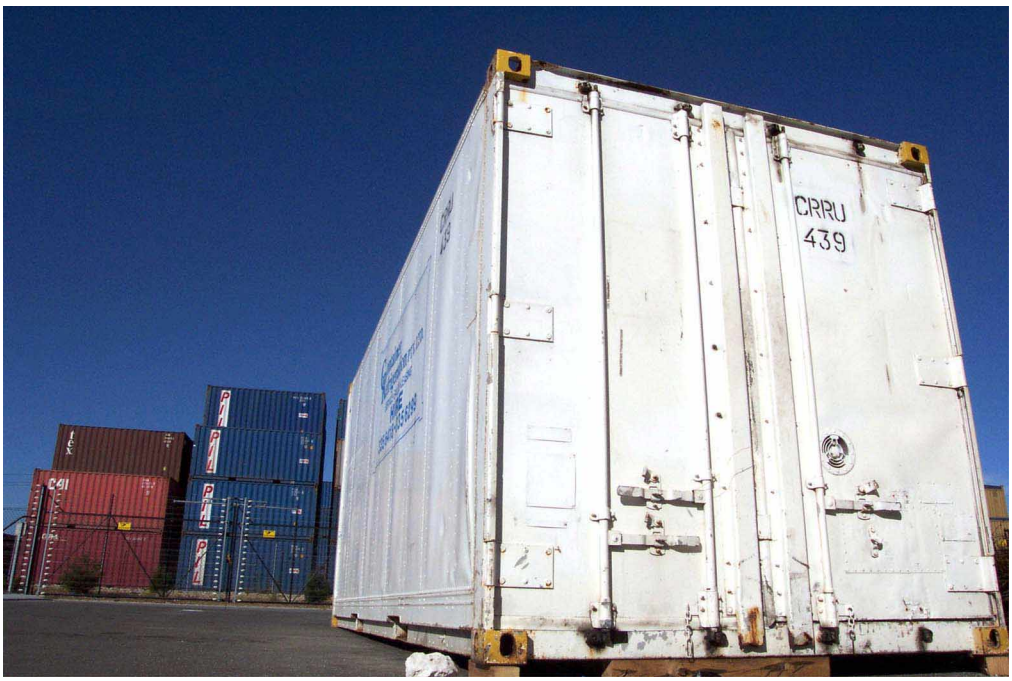


Test pattern timing.

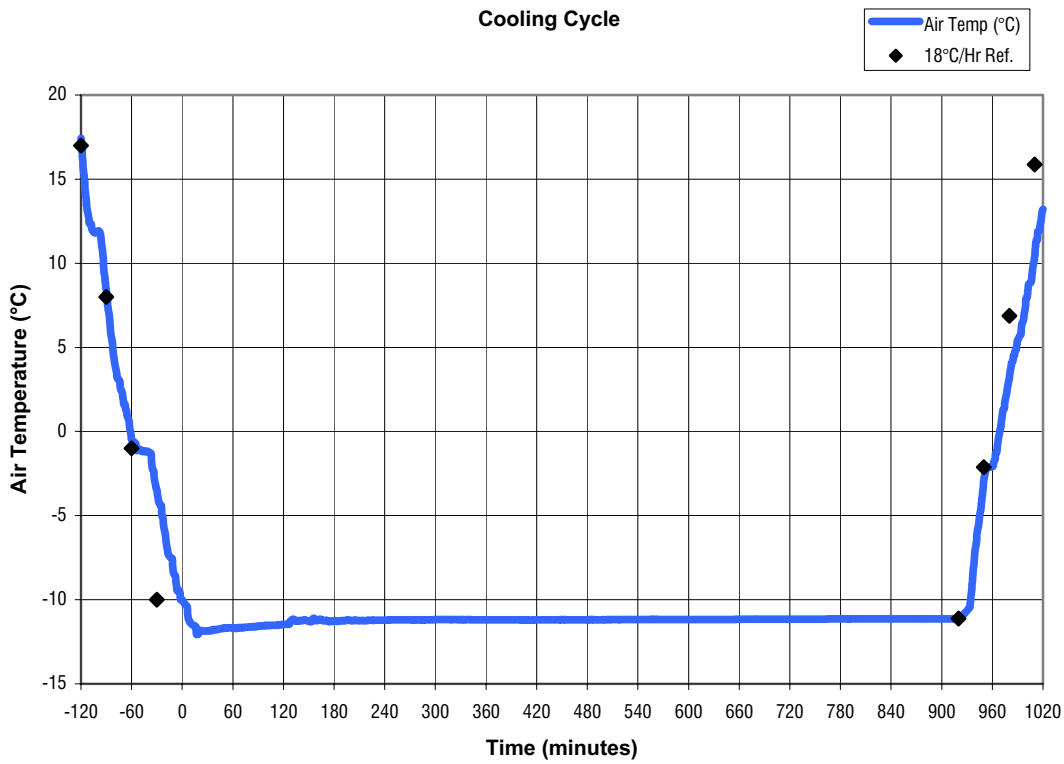
The air pulse generators have a considerable peak power demand so, to spread the load and reduce electrical noise, the pulse pattern is delivered in four phases (of thirty ATRs). Each ATR receives a vehicle pattern at approximately ten second intervals. This period was extended to one minute for the room temperature cycle due to its extended duration.

