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Summary of motor vehicle and pedal cycle conspicuity: part 2 - pedal cycles.

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Summary of Motor Vehicle and Pedal Cycle Conspicuity

Part 2: Pedal Cycles

Undertaken on behalf of

The Department of the Environment
Transport and the Regions

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Checked by

1.0 Objectives

- Do flashing lights improve conspicuity ? If it is found that they do, then suitable performance characteristics must be developed;
- Do steady LED's provide adequate conspicuity ? If it is found that they do, then suitable performance characteristics must be developed;
- Do existing and proposed legislation and standards provide adequate conspicuity ? If they do not, then proposed improvements must be developed.;
- Do existing and proposed legislation and standards provide adequate front illumination ? If they do not then proposed amendments must be developed.

2.0 Literature review

There appears to be conflicting evidence for the visual performance of different lighting systems. Fundamental issues such as colour appear to remain unresolved, often because each study approaches the problem with a slightly different perspective. When combined with other factors, such as location or intensity, it seems that the specification for an optimum has so far been elusive. Lighting is clearly a significant factor in conspicuity, though the means by which this is determined do not appear to have clarified the issue greatly.

Strong arguments are made for the purpose of rear lights to be to draw other road users' attention and permit accurate placement of the cycle light. Identification of the object as being a cyclist is claimed to occur once the other vehicle's lights fully illuminate it. Red lights are reported as being more detectable than yellow or amber, given certain conditions. They may also offer other performance benefits related to user behaviour and expectations. It also seems that flashing lights may be more attention getting but may be more difficult to locate in the road environment, especially against a cluttered background.

3.0 Technologies

Essentially, cycle lighting can be broken down into types reflecting the different technologies used in the production of the illumination. The categories can be summarised thus:

- Battery powered filament lights using either Tungsten, Krypton, Xenon or Halogen light sources
- Battery powered flashing LED lights
- Battery powered static LED lights
- Dynamo powered filament lights

4.0 Standards and Regulations

In the hours of darkness cyclists are required by the Road Vehicle Lighting Regulations 1989 (RVLRL) to show a white light to the front and a red light to the rear. Those lights must comply with British Standard BS6102 : Part 3 : 1986 - Specification for photometric and physical requirements of lighting equipment, or offer equivalent performance. Other lights may also be fitted to the cycle, but must be supplementary to the obligatory lights. The fitting and use of flashing red lights on a bicycle is currently prohibited by the RVLRL. Despite this, flashing red lights are readily available and extensively used.

5.0 Interested parties

The following issues were identified among the responses from interested parties:

- There is a commonly held belief that rear LED lights are more conspicuous;
- Static rear LED lights appear to meet universal appeal, whilst flashing lights are more contentious;
- Many user groups do not recommend the use of flashing LED lights alone - though a combination of flashing and static seems popular;
- BS compliant lights are thought of as unreliable, expensive to run and that they offer poor performance;

- There are concerns over the validity of certain elements of the British Standard test procedure, particularly with regard to temperature and vibration resistance;
- Front LED lights receive little support, though may have benefits as supplementary aids to visibility;
- Enforcement agencies appear to support the use of flashing rear LED's;
- One party supplied a copy of comprehensive testing of lights to the British Standard which showed a wide variety in compliance and efficiency.

6.0 Subjective trials

Through a paired comparison methodology it has been possible to identify the key variables which seem to affect the apparent relative visibility of different cycle light options. These variables appear to be the angle from which the light is viewed, the apparent brightness of the light and the technology on which the light is based.

The issue of flashing versus static lights was addressed by the trials although the outcome was less clear than had been anticipated, with other factors, such as light intensity, appearing to greatly influence the perceived performance. Overall, there was no clear preference for either static or flashing lights.

For front lights, the preference was for the brightest and 'whitest' light, with lights of less output being rated as less visible. Front LED lights ranked poorly against other light types.

7.0 Objective trials

The method used to compare the filament and LED cycle lights was primarily to record the visual search behaviour of subjects as they were shown groups of cycle lights. Monitoring visual search is a powerful tool that can investigate the response of subjects to certain stimuli by indicating where, or to what, subjects are visually attending. The method does not suffer from the cognitive distortion associated with other methods such as interrogation or verbalisation.

The lights all performed to approximately the same level (there were no statistically significant differences). Within this overall similarity were trends that suggested that in general static filament lights performed slightly better than other static and flashing LED lights.

There was little difference in the rankings between the presence and absence of distraction lighting. This shows that any distraction appears to affect all lights similarly. There was, however, a clear subjective preference for one of the British Standard compliant filament lights. The apparent lack of correlation between subjective and objective recording techniques appears to indicate that, in this evaluation, those lights subjects consider most conspicuous are not the ones which are most attention getting. This information offers a rebuttal to those who claim the 'obvious' benefits of various lighting systems.

8.0 Forward visibility trials

In conditions where there is no street lighting (or other light sources), it appears unlikely that any of the lights tested would afford adequate forward illumination to a cyclist. Subjects were unable to accurately detect hazards on a simulated road at a distance of 5.5 metres, which represents the minimum braking performance of the British Standard. The situation was worse if the hazards did not fall within the focal centre of the beam, where detection rates no better than guessing may result.

If the lights are intended for use in a predominantly urban environment, this may not be an issue since primary road illumination will be achieved through street lighting. In this scenario, the main function of the cycle light will be to act as a position light to warn other road users of the cyclist's presence.

9.0 Glare effects

Bicycle lights utilising traditional technologies are unlikely to cause disability glare for other road users.

