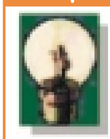
Our Signal Engineer reports...

Solid state illumination

Figure 1

	Tungsten Lamp	LED
		
Efficiency in converting energy into light	Poor	Excellent
Activation speed	Poor	Excellent
Ability to produce bright, distinct colours	Unable	Excellent
Robustness	Delicate	Tough
Endurance	Short life	Long life

Rationale

Signal engineers and railway operators have sought reliable methods of lighting signals right from the Victorian days of long burning paraffin lamps. 1980s aspirations to use the (then novel) technology of LEDs, has been discussed before in these columns. In the last five years however, rail signal manufacturers have been directly challenged by the UK rail infrastructure owners (Network Rail, and before them Railtrack) to provide a modern technology alternative to the traditional filament lamp colour light signal.

Success would appear to be in grasp of any company worth its salt - simply populate a circuit board with commercially available LEDs and fit them into an enclosure. But a number of attempts have met with varying degrees of success. Some well known names have dropped out of the race, very few managing to get to trialling. This competition is gruelling, in the extreme, with particular technical difficulties and (especially) in the UK, it has become the equivalent of seeking the Holy Grail.

The driving force for change is not rocket science. In technical terms filament lamps compare very unfavourably to LEDs (fig. 1). They are inefficient, unreliable, have a limited life, are costly to manufacture and difficult to source. (there is currently only one manufacturer of standard signal lamps in the UK). On economic grounds the argument for change is astounding. Maintenance costs for lamps can best be understood by appreciating 'how many men does it take to change a light bulb' - answer three!

First, filament lamp changing can occupy a significant portion of a three man maintenance team's work allocation. Whilst full 'lamp out' failures are rare, the consequence of such failures are significant in terms of delay and opportunity costs invoked by tying up the maintenance team for a significant portion of the shift. The speculation must be considerable.

Thus whilst a lamp might only cost £10 or so, its average life will be around 3,000 to 5,000 hours. That is a lot of men and equipment for bulb changing! Replacing just 5,000 of the UK's 25,000 main colour signals to LED's could result in a cost savings of more than €3m per year, on maintenance alone.

Failures have been negligible

Compared with long range running signals, the sub signal is relatively easy to design and produce (and to a less demanding specification as it is a very short range signal). Over the past two years 6,500 LED ground signals have been installed on Network Rail infrastructure alone. The signals now show a double red aspect for the 'on' condition.

Failures have been negligible (low single figures) compared with around 1,000 previous lamp out (wrong side) failures using conventional lamp/lit signals. This serves to illustrate the major impact that can result from changing to a high reliability device. This is the exciting prospect, which this latest design of long-range signals now fulfils.

The supplier

Variable Message Signs Limited (VMSL) has been a leading innovator and supplier of high tech LED messaging products and systems to the road transport sector for more than a decade. Their output includes the latest motorway signs. The Company was invited by Railtrack to produce a Category 1 (readable from 800 metres) long range colour light signal in accordance to group standard RT/E/S/10062 (1999).

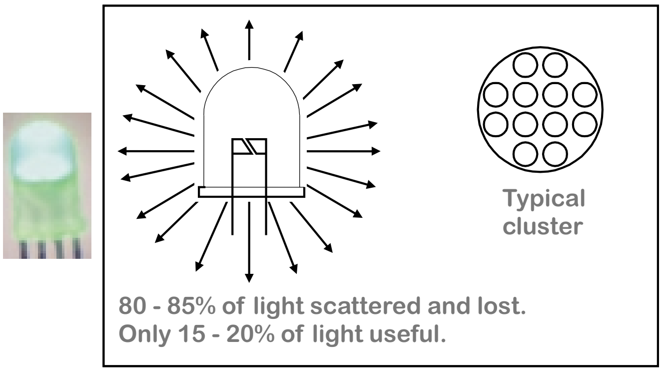
Challenges

Whilst there has been an ongoing debate regarding some aspects of the specification, in general it is not too prescriptive, thereby permitting suppliers to adopt creative ideas. However, there were two areas where VMSL (almost certainly in common with other potential suppliers) was really stretched.