Cooling Cycle

The cold environment was provided by a standard 20' refrigerated cargo container. These units can easily maintain the required -10°C within one degree for long periods and changing external conditions. They have considerable internal air circulation so conditions are uniform within the cooled space.



Standard 20ft reefer for cooling cycle.

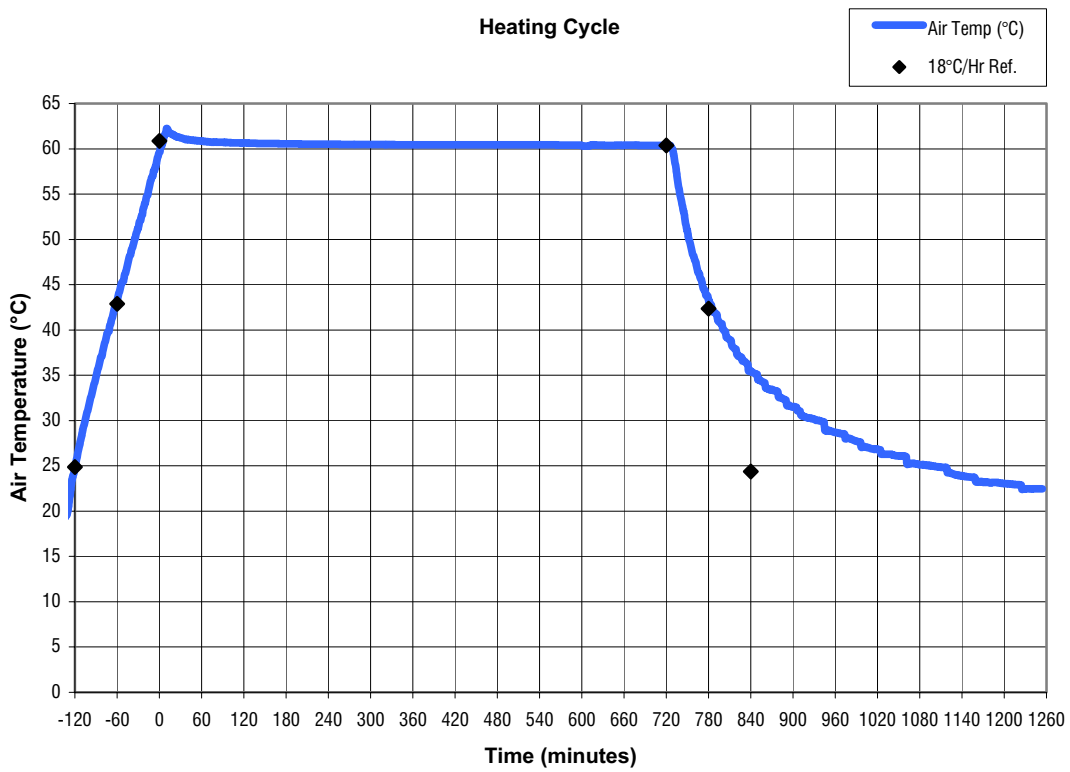


Typical temperature profile for cooling cycle.

Heating Cycle

The hot environment was provided by a custom built oven. This unit has a heating pack that blows controlled temperature air up a central mixing duct. This air flow is split in two and filters through two racks of 60 ATRs to the bottom of the chamber where it is recirculated through the heater. A small flow of external air is bled in to remove any harmful vapours. Temperature was maintained using a standard PID controller.

Custom-built oven for heating cycle, and controlling hardware.



Typical temperature profile for heating cycle.

Calibration

Temperature

A Type-K thermocouple was used as a working reference to 0.5°C accuracy over the range -10°C to +60°C. This has been calibrated against the combination of a Labfacility platinum RTD and a Hewlett Packard 3456A Integrating Voltmeter. This system has a combined accuracy of about 0.1%.

Temperature was logged in the environmental chambers with two standard ATR units (of the same model as being tested) that were modified to read internal and external temperature. This allows accurate inference of the internal temperature of the production units without the need for modification.

