CONCLUSIONS

A computer-controlled goniometer was designed, constructed, and used to test LED signals used in rail applications. Six 12 inch red LED crossing signals, and three 8 inch (red, yellow, green) LED wayside signals were tested. All lab tests were conducted using both the ITE and proposed Transport Canada evaluation patterns.

Two the 12 inch red LED signals tested do not use any type of power supply or regulator to control the voltage and current supplied to the LED circuit. Important observations about LED signals that do not use power supplies can be drawn from the lab tests:

- there is a threshold supply voltage below which the signals have no light output,
- above this threshold voltage the maximum light intensity is a strong, fairly linear function of the supply voltage, and
- the maximum light intensity is essentially proportional to the number of active LED elements across the wide range tested (20% to 100% active).

The remaining four 12 inch red LED signals used a power supply to regulate the voltage and current supplied to the LED circuit. Two important observations about LED signals that use power supplies or regulators can be drawn from the lab tests:

- above a threshold voltage, the maximum light intensity is not a strong function of the supply voltage, and
- the maximum light intensity is not a strong function of the percentage of active LED elements – for the open-circuit tests – in the ranges tested (60% to 100%).

In general, the light intensity responses (in terms of peak light output in candela) of units that do not use power supplies are very sensitive to both the supply voltage and the number of active LED elements. The LED signals that use power supplies have, in general, light intensity responses that are much less sensitive (in many cases insensitive) to power supply variations and the number of active LED elements. The primary conclusion that can be drawn from these observations is that there is no consistency in the performance of all types of LED crossing signals with respect to power supply variations or the number of active LED elements. Consequently, there is no overall conclusion that can be drawn about the light intensity output of an LED signal without knowledge of the way the signal is constructed, i.e. does it have a power supply or regulator?

The light intensity response of the three 8 inch wayside signals was similar to that of the four 12 inch crossing signals that used power supplies. The maximum light intensity was significantly different for each color, but for each signal there was little variation in light intensity with changes in supply voltage or the number of open-circuited elements.

All of the lab tests were conducted with a colorimeter that was capable of measuring the color of the signal as well as the light intensity. With a few exceptions, there were no significant changes or shifts in the color output from any of the LED signals tested during any of the tests. The few color shifts that were observed occurred primarily at very low supply voltages and low signal light intensity,

A field test procedure was developed that was used to determine how individuals perceive LED signals experiencing partial failure. Two test stands were designed and built to support four railroad warning signals during field tests. A manually operated switch system was designed to allow two operators to select patterns of non-illuminated LEDs during field tests. Two field tests were conducted with volunteers using the field test procedure. The field test was designed to allow volunteers to report misinterpretations of a signal at a short distances (100feet) as well as greater distances up to 1500 feet.

In general, all of the 12 inch red signals were correctly interpreted when 50% or more of the LED elements were active. Interestingly, the signals with approximately 25% of the LED elements active were often misinterpreted at the closest distance of 100 feet. Some of the volunteers were apparently confused by the discrete appearance of the “on” and “off” portions of the LED signal. Unfortunately, this type of field testing appears to be greatly affected by the volunteer’s experiences during the test, since the signals were fixed in the same location during all tests.

Also note that field test results for the WPS#3 and NPS#4 signals, which were located on the same test stand, were nearly identical. The results for the WPS#2 and NPS#1 signals were also similar. Therefore, there may be an undetermined factor related to the orientation of the signals with respect to the sun that may influence how an individual perceives each signal.