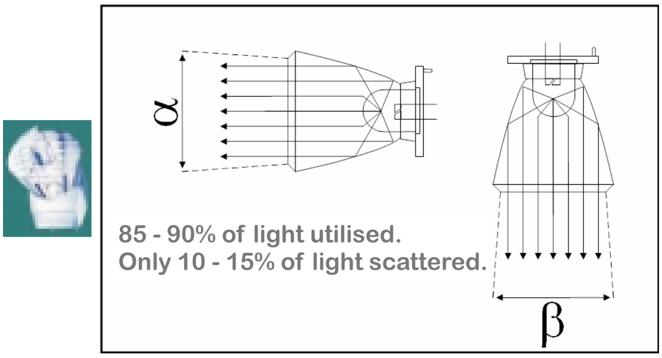
Firstly, there was the colour issue. Colours for railway signals are obviously closely specified, and standards have not changed from those usually applied to filament lamp signals. The railway group standards call up European standards within which the exact colours are closely defined (these do vary from the standards applied to highway signals and indeed to some other transport operators and other international railways).

Red and green were reasonably straightforward; devices, which are readily available, produce light at the appropriate wavelengths to fit the specification. Producing yellow colour compliance has proved more demanding to achieve, and it has been difficult to maintain compliance at the low temperature of minus 20degC. Various ingenious methods have been employed to meet this requirement.

Figure 2



Conventional application LEDs wastes most of the light output



The patented RIGEL technique captures and directs most of the light output

The second challenge has been to provide signal proving and fault reporting. The specification requires that LED signals must mimic the distinct levels of detection characterised by a double filament lamp - that it is healthy, and first filament failure and second filament failure are noticed.

LED aspect design strings a number of devices in one chain and subsequently provides a number of chains. Losing one LED (and therefore one chain) would reduce readability by a fraction; several chains would need to be lost to go below minimum readability.

Conventional lamp proving relies on monitoring current flow as an indication of lamp output (although this does not always give appropriate answers even for filament lamps), however with LED devices the light output is not related to current. This is particularly relevant as devices age - light output deteriorates over time, whilst input current remains constant. Testing of actual light output has therefore become a part of the regular maintenance regime of LED signals.

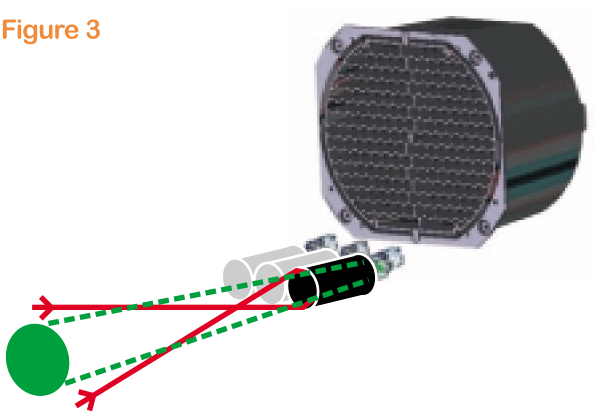
Electronics are provided to ensure that sufficient strings of devices are illuminated to maintain the required readability, and should insufficient strings be displayed the equivalent of lamp failure is indicated. One specific advantage of LED arrays is that failure and degradation can be predicted in advance of complete failure, in most cases many months in advance, thereby enabling a maintenance change to be undertaken at a convenient time.

VMSL have persevered with the task, and having prepared an exhaustive (and exhausting!) safety case they have obtained Network Rail approval to trial, and HMRI's consent to trialling.