Timing

Timing is ultimately referenced to a Hewlett Packard 5334B Universal Counter with Option 010 High Stability Timebase. This has an accuracy of better than one part in a million.

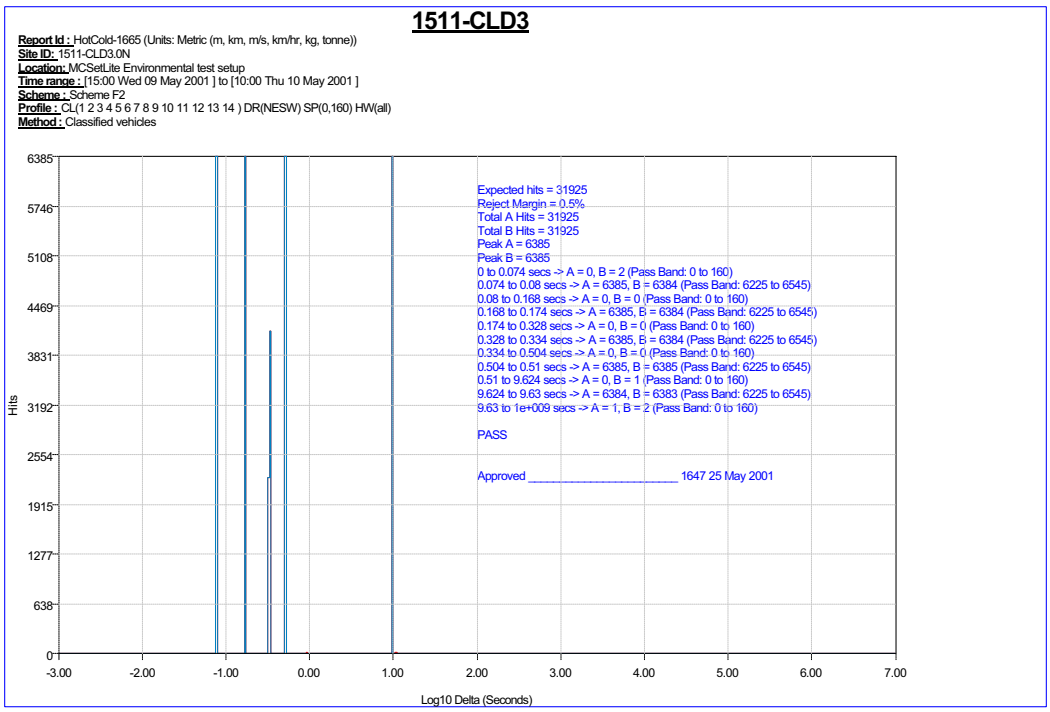
Pulser Pressure

Pulse pressure was referenced to a standardised MetroCount air-switch, using a Tektronix THS720 oscilloscope.

Certification

Data Analysis

Analysis of the 1200 data files produced from the testing was performed using a customised variant of MCReport's Spectrum of Axle Hits, and automated using the Batch Analysis feature.



Custom Spectrum of Axle Hits report used for certification.

The repetitive nature of the simulation results in a Hit Spectrum that consists of five concise peaks - four intra-pattern timings, and one for the repetition period. If hits are lost or additional hits generated, this pattern is disturbed in an obvious way.

Qualification Criteria

Two criteria are used to qualify a unit as a pass or fail:

- the total number of recorded sensor hits, and
- the distribution of time between hits.

A **Reject Margin** of ±0.5% is defined for all values.

Total Hits

The total number of hits for each cycle is known, given the length of the test cycle and the repetitive nature of the test pattern. This value (**Expected Hits**) is compared against the actual recorded number of hits, **Total A Hits** and **Total B Hits**, which must be within the reject margin.

Timing Bins

The distribution of timing between hits is divided into 11 bins:

Bins	Anticipated Hits in Bin
Intra-pattern timings (4)	20% Expected Hits ± Reject Margin
Repetition period (1)	20% Expected Hits ± Reject Margin
Dead bands (6)	< Reject Margin

Timing bins were determined by measuring actual pulse timing using the HP 5334B Universal Counter, and allowing an error band of ±3ms. Deviation within this error band is largely due to variation between pulse generators caused by resonances and transit time anomalies in the rubber tubes.

Any deviation from the anticipated hits in any of the timing bins results in a failed unit.

Documentation

Certification is defined to be a Pass in each of the three cycles.

All reports are provided on a CD in Adobe Acrobat format, grouped by unit serial number, and accompanied by a signed declaration of conformity.

Results

All MetroCount Roadside Units included in the environmental testing passed under the specifications defined in this document.