However, in these trials the example of a new technology, a halogen ‘micro’ bulb, did cause both discomfort and disability. It was also subjectively rated as the ‘most visible’ light in the Phase 1 subjective trials.

It may be the case, therefore, that improvements in technology results in lights of superior performance but which offer increased risk of glare. If the light is correctly aligned and the beam pattern suitably structured, there may be little argument against a similar upper output limit to powered two-wheelers.

However, since there is not any formal mechanical testing of cycles (akin to MOT testing for powered two-wheelers) it may be possible for cyclists to cause difficulties for other road users by the use of poorly aligned, high powered, lights.

10.0 Output of front lights

The majority of user groups repeatedly cite British Standard compliant lights as being unacceptable, either in performance criteria, or in terms of battery life or mechanical longevity. Five front lights were selected and their beam pattern, their light output and their battery performance were assessed.

From these trials it was found that the cost of superior performance of lights is a reduced battery life. Additionally, the majority of lights fall below the requirements of the British Standard within a short period of time as the batteries discharge. This results in a severely reduced light output with the attendant limitation of both forward vision and, potentially, conspicuity.

11.0 Output of rear lights

The development of British Standard compliant rear LED lights during the course of this project has negated a large amount of criticism of the Standard. The performance requirements of the Standard appear adequate, and the LED compliant lights offer significant benefits in terms of longevity and durability. Whilst all the flashing lights fail to comply with the Standard (in static mode), their performance from the objective trials does not appear to be inferior.

Battery life, and the associated depletion of performance in filament lights, is also a problem for rear lights, especially since the rider is unable to readily observe the light's status. It is also the case that cyclists may run the light to exhaustion. Filament lights will continue to work at very small outputs for a protracted period of time, whereas LED lights may have a threshold below which they are extinguished. This could be used to define a better overall level of performance.

12.0 Cost Benefit analysis

There were 24,585 cyclist casualties in 1997 (20,997 slight, 3405 serious, 183 fatal). From published data it can be estimated that 41 % of those killed or seriously injured were involved in accidents during the hours of darkness, which equates to 1471 individuals (41% of the 3405 + 183, totalling 3588). Watts noted that 76 % of cyclists use front and rear lights, of which 67% were considered as 'bright'. This equates to 51% (67% of 76%) of cyclists at night using bright front and rear lights.

Lighting used by the remaining 49% of night time cyclists could be termed deficient. Of these, 15% of cyclists have been observed as only using having one working light, whilst a further 9% have no lights at all. In summary, nearly half of all cyclists riding at night (49% or 100% - 51%) could benefit from improved lighting.

The provision and use of affordable, durable lighting equal in performance to the British Standard during use could, at a maximum, therefore save the lives of 37 (49% of 41% of 183) of fatally injured cyclists and reduce the severity of an additional further 684 (49% of 41% of 3405) seriously injured cyclists. A further 4286 who receive slight injuries could also benefit. These figures represent cyclists currently using no lights, a single light or a deficient pair of lights.

The current estimated cost of a fatal casualty is £902,500, a serious casualty £102,880 and a slight casualty £7,970.

Using these figures the potential saving from fatal casualties is approximately £33 million, serious casualties £70 million and slight casualties £34 million. The total potential saving could therefore be in the order of £137 million. Against this would be balanced a cost to each cyclist of, say, approximately £10 to furnish them with effective lighting. Of the 20 million cycles owned in the UK, it is estimated by the Countryside Commission that 3.6 million are used on a weekly basis. These are thought to be ‘regular’ cyclists, who commute or routinely exercise on bicycles. If these are to be assumed to be the cyclists at risk, the total cost would be in the order of £36 million.

Conclusions and Recommendations

The following conclusions are drawn and recommendations made.

13.1 Flashing lights

Conclusion

- Flashing lights do not improve conspicuity, neither do they impair it.

Recommendation

- Flashing lights should feature a static option for testing and consumer choice. In static mode they should comply with the current British Standard.

13.2 LED Lights

Conclusion

- Steady LED lights also do not enhance or impair conspicuity.
- Static LED lights compliant with the British Standard are already available, and these seem to overcome the main criticisms of the Standard, relating to durability and longevity of performance.

Recommendation

- Static LED lights should comply with the British Standard specification.

13.3 Current standards – lighting durability and performance

Conclusion

- Existing Standards appear to provide adequate conspicuity, as long as the light continues to maintain the test specification light output.

- It appears that the poor durability of some lights and the rapid decline of output in use may reduce the conspicuity to unacceptable levels.
- Current Regulations prohibiting the use of flashing red lights appear to deny legitimate access to a viable modern alternative to filament lights.
- The RVLRL appear to be ineffective or unenforced, as flashing lights are clearly being used by many cyclists.

Recommendations

- The Standard should be made more stringent with regard to these factors.
- Amending the RVLRL would allow control of the lights made available to the consumer, and would help provide a specific light characteristic that could be associated with vulnerable road users.

13.4 Current standards – frontal lighting

Conclusion

- Existing Standards provide adequate frontal conspicuity, which is the major requirement of lights used in urban environments, where most accidents occur.
- In these locations, the rider does not require, or use, the cycle lights for navigation.
- British Standard compliant front lights do not provide adequate forward visibility in areas where there are no street lights, either to navigate or to avoid hazards.

Recommendations

- The introduction of a front ‘Headlamp’ standard would permit the development of alternative lighting offering the same minimum conspicuity, but also the additional forward visibility necessary for negotiation of unlit environments.
- There should be an upper limit to light output, but this may be broadly in line with other road vehicles. Consumers could then make an informed choice.
- British Standard compliant front lighting also appears to offer inadequate durability and output over time, and these aspects of the Standard require revision.