Innovation

Whilst ensuring adherence to the requirements of the specification, VMSL has used its talent and experience in creating messaging displays to build in a number of innovative and unique features that improve the reliability and operation of the signal. At the heart of each aspect of the VMSL LED signal is the unique RIGEL optical lens (fig.2). This lens captures more than 85% of the light generated from each LED, and projects it in a focused, distortion-free beam. This ensures a highly intense and precise light pattern within the required three degree cone. Capturing more emitted light means that the devices need only

Figure 3



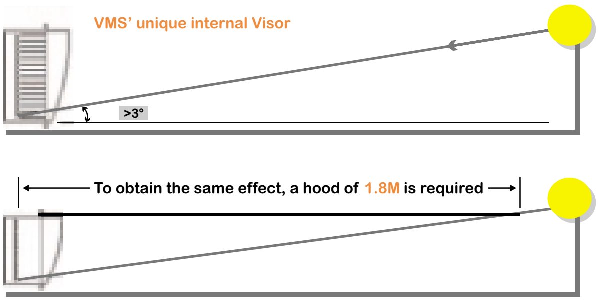


Figure 4

be driven at a fraction of their rated power. This extends their life considerably, and improves the reliability of the signal.

Light shining into the front of a signal may have dangerous consequences. With a filament signal the interior of the light compartment is matt black to ensure that any light entering the box cannot be reflected out and generate a 'phantom' aspect. External hoods provide further protection. LED signals do not need the same provisions, however incident light can still reflect back towards the driver, and obscure the aspect.

The VMSL signals (fig. 4) employ an internal visor. The unique design matt-black moulded plastic (fig. 3) prevents phantom signals by dispersing and absorbing any incident sunlight, ensuring that the only aspect appearing to be emitting light is the one actually illuminated. Conventional external hoods prevent full signal viewing and offer poor protection from low angled sunlight. With the integral visor these are superfluous. To obtain the same effect from the conventional external hood it would have to be 1.8 metres long!

The exit lens is made from toughened, scratch resistant coated polycarbonate, designed to have no effect on light beam distribution, whilst providing protection from rain, debris, pollution and vandalism. The lens is forward sloping, to minimise glare and deflect low level sunlight downwards (fig. 5). The lens incorporates a close-up viewing sector which is very similar to a conventional 'hot strip.' This sector diverts a small amount of light from the main beam to enable visibility at close range. The angular position is easily selectable (figs. 6 & 17).

The specifications deal with all of the requirements for the signal, including how the signal behaves in hot and cold conditions, and how it copes with the weather. The filament lamps in conventional and ground signals, generate sufficient warmth to keep the lenses clear under most snow and frost conditions, but the much greater efficiency of LED devices denies the use of waste heat, and may require the signal to be warmed specifically in cold weather! The internal hoods on the VMSL signal effectively prevents snow from accumulating, in order to obscure the lens above.

Trialling

As with any product being introduced onto the UK network, trialling is required prior to gaining approval, in order to test the performance in real-life situations. By the very nature of their operation, colour light signals have a huge potential impact on safety. Therefore, once a 'sponsor area' is agreed, extensive assessment needs to be conducted to ensure compatibility with existing schemes.

VMSL have obtained the support of a WCML team who are actively identifying suitable sites for trialling six signals, which are expected to be completed within a number of weeks of going to press.

Variable Message Signs Limited are probably best known for the giant variable message signs we are used to seeing on the motorway and trunk road network; the car parking guidance systems employed in many towns and cities, and the speed and vehicle activated signs for road safety and speed management.

Figure 5

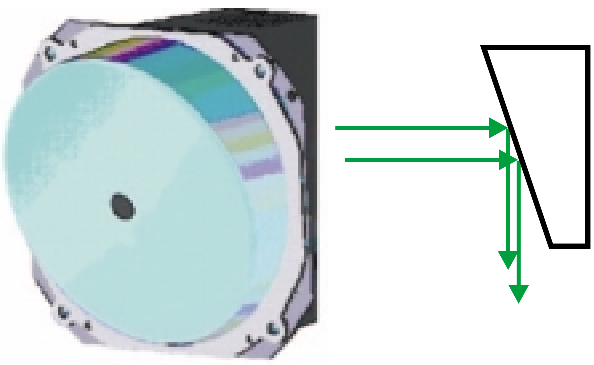


Figure 6

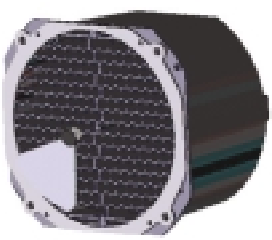


Figure 7